TEST ID: 512

ACE Engineering Academy

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ESE- 2019 (Prelims) - Offline Test Series Test-24

CIVIL ENGINEERING

FULL LENGTH MOCK TEST-2 (PAPER – II)

Solutions

01. Ans: (d)

Sol: Given data:

d = 40 mm, T = 0.16π kN.m

P = 24π kN

Shear stress due to T is,

$$\tau_{xy} = \frac{16T}{\pi d^3} = \frac{16\times 0.16\pi\times 10^6}{\pi\times(40)^3} = 40 \text{ MPa}$$

Tensile stress due to P is,

$$\sigma_x = \frac{P}{A} = \frac{24\pi\times 10^3}{\frac{\pi}{4}(40)^2} = 60 \text{ MPa}$$

Maximum tensile stress is given by,

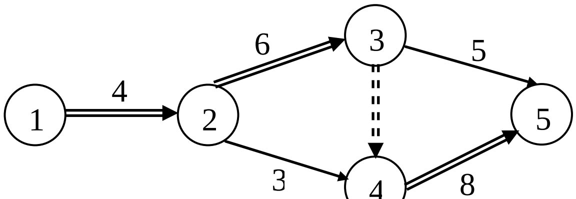
$$\sigma_1 = \frac{\sigma_x+\sigma_y}{2} \pm \sqrt{\left(\frac{\sigma_x-\sigma_y}{2}\right)^2+\tau_{xy}^2}$$

$$= \frac{60}{2} + \sqrt{\left(\frac{60-0}{2}\right)^2+(40)^2} = 80 \text{ MPa}$$

02. Ans: (a)

Sol:

Activity	$t_E = \frac{t_o+4t_m+t_p}{6}$
1-2	$\frac{2+4(3)+10}{6}=4$
2-3	6
2-4	3
3-5	5
4-5	$\frac{2+4(9)+10}{6}=8$



Path	Duration
1-2-3-5	15
1-2-3-4-5	18 $\Rightarrow \mu = 18$
1-2-4-5	15

$$\sigma_{cp} = \sqrt{\left(\frac{10-2}{6}\right)^2 + \left(\frac{8-4}{6}\right)^2 + \left(\frac{10-2}{6}\right)^2}$$

$$= \frac{1}{6}\sqrt{8^2 + 4^2 + 8^2} = 2$$

$\mu - 3\sigma = 18 - 3\,(2) = 12$

$\mu + 3\sigma = 18 + 3(2) = 24$

03. Ans: (d)

Sol: $f = \frac{M}{Z}$; Bending stress is independent of material proportion like 'E'.

04. Ans: (d)

Sol: Given data: $\theta_{BA} = 0.3$ radian,

$D_{AB} = 100$ mm, $D_{BC} = 50$ mm

Angle of twist is given by,

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

$$\therefore \quad \theta \; \alpha \; \frac{1}{J}$$

$$\therefore \quad \frac{\theta_{CB}}{\theta_{BA}} = \frac{J_{BA}}{J_{CB}}$$

$$\therefore \quad \frac{\theta_{CB}}{0.3} = \frac{\frac{\pi}{32}(100)^4}{\frac{\pi}{32}(50)^4}$$

$= 4.8$ radian

05. Ans: (d)

Sol:

We know

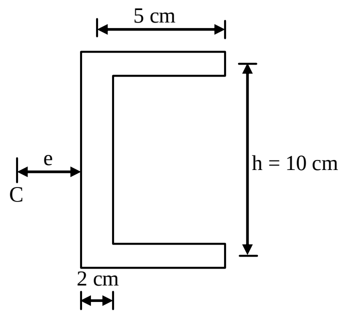
$$k \propto \frac{e^3}{1+e}$$

$$\frac{k_{0.5}}{k_1} = \frac{\frac{(0.5)^3}{1+0.5}}{\frac{(1)^3}{1+1}}$$

$\Rightarrow k_{0.5} = 0.667 \times 10^{-4}$ cm/sec

06. Ans: (c)

Sol:



C be the shear centre

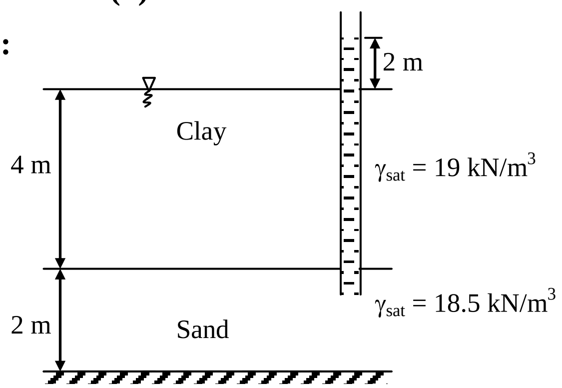
$$e = \frac{B^2 t h^2}{4 I_{xx}}$$

$$= \frac{(5)^2 \times (2) \times (10)^2}{4 \times (764)}$$

$e = 1.636$ cm

07. Ans: (d)

Sol:



σ' at 4m depth below G.L = ?

Just Above:

$$\sigma' = \sigma - u$$

$$= (19\times4)-(4\times10)$$

$$\sigma' = 36 \text{ kN/m}^2$$

Just Below:

$$\sigma' = \sigma - u$$

$$= (19\times4)-(6\times10)$$

$$\sigma' = 16 \text{ kN/m}^2$$

The critical condition of effective stress is taken for safety against quick sand, liquefaction etc. So, Effective stress is 16kPa.

