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ESE- 2020 (Prelims) - Offline Test Series Test- 7

CIVIL ENGINEERING

SUBJECT: SOLID MECHANICS & CONSTRUCTION PRACTICE, PLANNING AND MANAGEMENT

SOLUTIONS

01. Ans: (c)

Sol: Principal stresses are the eigen values of a matrix and can be obtained by

$$\begin{vmatrix} 4-\sigma & 2 & 6 \\ 2 & 4-\sigma & -4 \\ 6 & -4 & 2-\sigma \end{vmatrix} = 0$$

$\Rightarrow (4 - \sigma)\ [(4 - \sigma)\ (2 - \sigma) - 16] - 2[2\ (2 - \sigma) + 24] + 6[-8-6\ (4 - \sigma)] = 0$

Solving $\sigma_1 = 9.37$ MPa,

$\sigma_2 = +5.79$ MPa,

$\sigma_3 = -5.16$ MPa

Short cut:

$\sigma_1 + \sigma_2 + \sigma_3 = \sigma_x + \sigma_y + \sigma_z = 4 + 4 + 2$

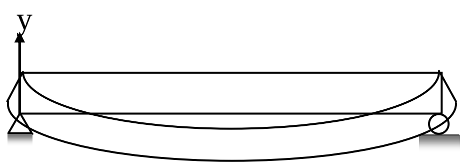
$= 10$ MPa

From the given options, only 'c' satisfies this.

Hence the correct answer is 'c'

02. Ans: (c)

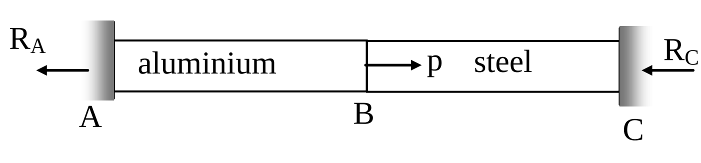
Sol: Since the temperature at the bottom fibre is higher than the top fibre, the deflection of bottom fibre is more than the top fibre, i.e. the beam concaves upwards.



Since it is a determinate structure, the internal forces due to temperature variation are zero. i.e. no thermal stresses are induced in the beam. The mean temperature expands the beam but no flexural stresses are induced.

03. Ans: (b)

Sol: Let R_A and R_C be the reactions at A, C



$R_A + R_C = P$ ---- (1)

Net deflection = 0

$$\Rightarrow \frac{R_A\left(\frac{L}{2}\right)}{AE_{al}} - \frac{R_C\left(\frac{L}{2}\right)}{AE_{st}} = 0$$

$$\Rightarrow \frac{R_A}{E_{al}} = \frac{R_C}{E_{st}}$$

$$R_C = R_A\left(\frac{E_{st}}{E_{al}}\right)$$

$= 3\ R_A$

$\therefore$ from (1)

$3\ R_A + R_A = P$

$$\therefore \quad R_A = \frac{P}{4}$$

$$R_C = \frac{3P}{4}$$

$\therefore$ Force in steel rod = $\frac{3P}{4}$ (compressive)

04. Ans: (a)

Sol: Bulk modulus $K = \frac{E}{3(1-2\mu)}$

Rigidity $G = \frac{E}{2(1+\mu)}$

$\therefore$ K = G

$$\frac{E}{3(1-2\mu)} = \frac{E}{2(1+\mu)}$$

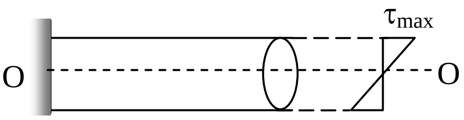
$\Rightarrow 2 + 2\mu = 3 - 6\mu$

$\Rightarrow 8\mu = 1$

$$\Rightarrow \mu = \frac{1}{8}$$

05. Ans: (d)

Sol: In a cylindrical bar subjected to pure torsion,



At centroidal axis O – O, shear stress is zero. Since it is pure torsion, no bending stresses are induced.

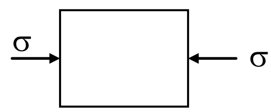
$\therefore$ Mohr's circle corresponds to a point i.e. origin.

06. Ans: (a)

Sol: Axial stress $\sigma = \frac{P}{A}$

Stress condition is

$\sigma_x = \sigma, \quad \sigma_y = 0, \tau_{xy} = 0$



$$\therefore \tau_{max} = \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$$

$$\Rightarrow 100 = \frac{\sigma}{2}$$

$\Rightarrow \sigma = 200$ MPa

$$\Rightarrow \frac{P}{A} = 200$$

$\Rightarrow P = 200 \times 100 \times 100$ N

$= 2000$ kN

07. Ans: (d)

Sol: Elongation in bar A,

$$(\delta_A) = \frac{4PL}{\pi D_1 D_2 E} = \frac{4PL}{\pi \times 4 \times 25E} = \frac{4PL}{100\pi E}$$

Elongation in bar B,

$$(\delta_B) = \frac{PL}{\frac{\pi D^2}{4}E} = \frac{4PL}{\pi E \times 10^2} = \frac{4PL}{100\pi E}$$

$$\therefore \frac{\delta_A}{\delta_B} = 1$$

08. Ans: (c)

Sol: Let R_A, R_B be reaction at A and B respectively.

