RIB-R | T3

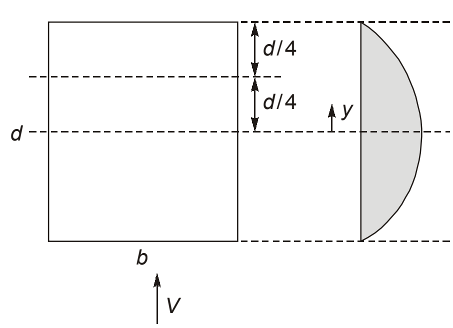
Session 2019-20 | S.No. : 300619_SK2A

ANSWER KEY ➤ Strength of Material

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

DETAILED EXPLANATIONS

2. (b)



As we know that, $\tau = \frac{6V}{bd^3} \cdot \left(\frac{d^2}{4} - y^2\right)$

To findout, $\tau_{max} = ?$

Given that (τ)1/4th of depth i.e.

$$\tau_{(y=d/4)} = \frac{6V}{bd^3}\cdot\left(\frac{d^2}{4}-\left(\frac{d}{4}\right)^2\right) = 120$$

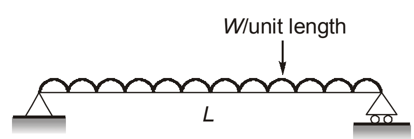
$$\Rightarrow \quad 120 = \frac{6V}{bd^3}\cdot\frac{3}{16}\left(d^2\right)$$

$$\Rightarrow \quad 120 = \frac{9}{8}\frac{V}{bd} = \frac{9}{8}\tau_{avg}$$

$$\tau_{avg} = \frac{8\times 120}{9} = \frac{320}{3}\text{ MPa}$$

$$\therefore \quad \tau_{max} = \frac{3}{2}\tau_{avg} = \frac{3}{2}\times\frac{320}{3} = 160\text{ MPa}$$

3. (d)



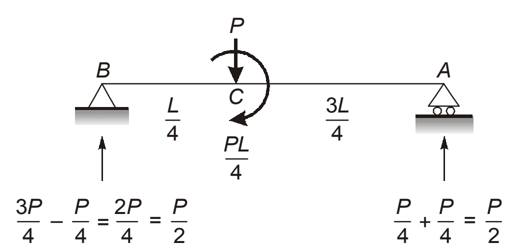
Deflection at mid span

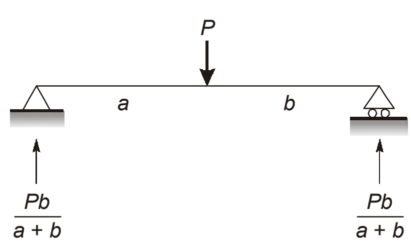
$$\delta_{max} = \left(\delta_{\text{mid-span}}\right) = \frac{5}{384}\cdot\frac{WL^4}{EI}$$

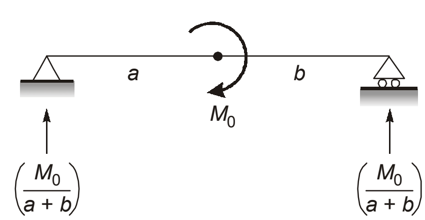
If $L = (2L)$ then

$$(\delta_{max}) = 16\,\delta_{max}$$

4. (b)







$$\therefore \quad \text{Maximum B.M occur @}C = R_A\times\frac{L}{4}+\frac{PL}{4}$$

$$= \frac{P}{2}\times\frac{L}{4}+\frac{PL}{4} = \frac{PL+2PL}{8} = \frac{3PL}{8}$$

$$(\text{BM})_{max} = \frac{3PL}{8}$$

5. (a)

Given, Diameter of shaft = 200 m

Maximum shear stress = 50 MPa

∴ From torsion formula we know that

$$\frac{\tau_{max}}{R} = \frac{T}{\left(\frac{\pi D^4}{32}\right)}$$

for solid circular shaft,
$$\tau_{max} = \frac{16T}{\pi d^3}$$

$$T = \frac{50\ \text{N/mm}^2 \times \pi \times (200)^3\ \text{mm}^3}{16}$$

$$= 78539816.34\ \text{N-mm}$$

$$T = 78.5\ \text{km}$$

6. (d)

From given Mohr's circle,

$$AB = \tau_{max} = R = 5\ \text{MPa}$$ (R = radius of Mohr's circle)

∴ Major principal stress, $(\sigma_1) = OA + AD = 4 + 5 = 9$ MPa

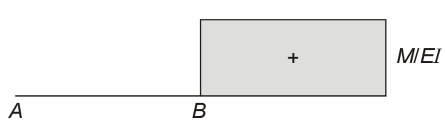
∴ Minor principal stress, $(\sigma_2) = AE - OA = 5 - 4 = 1$ MPa (but it is (–ve))

∴ Principal stresses are (+ 9MPa, – 1MPa)

7. (b)

1. Conjugate beam method is applicable for both prismatic as well as non-prismatic beams for which it is easy to draw $\frac{M}{EI}$ diagram.
2. If real beam is determinate and stable, conjugate beam will also be determinate and stable.
3. BMD of conjugate beam is deflection curve/elastic curve of the given real beam.
4. SFD of conjugate beam is the slope curve of given real beam.