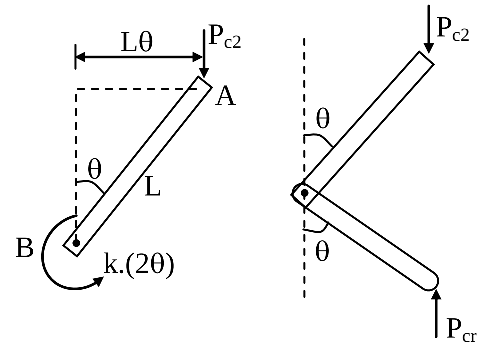
08. Ans: (b)

Sol: Given data:

L = 1 m, k = 1 kN.m/rad.

Due to application of load P_{cr}, column is rotated by θ at point B.

Free body diagram of bar AB:



Taking moment about point A,

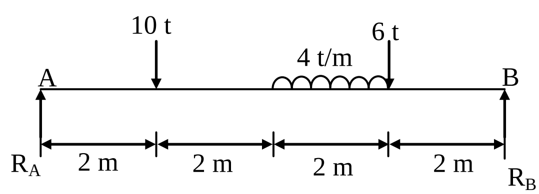
$\Sigma M_A = 0$

$$\therefore\ -P_{cr}\times L\theta + K\times 2\theta = 0$$

$$\therefore\ P_{cr} = \frac{2K}{L} = \frac{2\times10^3}{1} = 2 \text{ kN}$$

09. Ans: (d)

Sol:



$\Sigma M_B = 0$

$R_A \times 8 - 10 \times 6 - 4 \times 2 \times 3 - 6 \times 2 = 0$

$R_A = 12t$

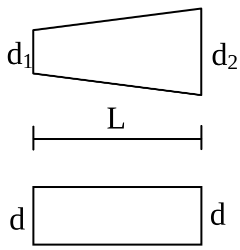
$R_A + R_B = 10 + 4 \times 2 + 6$

$R_B = 12t$

$$\therefore \frac{R_A}{R_B} = \frac{12}{12} = 1:1$$

10. Ans: (b)

Sol: Both bars are subjected to same load P(say) and elongate by the same amount.



Elongation of the tapered bar,

$$\delta\ell_1 = \frac{4PL}{\pi d_1 d_2 E}$$

Elongation of the uniform bar,

$$\delta\ell_2 = \frac{PL}{\left(\frac{\pi d^2}{4}\right)E} = \frac{4PL}{\pi d^2 E}$$

Equation both,

$$\frac{4PL}{\pi d_1 d_2 E} = \frac{4PL}{\pi d^2 E}$$

$$d^2 = d_1\, d_2$$

$$d = \sqrt{d_1\, d_2}$$

11. Ans: (b)

Sol: Whether it is maximum BM at a section or absolute maximum BM, the moving UDL should cover the entire span if a simple beam of span is **less than** load length.

12. Ans: (b)

Sol: At the fixed supports = 0

At joint ‘D' = 4 [Rotations]

At Joint 'E' = 1 [Rotation]

Kinematic Indeterminacy $D_k = 5$

13. Ans : (c)

Sol: Joint equilibrium equation at B

$$M_{BA} + M_{BC} + M_{BD} = 0$$

Fixed end Moments:

$$M_{FBA} = +\frac{wc^2}{12} = 16\ kN-m$$

$$M_{FBC} = -10\times 2 = -20\ kN-m$$

$$M_{FBD} = -\frac{WL}{8} = -5\ kN-m$$

Slope deflection equations:

$$M_{BA} = M_{FBA} + \frac{2EI}{L}\left[2\theta_B + \overset{0}{\cancel{\theta_A}} - \overset{0}{\cancel{\frac{3\delta}{L}}}\right]$$

$= 16 + EI\theta_B$

$M_{BC} = M_{FBC} = -20$ kN-m

$$M_{BD} = M_{FBD} + \frac{2EI}{L}\left[2\theta_B + \overset{0}{\cancel{\theta_D}} - \overset{0}{\cancel{\frac{3\delta}{L}}}\right]$$

$= -5 + EI\theta_B$

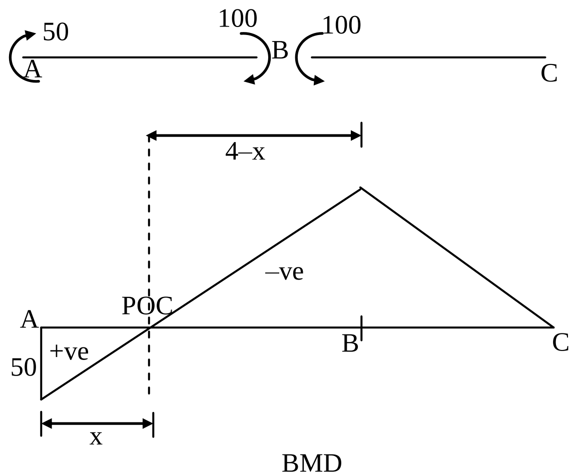
$M_{BA} + M_{BC} + M_{BD} = 0$

$16 + EI\theta_B - 20 - 5 + EI\theta_B = 0$

$$\theta_B = \frac{+4.5}{EI}$$

14. Ans: (d)

Sol:



from similar triangles

$$\frac{x}{50} = \frac{4 - x}{100}$$

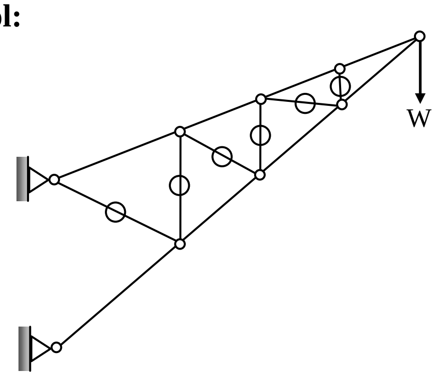
$$2x = 4 - x$$

$$3x = 4$$

$$x = 4/3 \text{ m}$$

15. Ans : (c)

Sol:



16. Ans: (c)

Sol:

- Pathline is a path travelled by fluid particle over period of time. Hence, it represents history of the fluid particle.
- If flow is steady, streamline and pathline are same. Hence, equation of pathline is same as equation of streamline i.e., $\frac{dx}{u} = \frac{dy}{v}$.
- As streamline cannot intersect each other, pathlines also will not intersect each other because in steady flow pathlines and streamlines are same.

