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Strength of Materials (Part-1)

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CLASS TEST 2019-2020

CIVIL ENGINEERING

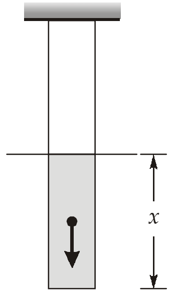
Date of Test : 21/09/2019

ANSWER KEY ➤ Strength of Materials (Part-1)

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

DETAILED EXPLANATIONS

2. (b)



$$\sigma_x = \frac{W_x}{A} = \frac{\gamma\, A \cdot x}{A} = \gamma\, x$$

If dimensions are increased in the proportion $n : 1$

$$\sigma'_x = \gamma . nx$$

$$\therefore \quad \sigma'_x : \sigma_x = n : 1$$

3. (d)

Taking compression as positive (since both the stresses are compressive thus equations will not change).

$$\in_{\text{lateral}} = \in_2 = \frac{\sigma_2}{E} - \frac{\mu(\sigma_1 + \sigma_2)}{E}$$

When σ_1 alone was acting, then lateral strain

$$\in_1 = \frac{-\mu\sigma_1}{E}$$

It is said in the question above that,

$$\in_2 = \frac{\in_1}{2}$$

$$\Rightarrow \quad \frac{\sigma_2}{E} - \frac{\mu(\sigma_1 + \sigma_2)}{E} = \frac{-\mu\sigma_1}{2E}$$

$$\Rightarrow \quad \sigma_2 - \mu(\sigma_1 + \sigma_2) = -\frac{\mu\sigma_1}{2}$$

$$\Rightarrow \quad 2\sigma_2 - 2\mu\sigma_2 = \mu\sigma_1$$

$$\Rightarrow \quad \sigma_1 = \frac{2\sigma_2(1 - \mu)}{\mu}$$

4. (c)

Since, the load will be taken by portion AB only.

$$\therefore \quad \text{Gap} = 0.8 \text{ mm} = \frac{W \times L_{AB}}{A_{AB} E}$$

$$\Rightarrow \quad \frac{W \times 2000}{400 \times 2 \times 10^5} = 0.8$$

$$\Rightarrow \quad W = 32000 \text{ N or } 32 \text{ kN}$$

5. (a)

$$\text{Strain energy stored} = \frac{\tau^2}{2G} \times V = \frac{(40)^2}{2 \times 10^5} \times 100 \times 80 \times 50 = 3200 \text{ N-mm} = 3.2 \text{ N-m}$$

6. (a)

Since the strain will be linear in the flitched beam and thus stress (maximum bending stress) will be depend upon the modulus of elasticity (E) of the material of the component.

7. (c)

$$\delta = \frac{\gamma L^2}{2E}$$

8. (c)

$$\text{Maximum shear stress} = \frac{(P/A)+0}{2} = \frac{P}{2A}$$

9. (c)

$$\text{Poisson's ratio, } \mu = \left|\frac{\text{Lateral strain}}{\text{Longitudinal strain}}\right|$$

$$= \frac{0.02}{0.05} = 0.4$$

Now, for E = 220 GPa and G = 90 GPa,

$$\mu = \frac{E}{2G} - 1 = \frac{220}{2 \times 90} - 1 = 0.22 \text{ which is not true}$$

For E = 212 GPa and G = 76 GPa,

$$\mu = \frac{E}{2G} - 1 = \frac{212}{2 \times 76} - 1 \simeq 0.4 \text{ which is true}$$

13. (b)

Let, the stress developed on each side is σ.

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

Strain along one side due to temperature rise = αT

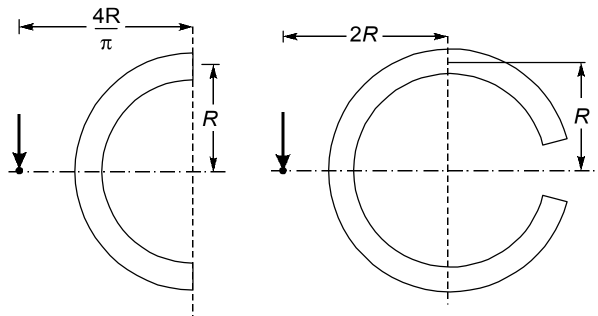
As cube is restrained from all sides, therefore, both strains should cancel out each other i.e. algebric sum of both strains should be zero.