9. (a)



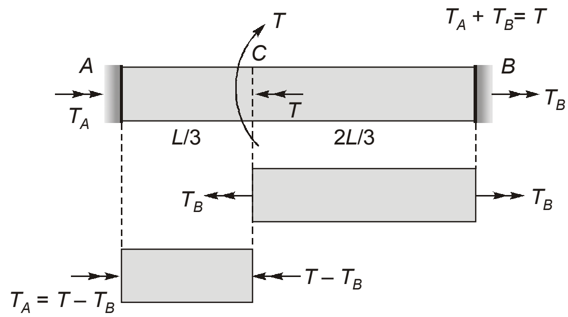
Deflection of C, with respect to tangent at A

$t_{AC} = \delta_C$ = Area under M/EI diagram × (C.G of area about point C).

$$\delta_C = \left(\frac{M}{EI} \times \frac{L}{2} \times \frac{L}{4}\right)$$

$$\delta_C = \frac{ML^2}{8EI}$$

12. (d)



As end is fixed,

$$\theta_{AB} = 0$$

$$\theta_{AC} + \theta_{CD} = 0$$

$$\frac{(T-T_B)L/3}{GI_P} + \left(-\frac{T_B.2L/3}{GI_P}\right) = 0$$

$$(T-T_B)\frac{L}{3} = T_B.\frac{2L}{3}$$

$$3T_B = T$$

$$T_B = \frac{T}{3}$$

$$T_A = \frac{2T}{3}$$

$$\theta_{AC} = \theta_C - \theta_A = \theta_C$$

$$\theta_C = \frac{\frac{2T}{3}\cdot\frac{L}{3}}{GI_P} = \frac{2TL}{9GP}$$

13. (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.

14. (a)

Given,

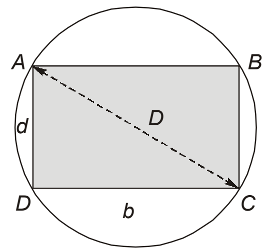
$$\varepsilon_1 = 8 \times 10^{-4}$$

$$\varepsilon_2 = 4 \times 10^{-4}$$

$$\sigma_1 = \frac{E}{1-\mu^2}(\varepsilon_1 + \mu\,\varepsilon_2) = \frac{75000}{1-(0.5)^2}\left(8\times10^{-4} + 0.5\times4\times10^{-4}\right)$$

$$= 100 \text{ kN/m}^2 = 100 \text{ kPa}$$

15. (b)



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

From ΔACD, $D^2 = b^2 + d^2$ ...(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), $D^2 = \frac{D^2}{3} + d^2$

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

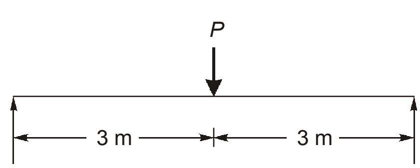
∴ Size/dimensions will be ($b \times d$) $d = \sqrt{2/3}\,D$

$$= \left(\frac{D}{\sqrt{3}} \times D\sqrt{\frac{2}{3}}\right)$$

16. (c)

Given, $D = 500$ mm

Allowable bending stress for the wood = 6 MPa



Let P (in kN)

$$(\text{BM})_{max} = \left(\frac{P}{2}\times3\right) = \frac{3P}{2} \text{ kN-m}$$

$$z = \frac{bd^2}{6} = \frac{\frac{D}{\sqrt{3}} \times \left(\sqrt{\frac{2}{3}}.D\right)^2}{6} = \frac{D^3}{9\sqrt{3}}$$

$$z = \frac{(500)^3}{9\sqrt{3}} = 8018753.739 \text{ mm}^3$$

From fixture formula

$$\frac{f}{y_{max}} = \frac{M}{I}$$

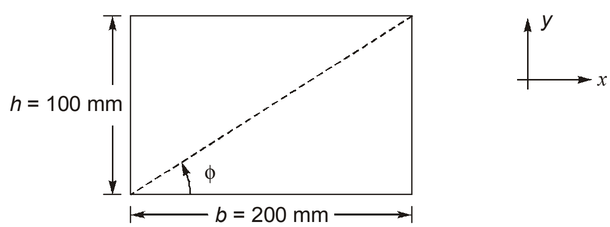
$$f_{max} = \frac{M}{Z}$$

$\therefore$
$$M = f_{max} \,.\, Z = \frac{6N}{\text{mm}^2} \times 8018753.739 \text{ mm}^3$$

$$\frac{3P}{2} \times 10^6 \text{ N-mm} = 6 \times 8018753.739 \text{ N-mm}$$

$$P = 32.075 \text{ kN}$$

17. (b)