17. Ans: (a)

Sol: Slaking is a process in which water reacts with lime to form white powdery substance known as hydrated lime. Slaking is not related to hardening of lime. Hence, option (A) is the correct answer.

18. Ans: (d)

Sol: When soil settles more than a pile, then negative skin friction occurs.

19. Ans: (b)

Sol: Given data:

$t_1 = 2t_2$

$d_1 = 3d_2$

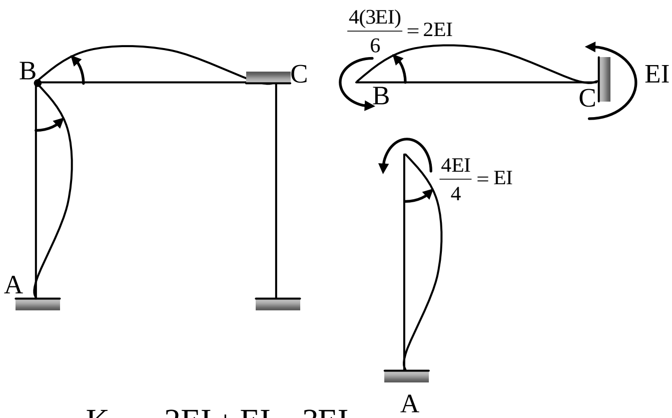
Longitudinal stress for a thin cylinder is given by,

$$\sigma_\ell = \frac{Pd}{4t} \Rightarrow \sigma_\ell \ \alpha \ \frac{d}{t}$$

$$\Rightarrow \frac{(\sigma_\ell)}{(\sigma_\ell)_2} = \left(\frac{d_1}{d_2}\right) \times \left(\frac{t_2}{t_1}\right) = \frac{3}{2}$$

20. Ans: (d)

Sol:



$$K_{11} = 2EI + EI = 3EI$$

$$K_{21} = EI$$

21. Ans: (d)

Sol: Given data:

$\varepsilon_x = 25 \times 10^{-6}$, $\varepsilon_y = -5 \times 10^{-6}$,

$\varepsilon_{xy} = 40 \times 10^{-6}$

Radius of Mohr circle is given by,

$$R = \frac{\gamma_{max}}{2} = \sqrt{\left(\frac{\varepsilon_x - \varepsilon_y}{2}\right)^2 + \left(\frac{\gamma_{xy}}{2}\right)^2}$$

$$= \sqrt{\left(\frac{25 \times 10^{-6} - (-5 \times 10^{-6})}{2}\right)^2 + \left(\frac{40 \times 10^{-6}}{2}\right)^2}$$

$$= \sqrt{(15 \times 10^{-6})^2 + (20 \times 10^{-6})^2}$$

$\therefore$ R = 25×10^{-6}

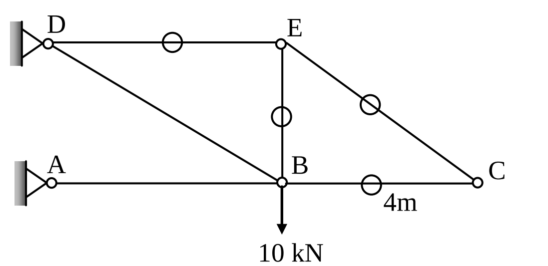
$\therefore$ D = 2R = 50 microns

22. Ans: (d)

Sol: Horizontal deflection at joint 'C'

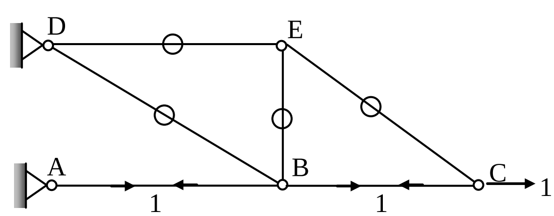
$$\delta_{HC} = \sum \frac{PKL}{AE}$$

P-values:



k-values:

To find horizontal deflection at 'C', remove real loads acting on the structure and apply unit load at 'C' in horizontal direction.



$$\delta_{HC} = \sum \frac{PKL}{AE} = \frac{P_{AB}K_{AB}L_{AB}}{AE} + \frac{P_{BC}K_{BC}L_{BC}}{AE}$$

'P' values in member BC is zero

$$\delta_{HC} = \frac{P_{AB}k_{AB}L_{AB}}{AE}$$

Only member AB

23. Ans: (b)

Sol: Length of plastic hinge $L_p = L\sqrt{1-\frac{1}{SF}}$

Shape factor (SF) for rectangular section

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

$$L_P = L\sqrt{\left(1-\frac{1}{\frac{3}{2}}\right)} = \frac{L}{\sqrt{3}}$$

24. Ans: (d)

Sol:

- For laminar flow, $f = \frac{64}{Re}$

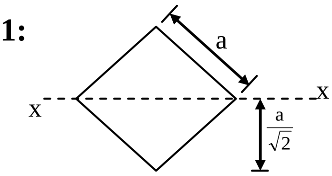
$\therefore f' = \frac{f}{4} = \frac{16}{Re} \Rightarrow$ statement (I) is correct.

- For Moody's diagram it can be concluded that statements 2 & 3 are also correct.