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

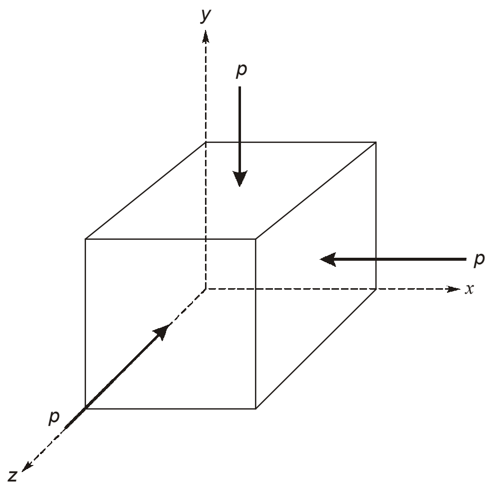
$$\Rightarrow \quad \sigma = \frac{E\alpha T}{1-2\mu}$$

14. (c)

For semi circular arc the shear centre is at $\frac{4r}{\pi}$ from centre of the arc. In the case of circular tube made open by means of a cut the shear centre lies at a distance $2r$ from the centre of the circle.



15. (b)



$\because$ Pressure is a compressive stress

$$\therefore \qquad \varepsilon_x = -\frac{200}{200\times10^3}-\frac{1}{4}\left(\frac{-200}{200\times10^3}\right)-\frac{1}{4}\left(\frac{-200}{200\times10^3}\right)$$

$$= -5\times10^{-4}\text{ mm/mm}$$

$$\therefore \qquad \text{Elongation, } \Delta_x = \varepsilon_x L_x = -5\times10^{-4}\times50$$

$$= -0.025\text{ mm} = -2.5\times10^{-2}\text{ mm}$$

16. (d)

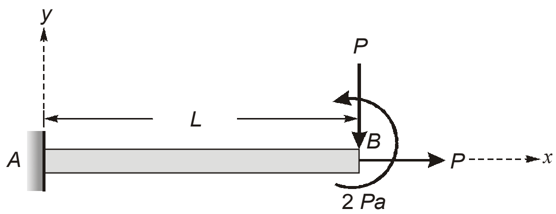
$$\text{Total load on beam, } w = 10+20 = 30\text{ kN/m}$$

$$\text{Maximum shear force, } F = \frac{wL}{2} = \frac{30\times8}{2} = 120\text{ kN}$$

$$\text{Average shear stress, } \tau_{avg} = \frac{F}{A} = \frac{120\times10^3}{\frac{1}{2}\times200\times300} = 4\text{ N/mm}^2$$

$$\text{Maximum shear stress, } \tau_{max} = \frac{3}{2}\tau_{avg} = \frac{3}{2}\times4 = 6\text{ N/mm}^2$$

17. (c)



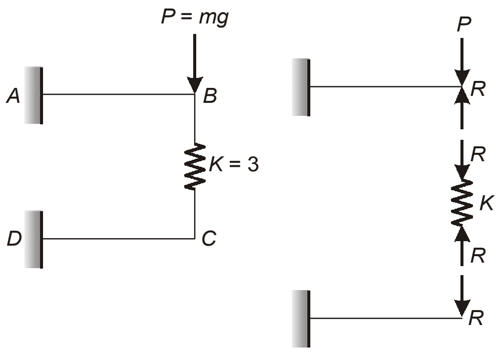
Load P along x axis does not account in the vertical deflection of point B.

Now, $\Delta_B = 0$

$$\Rightarrow \qquad \frac{PL^3}{3EI}-\frac{(2Pa)L^2}{2EI} = 0$$

$$\Rightarrow \qquad \frac{L}{a} = 3.00$$

18. (c)



Compression in spring = $\Delta_B - \Delta_C$

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

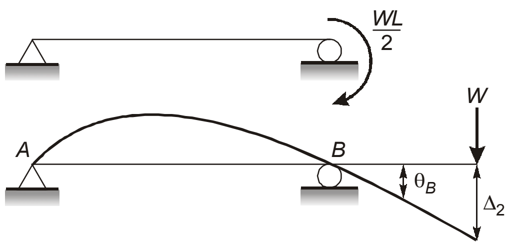
Given, $I = EI = L = 1$ unit

$$\therefore \quad R = \frac{P}{3}$$

Equivalent stiffness of structure

$$= \frac{P}{\frac{(P-R)L^3}{3EI}} = \frac{3P}{P - \frac{P}{3}} = 4.5$$

19. (b)



Deflection due to cantilever action of load in span BC.

$$\Delta_1 = \frac{W(L/2)^3}{3EI} = \frac{WL^3}{24EI}$$

$$\theta_B = \frac{(WL/2)L}{3EI} = \frac{WL^2}{6EI}$$

Now $$\Delta_2 = \theta_B \cdot \frac{L}{2} = \frac{WL^3}{12EI}$$

$$\therefore \quad \Delta = \Delta_1 + \Delta_2 = \frac{WL^3}{8EI}$$

20. (b)