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

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

$$\phi = 26.56°$$

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

$$= \frac{\left(195 \times 10^{-6} - 125 \times 10^{-6}\right)}{2} + \frac{19510^{-6} - \left(-125 \times 10^{-6}\right)}{2}\cos(2 \times 26.56)$$

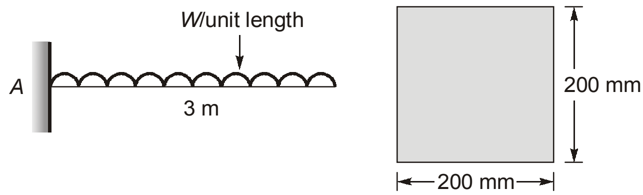
$$\varepsilon_{OD} = 1.31 \times 10^{-4}$$

$\therefore$ Change in length of diagonal *OD*

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

$$= 0.0293 \text{ mm}$$

19. (b)



$$f_{max} = 5 \text{ N/mm}^2$$

Let w in (kN/m)

$$\frac{M}{Z} = 5 \text{ N/mm}^2$$

($b = d$) for square section

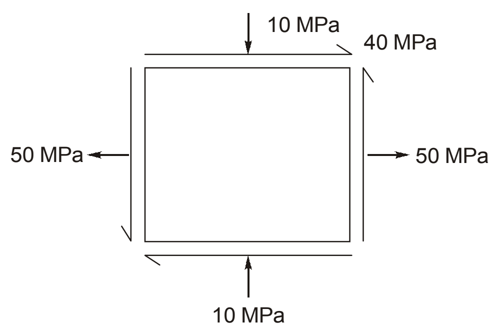
$$\frac{\left(\frac{WL^2}{2}\right)}{Z} = 5 \text{ N/mm}^2$$

$$Z = \frac{bd^2}{6} = \frac{d^3}{6}$$

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

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

21. (d)



∴ Principal stresses

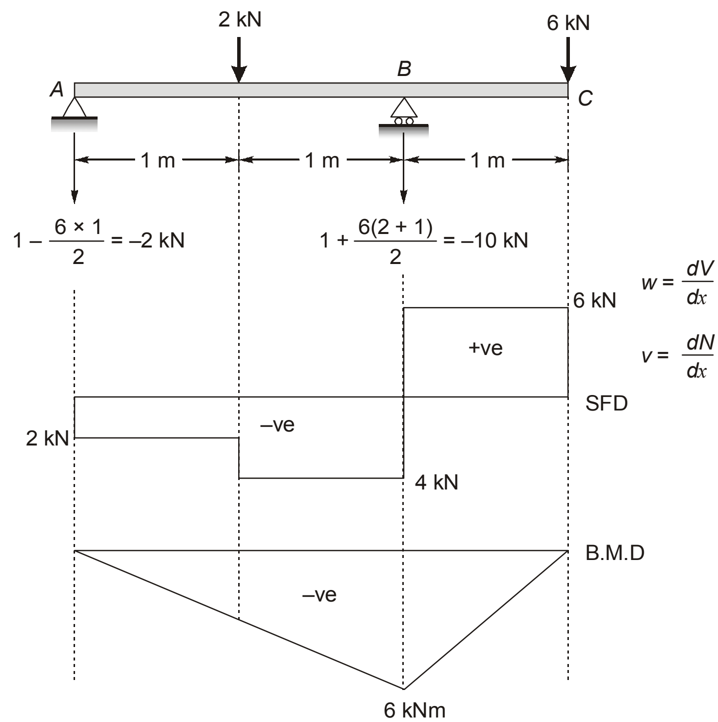
$$\sigma_{1,2} = \frac{\sigma_x + \sigma_y}{2} \pm \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$$

$$\sigma_{1,2} = \frac{50+10}{2} \pm \sqrt{\left(\frac{50-(-10)}{2}\right)^2 + (40)^2} = 20 \pm 50$$