25. Ans: (d)

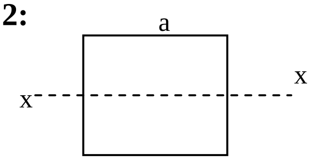
Sol:

Case 1:



$$M_1 = \sigma \times Z_1 = \frac{\sigma \times \left(\frac{a^4}{12}\right)}{\left(\frac{a}{\sqrt{2}}\right)} = \frac{a^3}{6\sqrt{2}} \times \sigma$$

Case 2:



$$M_2 = \sigma \times Z_2 = \sigma \times \frac{a^3}{6}$$

$$\therefore \frac{M_1}{M_2} = \frac{1}{\sqrt{2}}$$

26. Ans: (c)

Sol:

- The TEL represents variation of total energy in the direction of flow. The total energy $\left(\frac{P}{\rho g} + \frac{V^2}{2g} + z\right)$ always decreases in the direction of flow if pump is not present.

- HGL represents variation of piezometric head $\left(\frac{P}{\rho g}+z\right)$ in the direction of flow. The difference between TEL & HGL is kinetic energy head $\left(\frac{V^2}{2g}\right)$ which increases for flow through nozzle.

27. Ans: (c)

28. Ans: (a)

Sol: Static indeterminacy $D_s = D_{se} + D_{si}$ – Force releases

External indeterminacy $'D_{se}' = r - s$

No. of reactions 'r'=7

No. of equilibrium equations 's' = 3

$D_{se} = 7 - 3 - 4$

Internal indeterminacy $D_{si} = 3C$

No. of closed boxes 'C'=2

` $D_{si} = 3 \times 2 = 6$

Force releases at support 'B'= 2

$D_s = 4 + 6 - 2 = 8$

29. Ans: (c)

Sol: Static indeterminacy

$D_S = D_{Se} = r - S = 3 - 2 = 1$

No. of possible plastic 'N'=3

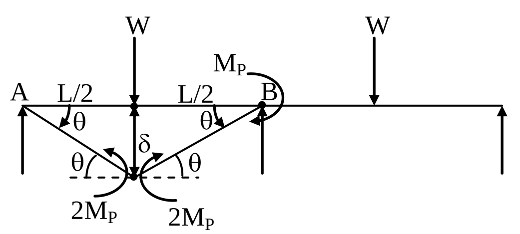
No. of plastic triangles required to form a mechanism 'n'= $D_S + 1 = 2$

No. of independent Mechanism I

$= N - D_S = 3 - 1 = 2$

[Two beam mechanism]

Beam mechanism in span 'AB':



External work done $W_e = W_c \times \delta$

$= W_c \times \frac{L}{2}\theta$

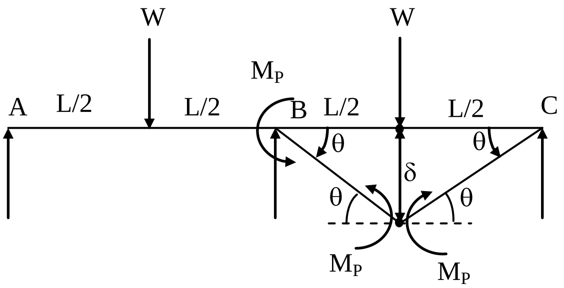
Internal work done $'W_i' = 5M_p\theta$

$W_e = W_i$

$$W_c \times \frac{L}{2}\ \theta = 5M_p\theta$$

$$W_C = \frac{10M_p}{L}$$

Beam mechanism in span BC:



$$W_e = W_C \times \delta \qquad \delta = \frac{L}{2}\theta$$

$$W_i = 2M_p\theta + M_p\theta = 3M_p\theta$$

$$W_e = W_i$$

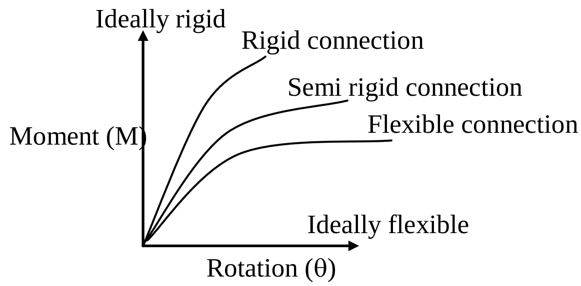
$$W_c \times \frac{L}{2}\theta = 3M_p\theta$$

$$W_c = \frac{6M_P}{L}$$

True collapse load is $\frac{6M_P}{L}$

30. Ans: (d)

Sol: The moment rotation relation-ships for different types of connections are shown below



31. Ans: (b)

Sol: Volume dilation rate = Volumetric strain-rate

i.e., $\dot{\varepsilon}_v = \dot{\varepsilon}_{xx} + \dot{\varepsilon}_{yy} + \dot{\varepsilon}_{zz}$

$$= \frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial w}{\partial z}$$

= (2x) + (x + z + 2y) + (x – 2z)

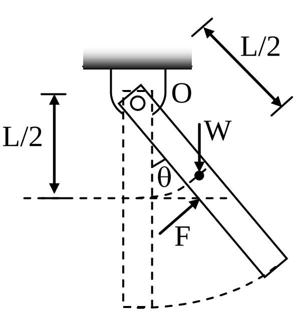
= 4x + 2y – z

= 4(1) + 2(2) – 3

= 5

32. Ans: (a)

Sol:



$\Sigma M_o = 0$

$$F \times \frac{\left(\frac{L}{2}\right)}{\cos\theta} - W \times \left(\frac{L}{2}\right)\sin\theta = 0$$

$F = W \sin\theta \cos\theta$

i.e., $\rho a V^2 \cos\theta = W \sin\theta \cos\theta$

$$\sin\theta = \frac{\rho a V^2}{W}$$

33. Ans: (c)

Sol: When two pumps are connected in series, the discharge remains same but head is added.