For equilibrium

(i) $\sum F_y = 0$

$$\Rightarrow R_A + R_B = \frac{2}{3}wL$$

(ii) $\sum M_A = 0$

$\Rightarrow$ Taking moments about A

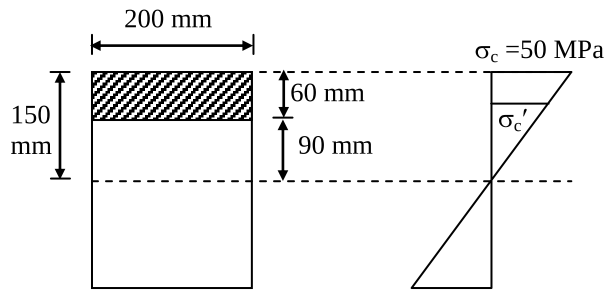
$$\Rightarrow \left(\frac{2}{3}w\ell\right)\frac{\ell}{2} - R_B(\ell) = 0$$

$$\Rightarrow R_B = \frac{w\ell}{3}$$

$$\therefore R_A = \frac{w\ell}{3}$$

09. Ans: (b)

Sol: Force on hatched area = $\frac{1}{2}(\sigma_c + \sigma_c') \times \text{area}$



$$\frac{\sigma_c}{150} = \frac{\sigma_c'}{90}$$

$$\Rightarrow \sigma_c' = \frac{50}{150} \times 90 = 30 \text{ MPa}$$

Compressive force = $\frac{1}{2}(30+50) \times 200 \times 60$

= 480×10^3 N

= 480 kN

10. Ans: (b)

Sol: Strength of the beam $\propto$ Z

$$\frac{S_2}{S_1} = \frac{Z_2}{Z_1} = \frac{\frac{b \times (nd)^2}{6}}{n \times \frac{bd^2}{6}} = n$$

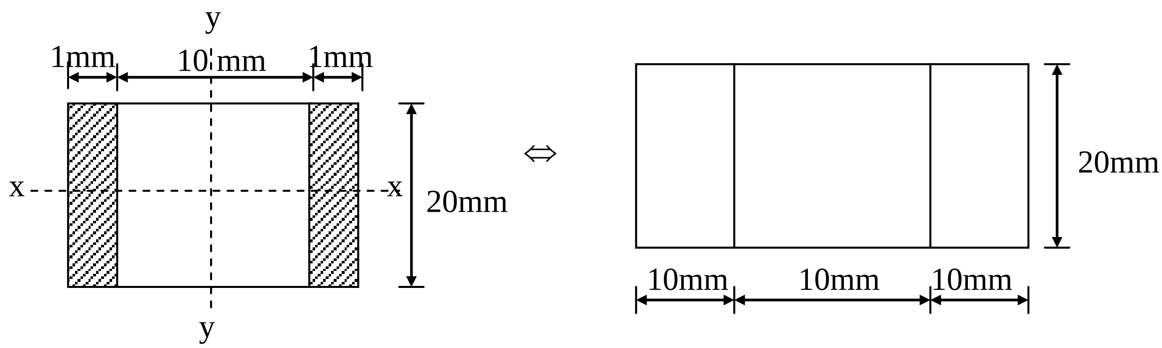
11. Ans: (b)

Sol: In the equivalent wooden section, depth of the beam is kept same as that of the composite beam to maintain the same strain variation and width is increased by 'm' times

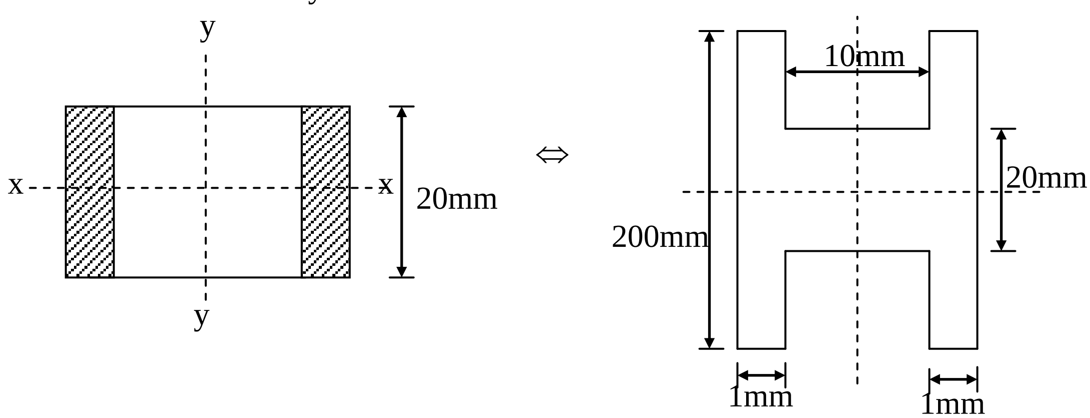
$$m = \frac{E_s}{E_w} = 10$$

(i) When moment is about x-x axis ; d = 20 mm

Equivalent section



(ii) When moment is about y-axis d = 12 mm



12. Ans: (d)

Sol: Expansion in the bar due to temperature rise $= l \propto \Delta T$

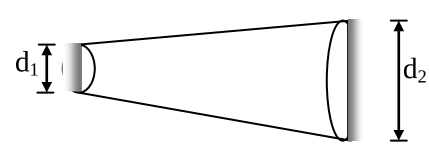
Since the ends are fixed, expansion is restrained and compression is induced in bar. Let the compressive force is 'P'.