σ_1 (major principal stress) = 70 MPa

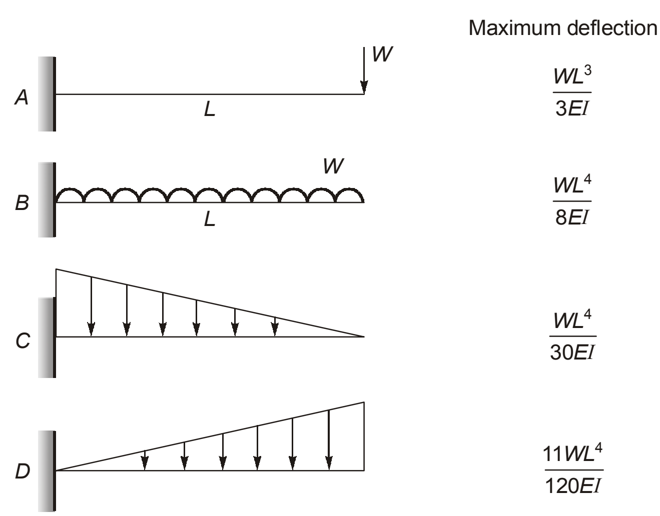
σ_2 (minor principal stress) = – 30 MPa

22. (a)



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

23. (a)



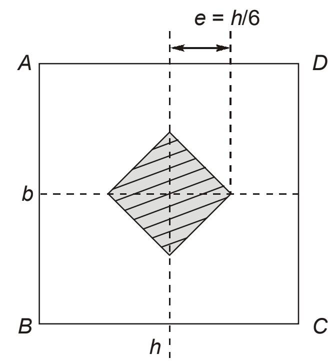
24. (a)

Loop/Circumferential stress

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

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

25. (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,

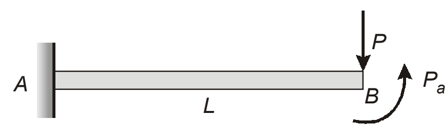
$$\text{Total stress} = -\sigma_1 + \sigma_2 \le 0$$

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

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

26. (d)

For vertical deflection at point *B* to be zero



i.e. $\delta_B = \frac{PL^3}{3EI} - \frac{(Pa).l^2}{2EI} = 0$

$$\left(\frac{a}{L}\right) = \frac{2}{3}$$

27. (c)

As per maximum shear stress theory

$$(\tau_{\text{lbs, maximum}}) \le \frac{f_y}{2}$$

$$\frac{1000-(-500)}{2} \le \frac{f_y}{(\text{FOS}).2}$$

$$(\text{FOS}) = \frac{2000}{1500} = \frac{20}{15} = \frac{4}{3}$$

$$(\text{FOS}) = 1.33$$

28. (c)

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

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

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

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

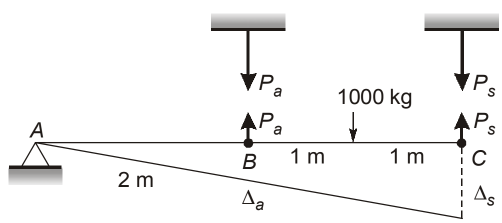
$$\epsilon_{\text{longitudinal}} = \frac{\epsilon_{\text{lateral}}}{\mu}$$

$$\epsilon_{\text{lateral}} = -\frac{\mu P}{AE} - \frac{0.42 \times 120 \times 10^3}{\frac{\pi}{4} \times (0.08)^2 \times 3 \times 10^9} = 3.3422 \times 10^{-3}$$

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

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

29. (c)



$$\Sigma M_A = 0$$

$$100 \times 3 - P_a \times 2 - P_s \times 4 = 0$$

$$P_a + 2P_s = \frac{3000}{2} = 1500 \quad \text{...(i)}$$

Also, from similarity of triangles

$$\frac{\Delta s}{4} = \frac{\Delta a}{2}$$

$$\therefore \quad \Delta_s = 2\,\Delta a$$

$$\frac{P_s . L_s}{A_s E_s} = 2\frac{P_a . L_a}{A_a . E_a}$$

$$\frac{P_s L_s}{4 \times 20000} = 2.\frac{P_a\ L_a}{6 \times 7000}$$

$$\left(\frac{P_s}{P_a}\right) = \frac{2 \times 4 \times 20000}{6 \times 7000} = \frac{80}{21}$$

$$\frac{P_s}{P_a} = \frac{80}{21}$$

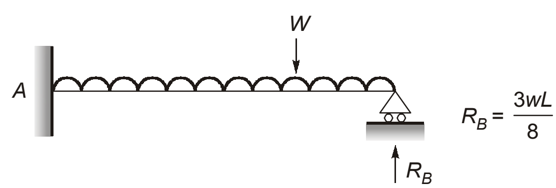
∴ From equation (i),

$$\frac{21}{80}P_s + 2P_s = 1500$$

$$P_s = 662.98 \simeq 663 \text{ kg}$$

∴ Load taken by steel bar 663 kg.

30. (d)



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