i.e, $Q = Q_1 = Q_2$, $H_s = H_1 + H_2$

Let, $H_s = a + b\,Q^2$ be the characteristic curve of series combination

$\therefore\ H_s = H_1 + H_2$

$a + bQ^2 = (50 - 1000\,Q^2) + (50 - 1000\,Q^2)$

$\Rightarrow a = 100,\ b = -2000$

$\therefore\ H_s = 100 - 2000\,Q^2$

The maximum head is obtained when Q = 0

$\therefore\ H_{s,max} = 100$ m

34. Ans: (b)

Sol: For homologous conditions,

$$P \propto D^2 H^{3/2}$$

$$\frac{P_2}{P_1} = \left(\frac{D_2}{D_1}\right)^2 \times \left(\frac{H_2}{H_1}\right)^{3/2}$$

$$\frac{P_2}{10} = \left(\frac{5}{1}\right)^2 \times \left(\frac{4}{1}\right)^{3/2}$$

$P_2 = 10 \times 25 \times 8 = 2000$ kW = 2 MW

35. Ans: (d)

Sol: $F_H = (P_{C.G}A)$ (A = projected area)

$$= \rho g R \times (2R \times L) = 2\rho g R^2 L$$

$$F_V = \rho g \forall = \rho g \times \frac{\pi R^2}{2} L = \frac{\pi \rho g R^2 L}{2}$$

$$F_R = \sqrt{F_H^{\ 2} + F_V^{\ 2}}$$

$$= \rho g R^2 L \sqrt{\frac{\pi^2}{4} + 4}$$

36. Ans: (b)

Sol: Modulus of resilience (u_r) is given by the area under the stress-strain diagram upto proportional limit only.

$$u_r = \frac{1}{2} \times (0.001 - 0) \times 210$$

$$= 0.105\ \frac{\text{N.mm}}{\text{mm}^3} = 105\ \text{kJ/m}^3$$

37. Ans: (d)

Sol: Plane strain follows that an element has zero normal strain, ε_z and zero shear strains, γ_{xz} and γ_{yz} in the xz and yz planes, respectively.

Thus, $\tau_{xz} = \tau_{yz} = 0$

Also, $\varepsilon_z = \dfrac{\sigma_z}{E} - \mu\left(\dfrac{\sigma_x + \sigma_y}{E}\right) = 0$

$\therefore\quad \sigma_z = \mu(\sigma_x + \sigma_y)$

38. Ans: (a)

Sol: Recovery ratio

$$= \frac{\text{Length of rock core recovered}}{\text{Length of coring}}$$

$$= \frac{1250}{2500} = 0.5$$

39. Ans: (b)

Sol: $V_A = V_B = \frac{W}{2}$

$BM_c = 0$ ↶-ve ↷+ve

$$\frac{W}{2} \times \frac{L}{2} = H \times h = 0$$

$$H = \frac{WL}{4h}$$

$H = W$

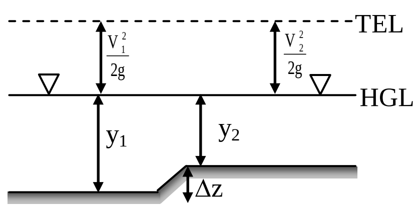
$$\frac{WL}{4h} = W$$

$$h = \frac{L}{4}$$

40. Ans: (b)

Sol: $y_1 = y_2 + \Delta z$

$\therefore y_2 = 2 - 0.5 = 1.5$ m



For no change in water surface elevation

$$\left[\frac{V_1^2}{2g} = \frac{V_2^2}{2g}\right]$$

$V_1 = V_2$

$A_1 = A_2$

$B_1y_1 = B_2y_2$

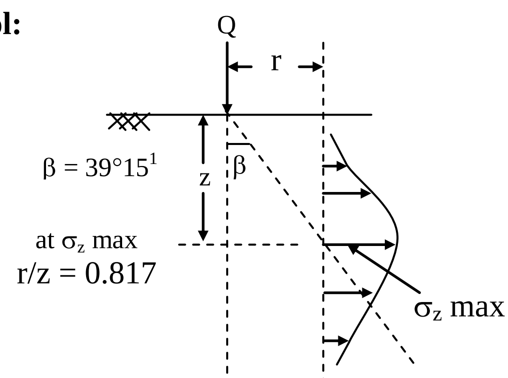
$3 \times 2 = B_2 \times 1.5$

$\therefore B_2 = 4$ m

Width should expand to 4m d/s

41. Ans: (d)

Sol:



σ_Z variation on a vertical plane at a distance 'r' from the load

$$\frac{r}{z} = 0.817 \quad (\because r = 2.45 \text{ m given})$$

$$z = \frac{2.45}{0.817} = 2.99 \simeq 3 \text{ m}$$

42. Ans: (d)

Sol: Strain values

General shear failure ⇒ less than 5%

Local shear failure ⇒ between 10% and 20%

43. Ans: (a)

Sol: $\delta^* = \int_0^\delta \left(1-\frac{u}{u_\infty}\right)dy = \int_0^\delta \left[1-\sin\left(\frac{\pi}{2}\frac{y}{\delta}\right)\right]dy$

$$= \left[y-\left(-\cos\left(\frac{\pi}{2}\frac{y}{\delta}\right)\right)\times\frac{2\delta}{\pi}\right]_0^\delta$$

$$= \left[y+\frac{2\delta}{\pi}\left(\cos\left(\frac{\pi}{2}\frac{y}{\delta}\right)\right)\right]_0^\delta$$

$$= \left[\delta+\frac{2\delta}{\pi}\cos\left(\frac{\pi}{2}\right)-\left(0+\frac{2\delta}{\pi}\cos(0)\right)\right]$$

$$= \delta-\frac{2\delta}{\pi}$$

$$\frac{\delta^*}{\delta} = 1-\frac{2}{\pi}$$

44. Ans : (d)

45. Ans: (c)

Sol: When channel bottom is rises by hump Δz and approaching flow subcritical.