For a uniformly tapered circular section,

compression = $\frac{4PL}{\pi d_1 d_2 E}$

Also,

Expansion due to Δ T = Compression due to P



$\therefore\ l \propto \Delta T = \dfrac{4PL}{\pi d_1 d_2 E}$

Maximum stress $\dfrac{P}{\frac{\pi}{4}d_1^2} = \dfrac{\pi d_1 d_2 E\ell\alpha \times \Delta T}{4\ell \times \frac{\pi}{4}d_1^2}$

$$= E\alpha\Delta T\frac{d_2}{d_1}$$

$$= 2\times10^5 \times 12\times10^{-6} \times 50 \times \frac{160}{80}\ \text{MPa}$$

$$= 240\ \text{MPa}$$

13. Ans: (c)

Sol: $\varepsilon_x = 100 \times 10^{-6}$

$$\varepsilon_x^1 = \left(\frac{\varepsilon_x + \varepsilon_y}{2}\right) + \left(\frac{\varepsilon_x - \varepsilon_y}{2}\right)\cos 2\theta + \frac{\phi_{xy}}{2}\sin 2\theta$$

$$\Rightarrow 500\times10^{-6} = \left(\frac{100\times10^{-6} + \varepsilon_y}{2}\right) + \left(\frac{100\times10^{-6} - \varepsilon_y}{2}\right)\cos(2\times240^\circ) + 0$$

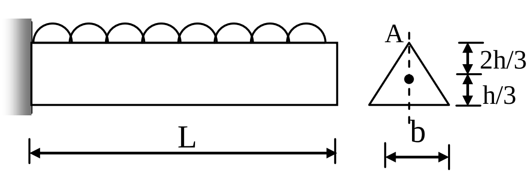
$\Rightarrow 1000 \times 10^{-6} = 100 \times 10^{-6} + \varepsilon_y + (100 \times 10^{-6} - \varepsilon_y) \times \left(\frac{-1}{2}\right)$

$$\Rightarrow 1000 \times 10^{-6} = 50 \times 10^{-6} + \frac{3\varepsilon_y}{2}$$

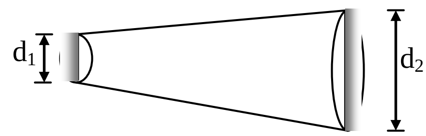
$$\Rightarrow \varepsilon_y = 633.33 \times 10^{-6}$$

14. Ans: (a)

Sol:



UDL due to self weight of the beam



$$= w' = wA = w \times \frac{1}{2} \times bh$$

$$w' = \frac{wbh}{2}$$

Maximum BM is at fixed end

$$= \frac{w'\ell^2}{2} = \frac{wbh}{2} \times \frac{\ell^2}{2}$$

$$= \frac{wbh\ell^2}{4}\ \text{(Hogging)}$$

Since it is hogging bending moment compression is induced at bottom and tension is induced at top

$\therefore$ From bending equation

$\sigma = \dfrac{M}{I}y$ i.e $\sigma \propto y$

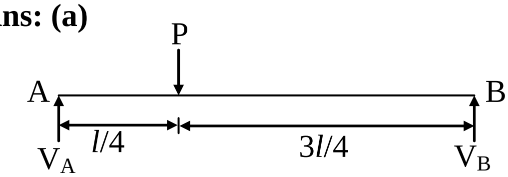
$\therefore$ Maximum stress is at A $= \dfrac{M}{I} \times \left(\dfrac{2h}{3}\right)$

$$= \frac{\frac{wbh\ell^2}{4}}{\frac{bh^3}{36}} \times \frac{2h}{3}$$

$$= \frac{6w\ell^2}{h}\ \text{(tensile)}$$

15. Ans: (a)

Sol:



(i) $V_A + V_B = P$

(ii) $\Sigma M_A = 0$

$\Rightarrow V_B(L) = P\left(\frac{L}{4}\right)$

$\therefore V_B = \frac{P}{4}$

$\therefore$ Shear force at midspan $= -V_B = \frac{-P}{4}$

Average shear stress $= \tau_{avg} = \frac{P}{A} = \frac{P}{4\times\frac{\pi}{4}\times D^2}$

$= \frac{P}{\pi D^2}$

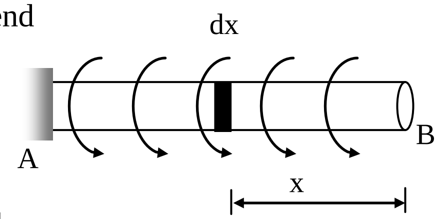
Maximum shear stress $= \frac{4}{3}\tau_{avg} = \frac{4}{3}\times\frac{P}{\pi D^2}$

16. Ans: (d)

Sol: Consider an element 'dx' at a distance 'x' from free end

$T_x = tx$

$\theta = \frac{TL}{GJ}$



$\therefore d\theta = \frac{Tdx}{GJ}$

$\therefore d\theta = \frac{txdx}{GJ}$

$\therefore \theta = \frac{t}{GJ}\int_0^L xdx$

$= \frac{tL^2}{2GJ}$

$= \frac{tL^2}{2G\frac{\pi D^4}{32}} = \frac{16tL^2}{G\pi D^4}$

Shortcut:

The net torsional moment for uniformly distributed 't' is '$t\ell$' acting at $\frac{\ell}{2}$

$$\theta = \frac{(t\ell)\frac{\ell}{2}}{GJ} = \frac{t\ell^2}{2GJ}$$

17. Ans: (b)

Sol: Poisson's ratio $= \frac{-\text{lateral strain}}{\text{Longitudinal strain}}$

$$\mu = -\frac{\left(\frac{D_f - D_i}{D_i}\right)}{\left(\frac{L_f - L_i}{L_i}\right)}$$

$\Rightarrow \mu = 0 \Rightarrow \frac{D_f - D_i}{D_i} = 0$

$\Rightarrow D_f = D_i$ i.e there is no lateral strain due to longitudinal strain. It can be said that the material is transversely rigid.