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

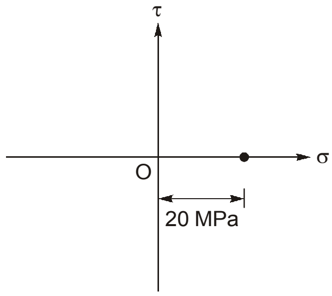
$$\therefore \quad R = \frac{EI}{M} = \frac{2\times10^5\times1\times10^8}{40\times10^6}$$

$$= 500{,}000 \text{ mm} = 500 \text{ m}$$

21. (a)

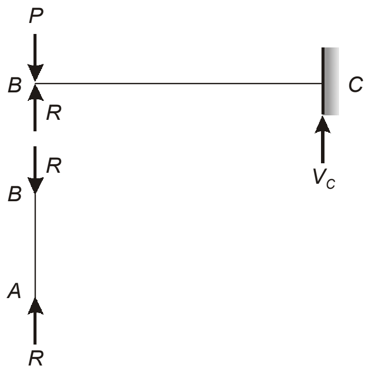
This is the case of hydrostatic loading and in this case Mohr's circle results in a point.

$\therefore$ Diameter of resulting Mohr's circle = 0 MPa



22. (b)

Let the reaction at support A be R.



Deflection at A in beam BC = Compression in column AB

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

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

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

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

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

23. (c)

While deriving the formula, following considerations are made:

- Linear variation of strain
- Pure bending
- Under pure bending

  $\sigma_y = \sigma_z = \tau_{xz} = \tau_{zx} = 0$

Option 1, 4 and 5 are correct.

24. (a)

$$\because \quad \Delta = \frac{4PL}{\pi E D_1 D_2}$$

Given: L = 500 mm, D_2 = 15 mm

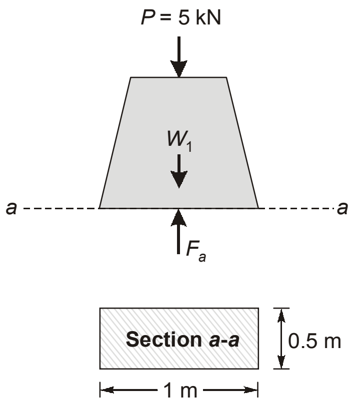
D_1 = 25 mm, Δ = 0.2 mm

$$\Rightarrow \quad 0.2 = \frac{4P \times 500}{\pi \times 2 \times 10^5 \times 25 \times 15}$$

$$\therefore \quad P = 23561.945 \text{ N} = 23.56 \text{ kN}$$

25. (a)

Total applied force, $P = 20 \times 0.5 \times 0.5 = 5$ kN



Weight of the pier above section a - a,

$$W_1 = \frac{(0.5+1)}{2} \times 0.5 \times 1 \times 25$$

$$= 9.375 \text{ kN}$$

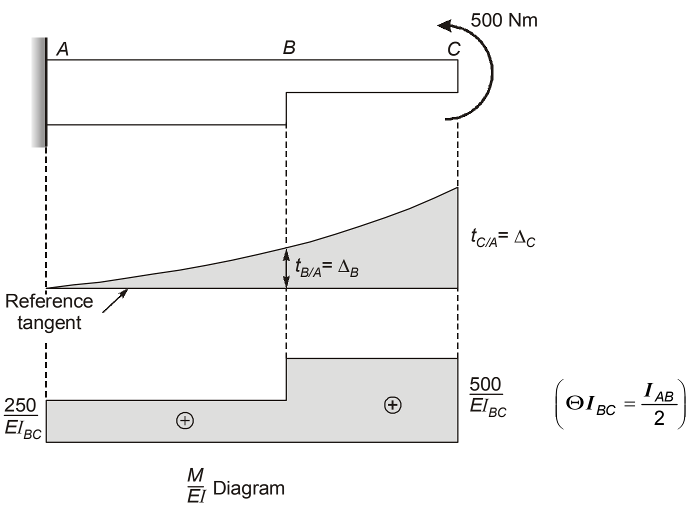
$$\Sigma F_y = 0$$

$$\Rightarrow \quad F_a = P + W_1$$

$$= 5 + 9.375 = 14.375 \text{ kN}$$

Normal stress at level a-a $= \dfrac{F_a}{A} = \dfrac{14.4}{0.5 \times 1} = 28.75 \text{ kN/m}^2$