1. $0 < \Delta z < \Delta z_c$: No change in up stream water level. Down stream water level falls.
2. $\Delta z = \Delta z_c$ = No change in up stream water level, down stream water level depth reaches to critical depth.
3. $\Delta z > \Delta z_c$ = upstream water level increase from y_1 to y_1' and down stream water level is at critical depth only.

46. Ans: (b)

Sol: Transverse shear for lacing should be designed for 2.5% of design axial column load.

$\therefore$ Transverse shear $(V) = \frac{2.5\times150}{100}$

$= 3.75$ N

47. Ans: (c)

Sol: Loss of stress due to anchorage slip $= E_s\frac{\Delta}{L}$

Percentage Loss of stress due to anchorage slip $(\sigma_1) = \frac{E_s\frac{\Delta}{L}}{P}\times100$

For constant P, slip ; $\sigma \alpha (1/L)$

$$= \frac{\sigma_1}{\sigma_2} = \frac{L_2}{L_1} = \frac{10}{20} = \frac{1}{2}$$

48. Ans: (a)

Sol: Thickness, Z = 4 m

e = 0.65

G = 2.65

For quick sand condition, $i_c = \frac{G-1}{1+e}$

$= \frac{2.65-1}{1+0.65} = 1$

The minimum head required, h = iZ = 1 × 4

= 4 m

49. Ans: (b)

Sol: For Prandtl pitot tube,

$$V = \sqrt{2gx\left(\frac{\rho_m}{\rho} - 1\right)}$$

i.e., $V \propto \sqrt{x}$ or $V = k\sqrt{x}$

$$\therefore\ dV = k\frac{1}{2\sqrt{x}}dx$$

$$\frac{dV}{V} = \frac{\left(\frac{kdx}{2\sqrt{x}}\right)}{k\sqrt{x}}$$

$$\frac{dV}{V} = \frac{1}{2}\frac{dx}{x}$$

$$\frac{dx}{x} = \frac{1\,mm}{100\,mm} = 0.01$$

$$\frac{dV}{V}\times 100 = \frac{1}{2}\times\frac{dx}{x}\times 100$$

$$= \frac{1}{2}\times 0.01\times 100 = 0.5\ \%$$

50. Ans: (b)

Sol: $C_d = \sqrt{1 - \frac{h_f}{h}}$

where, $h = \left(\frac{P_1}{\rho g} + z_1\right) - \left(\frac{P_2}{\rho g} + z_2\right)$

$$C_d = \sqrt{1 - \frac{1.28}{20}} = \sqrt{1 - 0.64} = \sqrt{0.36} = 0.6$$

51. Ans: (d)

52. Ans: (c)

Sol: The velocity profile for laminar flow through a pipe is,

$$u(r) = u_{max}\left(1 - \frac{r^2}{R^2}\right)$$

At a location u(r) = V (Given),

$$\therefore\ V = u_{max}\left(1 - \frac{r^2}{R^2}\right)$$

$$\text{i.e., } \frac{u_{max}}{2} = u_{max}\left(1 - \frac{r^2}{R^2}\right)$$

$$\Rightarrow r = \frac{R}{\sqrt{2}}$$

$$\tau = -\frac{dp}{dx}\times\frac{r}{2}$$

$$\frac{\tau_r}{\tau_w} = \frac{\left(-\frac{dp}{dx}\times\frac{r}{2}\right)}{\left(\frac{dp}{dx}\times\frac{R}{2}\right)} = \frac{r}{R} = \frac{1}{\sqrt{2}}$$

$$\Rightarrow \tau_r = \frac{\tau_w}{\sqrt{2}}$$

53. Ans: (b)

Sol: Curvature ductility is the ratio of the curvature at ultimate strength to the curvature at the first yield of tension steel

$\mu = \phi_u / \phi_y$

It is the property of the beam cross section and increases with

- Decrease in percentage tension steel
- Increase in percentage compression steel
- Decrease in tensile strength of steel
- Increase in compressive strength of concrete
- Increase in shear reinforcement
- Increase in confinement of concrete

54. Ans: (d)

Sol: The apparent viscosity can be calculated as,

$$\mu_a = \frac{\tau}{\left(\frac{du}{dy}\right)} = \infty, 0.01, 0.008, 0.007, 0.006, 0.005$$

As the apparent viscosity decreases with increase of shear strain rate the fluid is pseudo plastic.

55. Ans: (c)

Sol: Live load = 750 – 20(20–10) = 550 N/m^2

= 0.55 kN/m^2

56. Ans: (c) **57. Ans: (d)**

58. Ans: (a)

Sol: Torsion in the building may be due to Irregularities of mass, strength and stiffness. It also arises from eccentricity of the building layout i.e when the centre of mass does not coincide with centre of rigidity. The resultant lateral force acts through centre of mass. If there is torsion, the building rotates about centre of rigidity. Hence statement I is wrong.

Symmetry in the building ensures that centre of mass coincides with centre of rigidity

Also, Twist in the building causes different portion on the same floor of the building to move by different amounts.

59. Ans: (c)

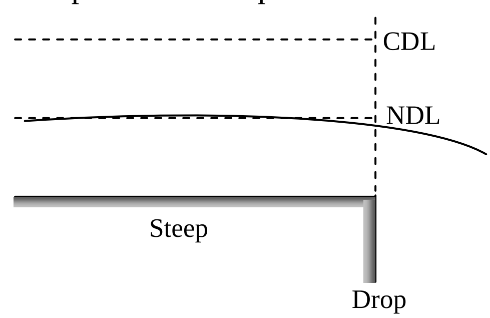
Sol: $y_n = 0.5$ m

Rectangle

$$y_c = \left(\frac{q^2}{g}\right)^{\frac{1}{3}} = \left(\frac{\left(\sqrt{g}\right)^2}{9.81}\right)^{\frac{1}{3}} = 1.0$$

$\therefore\ y_n < y_c \Rightarrow$ steep slope

As slope is steep, No GVF profile occurs on upstream of drop.



