

CLASS TEST

S.No. : 04 KS1_CE_S_170719

Strength of Material



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CLASS TEST 2019-2020

CIVIL ENGINEERING

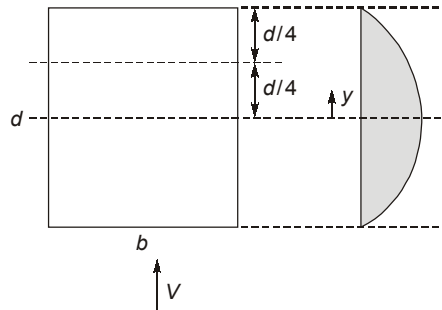
Date of Test : 17/07/2019

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,

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

To findout,

$$\tau_{\max} = ?$$

Given that (τ) 1/4th of depth i.e.

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

 \Rightarrow

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

 \Rightarrow

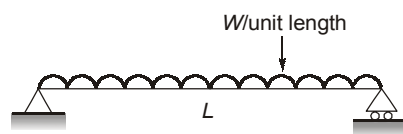
$$120 = \frac{9}{8} \frac{V}{bd} = \frac{9}{8} \tau_{\text{avg}}$$

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

 \therefore

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

3. (d)



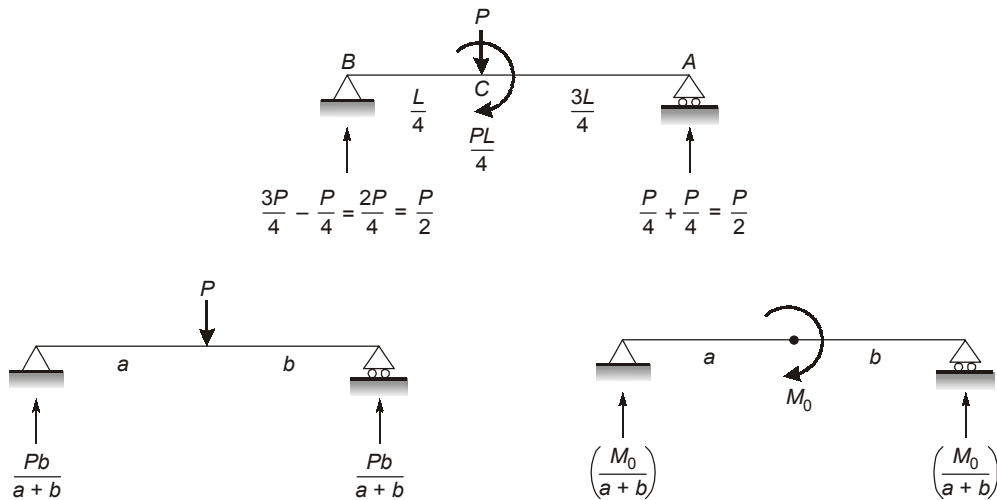
Deflection at mid span

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

If $L = (2L)$ then

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

4. (b)



$$\begin{aligned} \therefore \text{Maximum B.M occur @C} &= R_A \times \frac{L}{4} + \frac{PL}{4} \\ &= \frac{P}{2} \times \frac{L}{4} + \frac{PL}{4} = \frac{PL + 2PL}{8} = \frac{3PL}{8} \\ (\text{BM})_{\max} &= \frac{3PL}{8} \end{aligned}$$

5. (a)

Given, Diameter of shaft = 200 mm
Maximum shear stress = 50 MPa

\therefore 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,

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

$$\therefore \text{Major principal stress, } (\sigma_1) = OA + AD = 4 + 5 = 9 \text{ MPa}$$

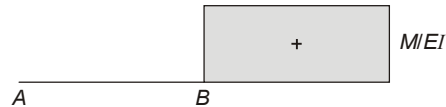
$$\therefore \text{Minor principal stress, } (\sigma_2) = AE - OA = 5 - 4 = 1 \text{ MPa} \quad (\text{but it is } (-ve))$$

\therefore 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)



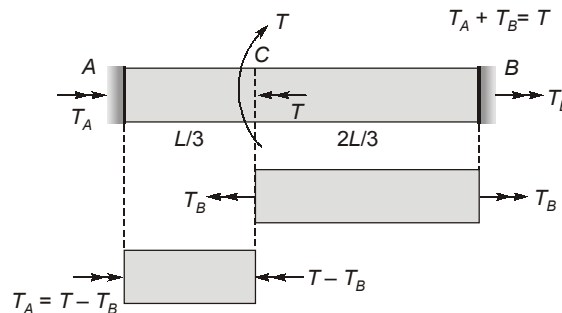
Deflection of C, with respect to tangent at A

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

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

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

12. (d)



As end is fixed,

$$\theta_{AB} = 0$$

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

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

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

$$3T_B = T$$

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

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

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

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

13. (b)

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

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.