18. Ans: (b)

Sol: Modulus of resilence

$= \frac{1}{2}\sigma_y\varepsilon_o = \frac{1}{2}\sigma_y\times\frac{\sigma_y}{E_s}$

$= \frac{\sigma_y^2}{2E_s}$

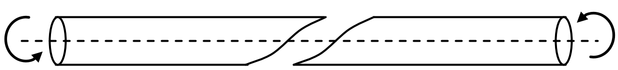
$= \frac{250\times 250}{2\times 2\times 10^5}$

$= 0.156$ MPa

19. Ans: (b)

Sol: Brittle materials are weak in tension than in shear. When subjected to torsion, the failure takes place along the plane subjected to maximum tensile stress under pure torsion. This is inclined at an angle of 45^o to the axis.

Hence the failure is

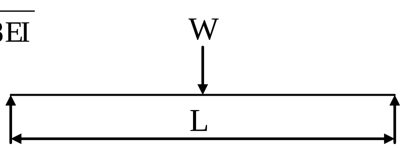


20. Ans: (b)

Sol: Strain energy due to bending

$$= \frac{1}{2} w \times \delta$$

$$= \frac{1}{2} \times W \times \frac{WL^3}{48EI}$$



$$= \frac{W^2L^3}{96EI}$$

$$= \frac{30 \times 30 \times 8^3}{96 \times 300}$$

= 16 kN-m

21. Ans: (d)

Sol: $\therefore$ Let moment at A be M_A (↶)

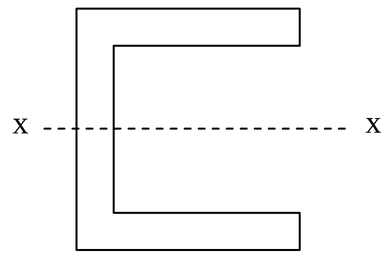
Taking moment about A

$\Rightarrow M_A - 100\ (2) = 0$

$\Rightarrow M_A = 200$ kN-m

22. Ans: (b)

Sol:



Product of inertia = $I_{xy} = \int xy\ dA$

It can be positive or negative or zero based on coordinate system

It is always zero, if any of the reference axis is axis of symmetry

In channel section, x-axis is axis of symmetry.

Hence $I_{xy} = 0$

23. Ans: (b)

Sol: Let maximum permissible shear stress = τ_{max}

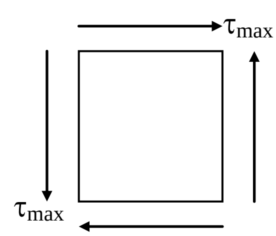
Under pure shear

$\sigma_1 = \tau_{max}$

$\sigma_2 = -\tau_{max}$

As per St Venant's theory / maximum principal strain theory

$$\varepsilon \le \frac{\sigma_y}{E}$$



$$\Rightarrow \frac{\sigma_1 - \mu\sigma_2}{E} \le \frac{\sigma_y}{E}$$

$\Rightarrow \tau_{max}\ (1+\mu) \le \sigma_y$

$$\Rightarrow \tau_{max} \le \frac{\sigma_y}{1+\mu}$$

$$\le \frac{200}{1+0.25}$$

≤ 160 MPa

24. Ans: (d)

Sol: P = Tω

$$\Rightarrow 50\times10^3 = T\times2\pi\times\frac{120}{60}$$

T = 3978.9 Nm

25. Ans: (d)

Sol: $\frac{T}{J}=\frac{\tau}{R}=\frac{G\theta}{\ell}$

$$\Rightarrow R=\frac{\tau\ell}{G\theta}$$

$$=\frac{120\times2\times1000}{0.8\times10^5\times\left(\frac{1\times\pi}{180}\right)}$$

$$=\frac{540}{\pi}\text{mm}$$

26. Ans: (c)

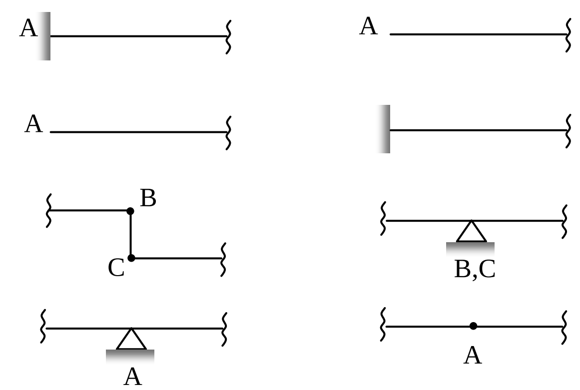
Sol: Slope at free end 'D' = slope due to loading '3P' at B + slope due to loading '2P' at C+ slope due to loading 'P' at D