60. Ans: (c)

61. Ans: (c)

Sol: For equi-potential line, $d\phi = 0$

$$\frac{\partial \phi}{\partial x}dx + \frac{\partial \phi}{\partial y}dy = 0$$

$(-u)dx + (-v)\,dy = 0$

$$\text{i.e., } \frac{dx}{v} = -\frac{dy}{u}$$

62. Ans: (c)

Sol: At section A:

$Q_A = A.\ V_{avg}$

$B_1 = 2$ m

$y_1 = 2$m

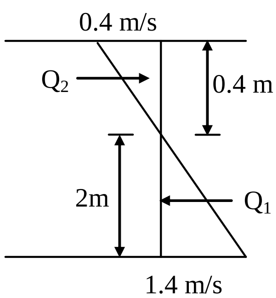
Area of velocity distribution is discharge

$Q_A = 1.25\times2\times2$

$= 5\ m^3/s$

At section B:

$Q_B = Q_1 - Q_2$



$$= \frac{1}{2}\times1.4\times2\times3.5 - \frac{1}{2}\times0.4\times0.4\times3.5$$

$= 4.62\ m^3/s$

$\therefore\ Q_A > Q_B$

Some amount of flow has been extracted out of canal.

63. Ans: (b) **64. Ans: (d)**

65. Ans: (c)

66. Ans: (d)

Sol: For Fe250 steel, limiting depth of neutral axis = 0.53d = 0.53 x 500 = 265mm

Area of steel = 4 x π/4 x 16^2 = 804.24sqmm

Actual depth of neutral axis : $0.36\ f_{ck}\ bx_u$

$= 0.87\ f_y\ A_{st}$

$$x_u = \frac{0.87 f_y A_{st}}{0.36 f_{ck} b}$$

$$= \frac{0.87\times250\times804.24}{0.36\times20\times300} = 80.98 < x_{u,lim}$$

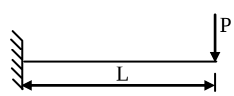
Hence the section is under reinforced

Lever arm = $(d - 0.42x_u) = 500 - (0.42\times80.98)$

$= 465.98$ mm

67. Ans: (b)

Sol:



Bending moment $M = -Px = EI\frac{d^2y}{dx^2}$

$$\int -px = \int EI\frac{d^2y}{dx^2}$$

$$\frac{-px^2}{2} + c = EI\frac{dy}{dx}$$

At $x = L$ $\frac{dy}{dx} = 0$

$$C = \frac{PL^2}{2}$$

$$\frac{-px^2}{2} + \frac{pL^2}{2} = EI\frac{dy}{dx}$$

$$\frac{-6\times10^3\times(0.8)^2}{2} + \frac{6\times10^3\times(1)^2}{2} = EI\frac{dy}{dx}$$

$$\frac{6\times10^3}{2}\left(-(0.8)^2+1\right) = EI\frac{dy}{dx}$$

$$\frac{6\times10^3}{2}(0.36) = EI\frac{dy}{dx}$$

$$\frac{dy}{dx} = \frac{1080}{EI}$$

68. Ans: (a)

Sol: Yield strain of mild steel

$$\frac{0.87f_y}{E_s} = \frac{0.87\times250}{2\times10^5} = 0.0010875$$

Yield strain of Fe415

$$= 0.002 + \frac{0.87f_y}{E_s} = 0.002 + \frac{0.87\times415}{2\times10^5} = 0.003805$$

Difference in yield strain = 0.003805 – 0.0010875 = 0.00271 = 2.717 x 10^{-3}

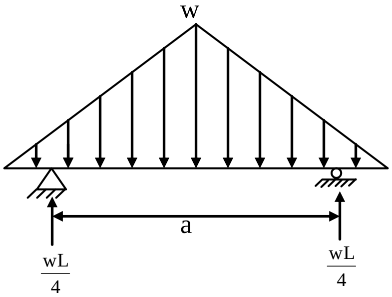
69. Ans: (a)

Sol: SRC has low percentages of C_3A and C_4AF and is ground finer than OPC. More the fineness, more will be the specific surface area. Hence, option (A) is the correct answer.

70. Ans: (d)

71. Ans: (b)

Sol:



B.M at centre = 0

$$\Rightarrow \frac{1}{2}w\left(\frac{L}{2}\right)\times\frac{1}{3}\left(\frac{L}{2}\right) - \frac{wL}{4}\times\frac{a}{2} = 0$$

$$a = \frac{L}{3}$$

72. Ans: (c)

Sol: Flexural shear cracks will form under large bending moment & less shear force.

73. Ans: (b)

- Response spectra shown the maximum response of a Single degree freedom oscillators subjected to specified earthquake ground motion (i.e. same damping) for different time periods/frequencies.
- Response can be displacement or velocity or acceleration. Hence .The

response spectra can be plotted with any of the three parameters (acceleration, velocity and displacement) as ordinate and time period as abscissa.

- It depends on the soil condition, damping in the system , time period of the system, focal depth, richter magnitude etc.

74. Ans: (c)

Sol: Strength of concrete from Rebound Hammer test is more accurate when thickness of concrete tested is less than 30 mm.

75. Ans: (c)

Sol: $a_v = \dfrac{\Delta e}{\Delta \sigma_1}$

$C_v = \dfrac{K}{m_v \gamma_w}$

K – depends on e and structure of soil

$m_v = \dfrac{a_v}{1+e}$

76. Ans: (d)

Sol: As per IS Code, the Initial Setting Time of Ordinary Portland Cement must be more than 30 minutes and the Final Setting Time of Ordinary Portland Cement must be less than 600 minutes. Hence, Option (d) is the correct option.

77. Ans: (a)

Sol: The word ceramic means burnt material. Hence, option (a) is the suitable.