\therefore The resultant stress at P is compressive.

14. (a)

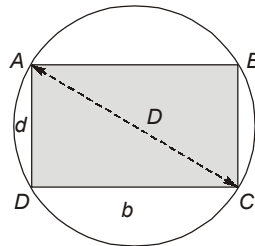
Given,

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

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

$$\begin{aligned} \sigma_1 &= \frac{E}{1-\mu^2} (\varepsilon_1 + \mu \varepsilon_2) = \frac{75000}{1-(0.5)^2} (8 \times 10^{-4} + 0.5 \times 4 \times 10^{-4}) \\ &= 100 \text{ kN/m}^2 = 100 \text{ kPa} \end{aligned}$$

15. (b)



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

From $\triangle ACD$, $D^2 = b^2 + d^2$... (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),

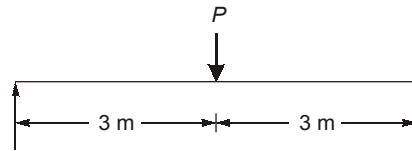
$$D^2 = \frac{D^2}{3} + d^2$$

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

\therefore 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, $D = 500 \text{ mm}$
 Allowable bending stress for the wood = 6 MPa

Let P (in kN)

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

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

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

From fixture formula

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

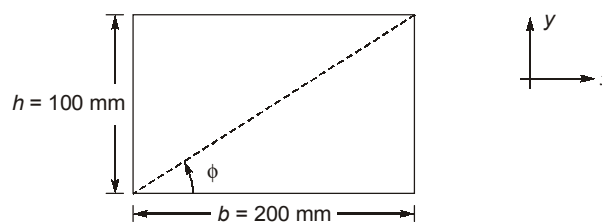
$$f_{\max} = \frac{M}{Z}$$

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

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

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

17. (b)



Given,

$$\epsilon_x = 195 \times 10^{-6}$$

$$\epsilon_y = -125 \times 10^{-6}$$

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

$$\phi = 26.56^\circ$$

$$\epsilon_{OD} = \frac{\epsilon_x + \epsilon_y}{2} + \frac{\epsilon_x - \epsilon_y}{2} \cos^2 \phi + \frac{\gamma_{xy}}{2} \sin 2\phi$$

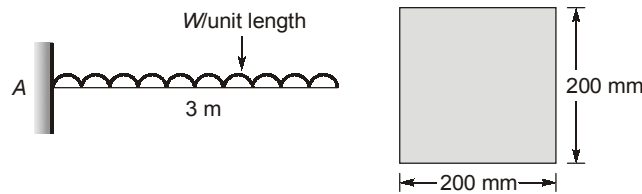
$$= \frac{(195 \times 10^{-6} - 125 \times 10^{-6})}{2} + \frac{195 \times 10^{-6} - (-125 \times 10^{-6})}{2} \cos(2 \times 26.56)$$

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

∴ Change in length of diagonal OD

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

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

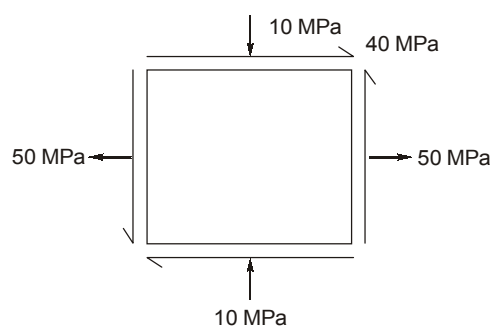
$$\left(\frac{WL^2}{2} \right) \frac{1}{Z} = 5 \text{ N/mm}^2$$

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

$$\frac{W \times (3)^2 \times 10^6}{200 \times (200)^2} \frac{1}{6} = 5$$

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

21. (d)