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

$$=\frac{20PL^2}{2EI}=\frac{10PL^2}{EI}$$

27. Ans: (c)

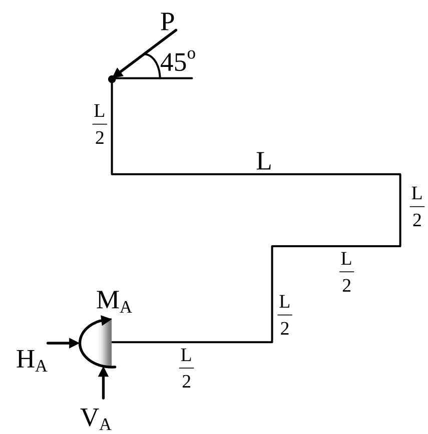
Sol: **Real Beam** **Conjugate Beam**



∴ Option 'c' is correct

28. Ans: (d)

Sol:



For equilibrium:

(i) $\Sigma F_x = 0$

$$\Rightarrow H_A = P\cos45=\frac{P}{\sqrt2}$$

(ii) $\Sigma F_y = 0$

$$\Rightarrow V_A = P\sin45=\frac{P}{\sqrt2}$$

(iii) $\Sigma M_A = 0$

$$\Rightarrow M_A - P\cos45^o\left(\frac{L}{2}+\frac{L}{2}+\frac{L}{2}\right)=0$$

$$\Rightarrow M_A = \frac{3PL}{2\sqrt{2}}$$

$$\therefore \text{ Reaction at } A = \sqrt{H_A^2 + V_A^2} = P$$

$$M_A = \frac{3PL}{2\sqrt{2}}$$

29. Ans: (a)

Sol: Net deflection at 'B' towards left

$$= \frac{20(3)^3}{3EI} + \frac{20\times 3^2}{2EI}\times 3 - \frac{P(6)^3}{3EI} = \frac{25\text{ mm}}{1000}$$

$$\Rightarrow \frac{180}{EI} + \frac{270}{EI} - \frac{72P}{EI} = \frac{25}{1000}$$

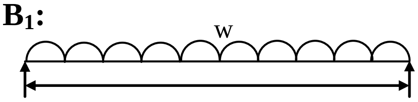
$$\Rightarrow 450 - 72P = \frac{25}{1000}\times 3000$$

$\Rightarrow$ 72P = 450 – 75 = 375

$\Rightarrow$ P = 5.2 kN

30. Ans: (a)

Sol: **B_1:**



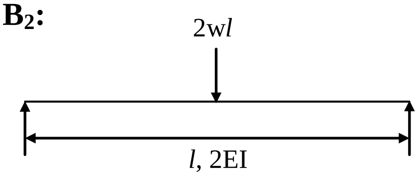
2*l*, 4EI

$$\text{Deflection at midspan} = \frac{5}{384}\frac{w\ell^4}{EI}$$

$$\delta_1 = \frac{5}{384}\times\frac{w\times(2\ell)^4}{4EI}$$

$$= \frac{20}{384}\frac{w\ell^4}{EI}$$

B_2:



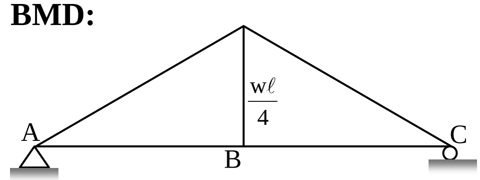
$$\text{Deflection at midspan} = \frac{P\ell^3}{48EI}$$

$$\delta_2 = \frac{(2w\ell)\ell^3}{48\times 2EI} = \frac{w\ell^4}{48EI}$$

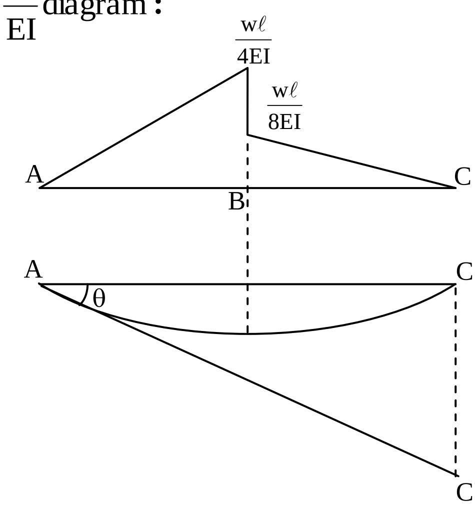
$$\frac{\delta_1}{\delta_2} = \frac{\frac{20}{384}\frac{w\ell^4}{EI}}{\frac{w\ell^4}{48EI}} = 2.5$$

31. Ans: (b)

Sol: **BMD:**



$\frac{M}{EI}$ diagram **:**



Using second moment area theorem;

CC' = area of $\frac{M}{EI}$ diagram between A & C about 'C'

$$= \left(\frac{1}{2}\times\frac{\ell}{2}\times\frac{w\ell}{4EI}\times\left(\frac{\ell}{2}+\frac{\ell}{2\times 3}\right)\right) + \left(\frac{1}{2}\times\frac{\ell}{2}\times\frac{w\ell}{8EI}\times\left(\frac{2\ell}{3\times 2}\right)\right)$$

$$= \frac{w\ell^3}{16EI}\left(\frac{2}{3}\right) + \frac{w\ell^3}{32EI}\left(\frac{1}{3}\right)$$