26. (c)



$$\Delta_C = t_{C/A} = \text{Moment of } \frac{M}{EI} \text{ diagram between } A \text{ and } C \text{ about } C$$

$$\Delta_C = \frac{500}{EI_{BC}} \times 3 \times 1.5 + \frac{250}{EI_{BC}} \times 4 \times 5 = \frac{7250}{EI_{BC}}$$

$$\Delta_C = \frac{7250}{2 \times 10^5 \times 4 \times 10^6 \times 10^{-6}} \text{m}$$

$$\Delta_C = 9.0625 \times 10^{-3} \text{ m} \simeq 9.06 \text{ mm}$$

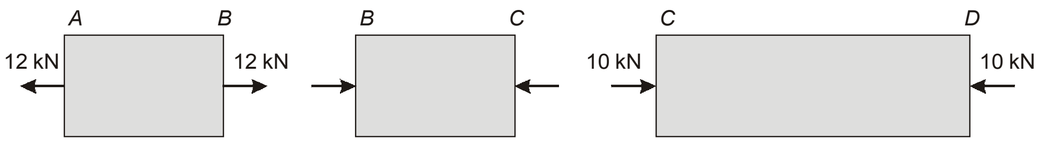
Now, $$t_{B/A} = \Delta_B = \frac{250}{EI_{BC}} \times 4 \times 2 = \frac{2000}{2 \times 10^5 \times 4 \times 10^6 \times 10^{-6}} \text{m}$$

$$\Delta_B = 2.5 \times 10^{-3} \text{ m} = 2.5 \text{ mm}$$

$\therefore$ $$\frac{\Delta_C}{\Delta_B} = \frac{9.06}{2.5} \simeq 3.62$$

27. (c)

FBD diagram of the bar



Deflection of free end

$$\delta_D = \delta_{AB} + \delta_{BC} + \delta_{CD}$$

$$\delta_D = \frac{P_1 L_1}{AE} + \frac{P_2 L_2}{AE} + \frac{P_3 L_3}{AE}$$

$$\delta_D = \frac{12 \times 1000}{\frac{\pi}{4} \times 40^2 \times 200} + 0 - \frac{10 \times 2000}{\frac{\pi}{4} \times 40^2 \times 200}$$

$$\delta_D = \frac{4}{\pi \times 40^2 \times 200}[12 \times 1000 - 10 \times 2000]$$

$$\delta_D = \frac{-4 \times 8000}{\pi \times 40^2 \times 200}$$

$$\delta_D = 0.0318 \text{ mm (shortening)}$$

Let at distance 'a' from 'C', the deflection is zero.

$$\delta_x = \delta_{AB} + \delta_{BC} + \delta_{CX}$$

$$\delta_x = \frac{12 \times 1000}{\frac{\pi}{4} \times 40^2 \times 200} - \frac{10 \times a}{\frac{\pi}{4} \times 40^2 \times 200}$$

$$\delta_x = 0$$

$\Rightarrow$ $$12 \times 1000 = 10 \times a$$

$\Rightarrow$ $$a = 1.2 \text{ m}$$

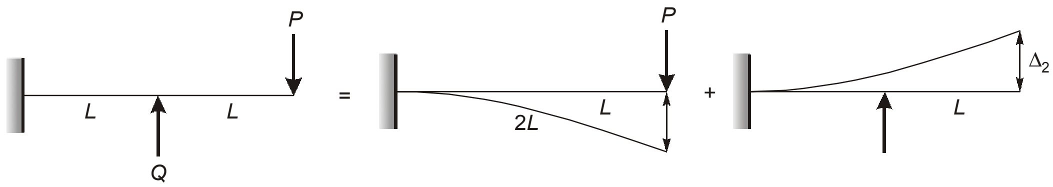
So deflection is zero at 3.2 m from left end.

28. (a)

Moment of inertia of composite beam

$$= I_w + mI_s = \frac{bh^3}{12} + \frac{mth^3}{12}$$

29. (b)



$$\frac{P(2L)^3}{3EI} = \Delta_1$$

$$\Delta_2 = \frac{QL^3}{3EI} + \frac{QL^3}{2EI} = \frac{5QL^3}{6EI}$$

For deflection to be zero at free end,

$$\Delta_1 = \Delta_2$$

$$\Rightarrow \quad \frac{P(2L)^3}{3EI} = \frac{5QL^3}{6EI}$$

$$\therefore \quad Q = \frac{16P}{5} = 3.2P$$

30. (b)

$$\frac{dV}{dx} = -w \quad \text{and} \quad \frac{dM}{dx} = V$$

$$\therefore \quad w = -\frac{d^2M}{dx^2}$$

Thus (b) represents the relation between load and BM at any section.

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