∴ Principal stresses

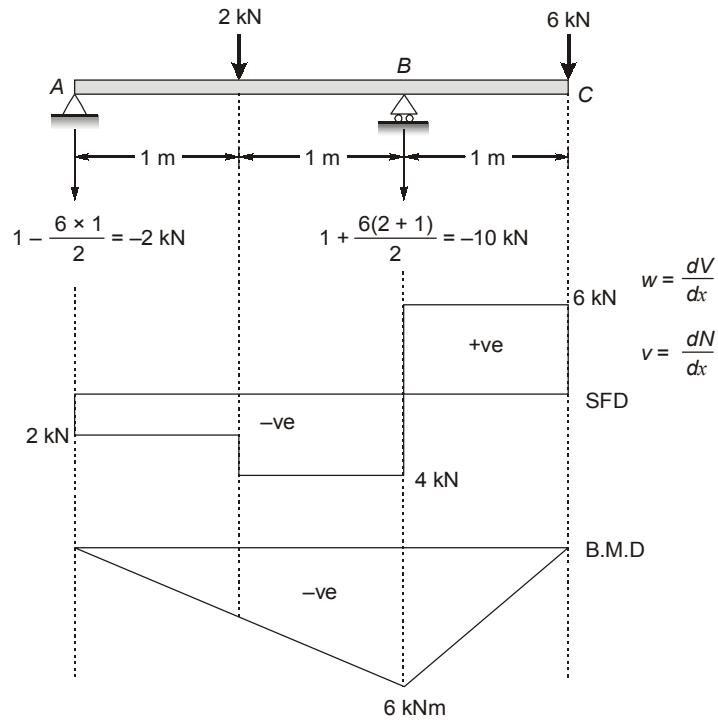
$$\sigma_{1,2} = \frac{\sigma_x + \sigma_y}{2} \pm \sqrt{\left(\frac{\sigma_x - \sigma_y}{2} \right)^2 + \tau_{xy}^2}$$

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

$$\sigma_1 \text{ (major principal stress)} = 70 \text{ MPa}$$

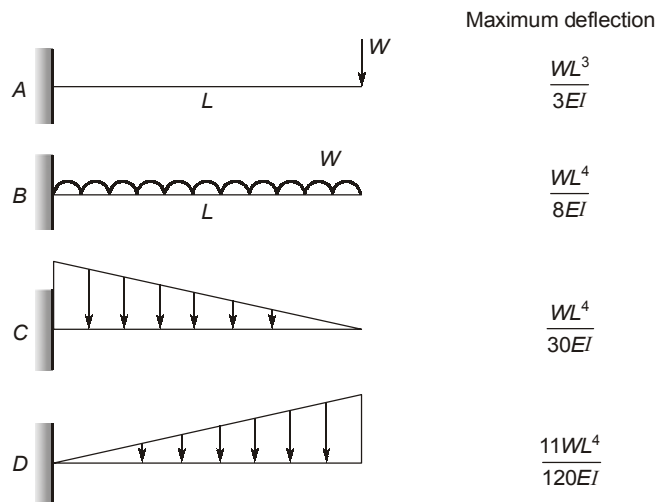
$$\sigma_2 \text{ (minor principal stress)} = -30 \text{ MPa}$$

22. (a)



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

23. (a)



24. (a)

Loop/Circumferential stress

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

Circumferential strain,
$$\epsilon_h = \frac{PD}{4tE} \cdot (2 - \mu) = \frac{80}{2 \times 2 \times 10^5} (2 - 0.28) = 3.44 \times 10^{-4}$$

25. (b)

Direct stress,

$$\sigma_1 = \frac{P}{b.h}$$

Bending stress,

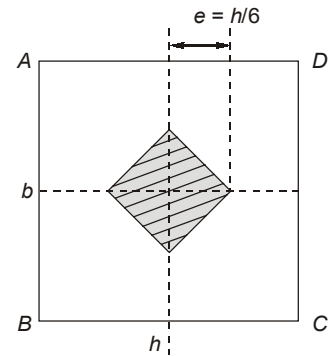
$$\sigma_2 = \frac{M}{Z} = \frac{Pe}{(bh^2/6)}$$

To avoid tensile stress,

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

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

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



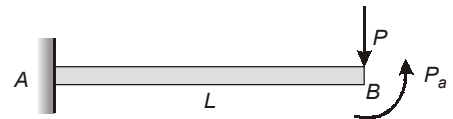
26. (d)

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

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

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

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

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

28. (c)

$$\sigma = \epsilon E \text{ and } \sigma = \frac{P}{A}$$

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

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

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

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

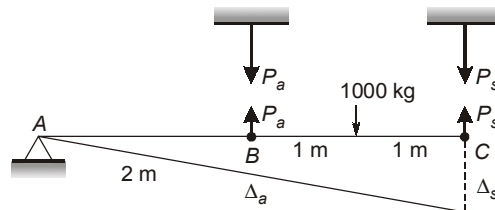
$$\epsilon_{\text{lateral}} = -\frac{\mu P}{AE} = \frac{0.42 \times 120 \times 10^3}{\frac{\pi}{4} \times (0.08)^2 \times 3 \times 10^9} = 3.3422 \times 10^{-3}$$

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

∴

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

29. (c)



$$\begin{aligned} \sum M_A &= 0 \\ 100 \times 3 - P_a \times 2 - P_s \times 4 &= 0 \end{aligned}$$

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

Also, from similarity of triangles

$$\frac{\Delta_s}{4} = \frac{\Delta_a}{2}$$

∴

$$\Delta_s = 2 \Delta_a$$

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

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

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

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

∴ From equation (i),

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

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

∴ Load taken by steel bar 663 kg.

30. (d)