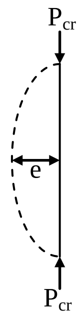
$$= \frac{w\ell^3}{8EI \times 3}\left[1+\frac{1}{4}\right] = \frac{5w\ell^3}{96EI}$$

Slope at A = $\frac{CC'}{\ell}$

$$= \frac{5w\ell^2}{96EI}$$

32. Ans: (b)

Sol: $M = P_{cr}\, e$



$\sigma_{bend} = \sigma_y$

$$\Rightarrow \frac{M}{I} \times y_{max} = \sigma_y$$

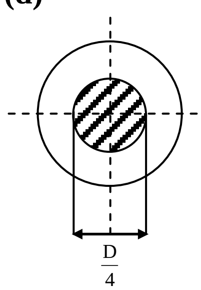
$$\Rightarrow \frac{P_{cr}e}{I} \times y_{max} = \sigma_y$$

$$\Rightarrow e = \frac{\sigma_y \times I}{P y_{max}} = \frac{\sigma_y \times \frac{\pi D^4}{64}}{P \times \frac{D}{2}} = \frac{\sigma_y}{P} \times \frac{\pi D^3}{32}$$

$$= \frac{300}{3000 \times 10^3} \times \frac{\pi}{32} \times 20^3 = 0.025\pi \text{ mm}$$

33. Ans: (d)

Sol:

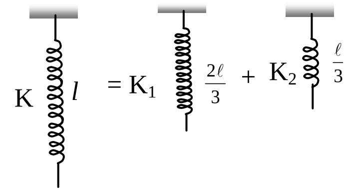


Core of the circular section is a circle of diameter $\frac{D}{4}$

$\therefore$ Radius $= \frac{D}{8} = \frac{100}{8} = 12.5$ mm

34. Ans: (b)

Sol:



$$K \alpha \frac{1}{\ell}$$

$$\therefore K \times \ell = K_2 \times \frac{\ell}{3}$$

$\Rightarrow K_2 = 3K$

35. Ans: (c)

Sol: Stiffness, $K = \frac{Gd^4}{64R^3n}$ = 10 N/mm

Strain energy, $U = \frac{32P^2R^3N}{Gd^4}$

$$= \frac{64R^3N}{Gd^4} \times \left(\frac{P^2}{2}\right)$$

$$= \frac{P^2}{2K}$$

$$= \frac{300 \times 300}{2 \times 10} = 4500 \text{ N-mm}$$

36. Ans: (a)

Sol: Hoop stress, $\sigma_h = \frac{PD}{2t}$

$P = \rho g H = 1000 \times 10 \times 200 = 2 \times 10^6$ N/m^2

$$\therefore \sigma_h = \frac{2 \times 10^6 \times 1}{2 \times t} = \frac{10^6}{t} \text{ N/m}^2$$

$\sigma_h \leq \sigma_t$

$$\Rightarrow \frac{10^6}{t} \le 25\times10^6$$

$$\Rightarrow t \ge \frac{1}{25} m$$

$$\Rightarrow t \ge \frac{1000}{25} mm$$

$$\Rightarrow t \ge 40 \text{ mm}$$

37. Ans: (c)

Sol: Volumetric strain in thin sphere

$$= \frac{3PD}{4tE}(1-\mu)$$

$$\frac{\Delta V}{V} = \frac{3\times2\times200(1-0.2)}{4\times1\times10^5}$$

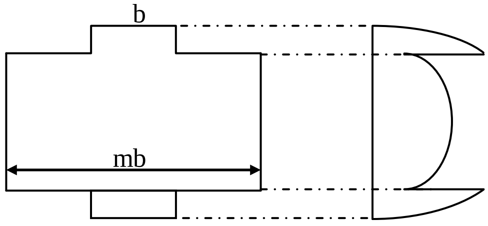
$$\Rightarrow \frac{\Delta V}{V} = 2.4\times10^{-3}$$

$\therefore$ % increase = $2.4 \times 10^{-3} \times 100$

= 0.24%

38. Ans: (b)

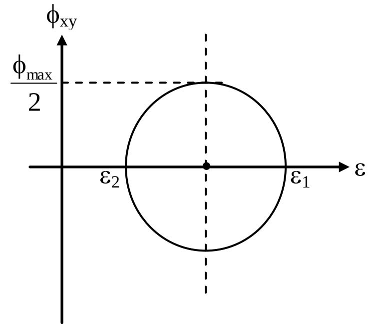
Sol: Since $E_2 > E_1$, equivalent section corresponding to E_1 is



(Shear Stress Variation)

39. Ans: (d)

Sol:



$\varepsilon_1 = 900 \times 10^{-6}$

$\varepsilon_2 = 100 \times 10^{-6}$

Maximum shear strain

ϕ_{max} = 2 (radius of Mohr's circle)

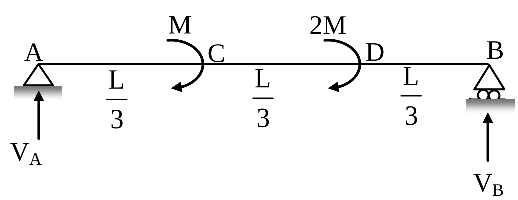
$$= 2\left(\frac{1}{2}(\varepsilon_1 - \varepsilon_2)\right)$$

$= \varepsilon_1 - \varepsilon_2$

$= 800 \times 10^{-6}$

40. Ans: (a)

Sol:



(i) $V_A + V_B = 0$

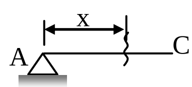
(ii) $\Sigma M_A = 0$

$\Rightarrow M + 2M = (V_B) L$

$$\Rightarrow V_B = \frac{3M}{L}$$

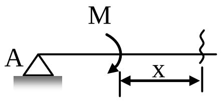
$$\therefore V_A = \frac{-3M}{L}$$

In AC: BM = V_A x



$\therefore M_{max} = \frac{-3M}{L} \times \frac{L}{3} = -M$

In CD: $BM = V_A\left(x + \frac{L}{3}\right) + M$

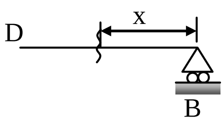


$= \frac{-3M}{L}\left(x + \frac{L}{3}\right) + M$

$= \frac{-3M}{L}x$

$\therefore M_{max} = \frac{-3M}{L} \times \frac{L}{3} = -M$

In BD: $BM = \frac{3M}{L}x$



$\therefore M_{max} = \frac{3M}{L} \times \frac{L}{3} = M$

41. Ans: (b)

Sol: $Q = \frac{\text{Fixed Cost}}{\text{Selling Price} - \text{Varible Cost}}$

Break even quantity $\propto$ fixed cost

Break even quantity is inversely proportional to contribution margin ratio.

42. Ans: (d)

43. Ans: (c)

Sol: In PERT, for an activity β-distribution is used but for entire project normal distribution is used.

44. Ans: (d)

45. Ans: (c)

Sol: Safety manual describes comprehensive set of safety rules and regulations in order to achieve better safety performance of the projects executed by company. The new employees have to be through with the safety manual of the company.

46. Ans: (a)

Sol: Network diagrams are better at scheduling of a project than bar charts.

47. Ans: (c)

Sol: Critical path is the longest path, in terms of time

Path: (1)–(3)–(6)–(8)–(9),

Total duration = 46.

$\therefore$Critical path is: (1) – (3) – (6) – (8) – (9) and total duration of the project is 46 units.

48. Ans: (b)

Sol: Precedence networks uses start to start, finish to finish, start to finish and finish to start relationships

49. Ans: (d)

Sol: To evaluate competing projects by equivalence in economic analysis

1. Present worth comparison.
2. Future worth comparison.
3. Rate of return method.
4. Annual cost and worth method.

50. Ans: (d)

Sol: Factors affecting rate analysis of items of work

1. Quantity of materials.
2. Location of the construction site.
3. Specification of the work and materials used.
4. Profit of the contractor.
5. Labour cost.

51. Ans: (b)

Sol: There can be multiple critical paths.

Crashing is used to optimize for minimum cost

52. Ans: (a)

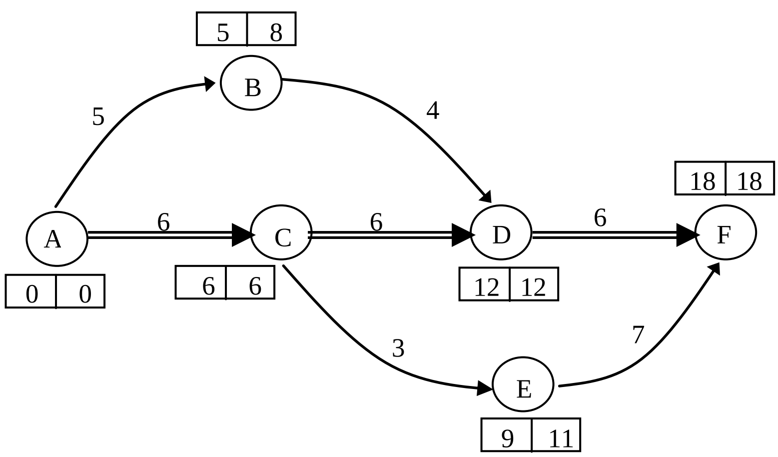
Sol: Straight line method is used for assets not fearing obsolescence.

Ex: construction equipment

For assets fearing obsolescence we use accelerated methods of depreciation.

53. Ans: (c)

Sol:



Free float on CE = (9 – 6) – 3 = 0

Free float on EF = (18 – 9 – 7) = 2

54. Ans: (a)

Sol: Planned labour performance = 8 men × 15 days = 120 man-days

Actual labour performance = 8 men × 18 days = 144 man-days

Labour performance efficiency

$$= \frac{\text{Workdone per Man} - \text{day}}{\text{Work planned per Man} - \text{days}}$$

$$= \frac{1200/144}{1200/120} = \frac{120}{144} = \frac{5}{6}$$

55. Ans: (b)

Sol: Sheep foot roller is used to compaction of cohesive soils.

56. Ans: (a)

Sol: Indirect cost: These are associated with the project as a whole. This cost cannot be calculated activity wise but it is spread over a group of activities or project as whole.

It includes over head charges like establishment charges, supervision charges etc.

57. Ans: (b)

Sol: Total float(F_T)= LST - EST = LFT - EFT

Free float(F_F)= Total float - head event slack

$= F_T - Sj$

Independent float (F_{1D}) = free float -slack at tail event

$= F_T - F_F$

Interference float: It is the difference between total float and free float

$F_{1T} = F_T - F_F$

= Slack at head event

If the Project duration for backward pass is taken less than the project duration after forward pass then the interference float can be negative also.

Independent float and interference float equations may never be equal but they can be equal in their numerical value

58. Ans: (a)

Sol: Critical path: It is the path that joins the critical activities or those activities for which total float is zero. (i.e., in PERT connects those events for which earliest and latest times are same i.e., zero slack time). Hence for critical path as soon as the preceding activity is over, succeeding activity has to begin on with no slack if the project is to be on schedule. Delay in critical activities extends the project duration.

59. Ans: (a)

Sol: Expected time divides the beta distribution in half even for skewed distribution also.

60. Ans: (b)

Sol: Crash time: It is the minimum possible time in which an activity can be completed by employing extra resources.

Critical path in a project network represents the longest duration of the project.

61. Ans: (c)

Sol: Variance,

$$\sigma^2 = \left(\frac{t_p - t_o}{6}\right)^2 = \left(\frac{15-4}{6}\right)^2 = 3.36$$

62. Ans: (d)

63. Ans: (a)

Sol: Output of earthmover in an hour = 120cum

Output of truck in a cycle = $\dfrac{12\times 0.8}{\frac{24}{60}} = 24$ cum

Number of trucks required $= \dfrac{120}{24} = 5$

64. Ans: (c)

65. Ans: (d)

Sol: After completion of forward pass only the project duration is known.

66. Ans: (c) **67. Ans: (c)**

68. Ans: (c)

Sol: Expected duration of the project follows normal distribution.

69. Ans: (d)

Sol: Essential elements of a Valid Contract

1. Offers and Acceptance
2. Legal Relationship
3. Lawful Consideration
4. Capacity of Parties
5. Free Consent

All the essentials must be satisfied to make a valid contract. 'Lawful consideration' is necessary and insufficient condition of contract.

70. Ans: (a)

71. Ans: (a)

Sol: According to maximum shear strain energy theory (or) distortion energy theory, for no failure

$$\frac{1}{3G}\left[\left(\frac{\sigma_1-\sigma_2}{2}\right)^2+\left(\frac{\sigma_2-\sigma_3}{2}\right)^2+\left(\frac{\sigma_3-\sigma_1}{2}\right)^2\right]\le\frac{\sigma_y^2}{6G}$$

for 2D-case

$$\frac{1}{3G}\left[\left(\frac{\sigma_1-\sigma_2}{2}\right)^2+\left(\frac{\sigma_1}{2}\right)^2+\left(\frac{\sigma_2}{2}\right)^2\right]\le\frac{\sigma_y^2}{6G}$$

$$\Rightarrow(\sigma_1^2+\sigma_2^2-\sigma_1\sigma_2)\le\sigma_y^2$$

under pure shear

$\sigma_1 = \tau_{max}$; $\sigma_2 = -\tau_{max}$

$$\tau_{max}^2+\tau_{max}^2+\tau_{,max}^2\le\sigma_y^2$$

$$\Rightarrow \tau_{max}\le\frac{\sigma_y}{\sqrt{3}}$$

$\le 0.577\,\sigma_y$

This is similar to experimental results

Hence maximum shear strain energy theory is suitable for ductile materials.

72. Ans: (b)

Sol: In beams subjected to shear loads, the shear stress varied parabolically with maximum at the neutral axis. Thus, for a given sectional area, a section which has more area concentrated near the neutral axis has more shear capacity. Hence, for a given section area, circular section can take more shear loads than a square section.

In beams subjected to bending moment, the bending stress varies linearly with maximum being at the ends. Thus, for a given sectional area, a section which has more area concentrated at the ends (away from neutral axis) has more moment carrying capacity. hence, for a given sectional area, square section can take more bending moments than a circular section.

Both the statements are independently correct, i.e., statement (II) is not the correct explanation for Statement (I). Hence, (b) is the correct option.

73. Ans: (c)

Sol: A shaft is a member subjected to torsion

Hence the variation of shear stress is linear w.r.t radius

i.e. $\tau \alpha y$

Also $\frac{T}{J} = \frac{\tau}{R} = \frac{G\theta}{\ell}$

At any point (x,y),

Radial distance $r = \sqrt{x^2 + y^2}$

$$\therefore \tau = \frac{\tau_{max}}{R} r$$

$$= \frac{f}{R}\sqrt{x^2 + y^2}$$

74. Ans: (d)

Sol: Crushing load = f_c A

Buckling load $= \frac{\pi^2 EI}{\ell_e^2}$

For short column, l_e is small

$\therefore$ Buckling load is more.

As per Rankine's formula

$$\frac{1}{P} = \frac{1}{P_c} + \frac{1}{P_e}$$

For short column: $P_e >> P_c$

$\therefore P \simeq P_c$

For long column: P_e is small

$$\therefore \frac{1}{P_e} >> \frac{1}{P_c}$$

$\therefore P \simeq P_e$

For intermediate column: both P_c and P_e are considerable and $P_e > P_c$

$P_c < P < P_e$

75. Ans: (d)

Sol: Nominal stress = $\frac{P}{A_o}$

True stress = $\frac{P}{A_o \pm \Delta A}$

Under tension, due to Poisson's effect cross section area decreases.

Hence true stress > nominal stress

Under compression, due to Poisson's effect cross section area increases.

Hence true stress < nominal stress.