78. Ans: (a)

Sol: Both C_3A and C_4AF give some undesirable properties to cement, but C_3A is more undesirable than C_4AF, as it has more heat of hydration, responsible for flash set and makes the structure prone to sulphate attack. Hence, option (A) is the correct answer.

79. Ans: (b)

Sol: First equation, coefficient of A is 1 and weight of observation is 2. Hence multiply it by 2 (=2 × 1)

Second equation, the coefficient of A is 3 and weight of the observation is 3. Hence multiply it by 9 (= 9 ×3)

$\therefore\ 2A = 60^o57'20''$

$27A = 822^o53'15''$

$29A = 883^o50'35''$

$A = 30^o28'38.5''$

80. Ans: (d)

Sol: $H_1 = 5\text{ m} = 5000\text{ mm}$ $H_2 = 5\text{ m}$

$d_1 = \dfrac{H_1}{2} = 2500\text{ mm}$

$$d_2 = \frac{H_2}{1} = 5000\,mm$$

$U_1 = 50\%$ $U_2 = 50\%$

$t_1 = 300$ days $t_2 = ?$

Time factor $T_V = \frac{C_v t}{d^2}$

$$\frac{t_2}{t_1} = \left[\frac{d_2}{d_1}\right]^2$$

$$t_2 = 300\left[\frac{5000}{2500}\right]^2$$

= 1200 days

81. Ans: (d)

Sol: Depth of rainfall

= Intensity of R.F × Duration

= 2 × 6 = 12 cm

Volume of runoff = 20×10^6 m^3

Area of basin = 300 km^2 = 300×10^6 m^2

$$\text{Depth of runoff} = \frac{\text{Volume of runoff}}{\text{Area of basin}}$$

$$= \frac{20\times10^6}{300\times10^6}$$

= 6.7 cm

Total infiltration = 12 – 6.7 = 5.3 cm

Average infiltration rate = $\frac{5.3}{6}$ = 8 mm/hr

82. Ans: (b)

Intake → Pumping of Raw water

→ Treatment → Distribution

83. Ans: (b)

84. Ans: (c)

Sol: Volume of water required at field

$= A_1\Delta_1 + A_2\Delta_2 + A_3\Delta_3 = 8.64\left[\Sigma\frac{AB}{D}\right]$

$$= 8.64\left[\frac{20000(120)}{1800} + \frac{24000(120)}{2000} + \frac{16000(320)}{2500}\right]ha - m$$

Capacity of the reservoir

$$= \frac{\text{Volume required}}{\eta}$$

$$= \frac{41656.32}{0.95\times0.9} = 48{,}700 \text{ ha-m}$$

85. Ans: (c)

Sol:

Contour (m)	198	198.5	199	199.5	200
Area m^2	1750	2200	15900	19000	21000

Using simpson's

Volume = $\frac{0.5}{3}$

[(1750+21000)+4(2200+19000)+ 2(15,900)]

= 23225 m^3

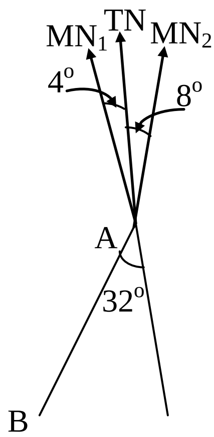
Time = 2 hours

$$Q_{design} = \frac{Vol}{time\ C_p t_p} = \frac{23225}{2(3600)(0.8)(0.75)}$$

= 5.4 cumec

86. Ans: (b)

Sol:



Let AB be the given line

Magnetic bearing of AB is S 32° W

$= 180^o + 32^o = 212^o$

Magnetic declination at the time of drawing the line

$= 4^o W$

$\therefore$ True bearing of AB

= Magnetic bearing – Declination

$= 212^o - 4^o = 208^o$

Present Magnetic declination = 8^o E

$\therefore$ Present Magnetic bearing of AB

= True bearing of AB – Magnetic declination

$= 208^o - 8^o = 200^o$

$\therefore$ The present magnetic bearing AB = S 20^oW

87. Ans: (c)

Sol: When carbon content is more than 1.5 %, free carbon in the form of graphite is formed in the steel hence, its tensile strength decreases but compressive strength keeps on increasing before this point (Example: Cast Iron). Hence, Option c) is the correct option.

88. Ans: (b)

89. Ans: (c)

Sol: The relationship between strength of concrete and water cement ratio is non-linear and inversely proportional, but the relationship between strength of concrete and cement water ratio is linear and directly proportional

90. Ans: (c)

Sol: Both Strength and Weight of timber are compared at 12% moisture content.

91. Ans: (d)

92. Ans: (a)

93. Ans (a)

94. Ans: (b)

95. Ans: (c)

96. Ans (a)

Sol: Hydraulic conductivity, k = 0.1 mm/s

$$q = \frac{k}{2L}\left(h_1^2 - h_2^2\right)$$

$$k = \frac{0.1}{1000} \times 60 \times 60 \times 24 = 8.64 \text{ m/day}$$

$$q = \frac{8.64}{2 \times 3500}\left(15^2 - 10^2\right)$$

$$= \frac{8.64 \times 125}{7000}$$

$= 0.15$ m^3/day

97. Ans: (d)

Sol: VMA = 15%

$V_a = 4.5\%$

$V_b = 15 - 4.5 = 10.5\%$

$$VFB = \frac{V_b}{VMA} \times 100$$

$$= \frac{10.5}{15} \times 100 = 70\%$$

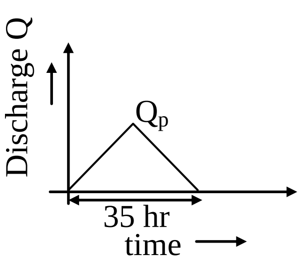
98. Ans: (d)

99. Ans: (b)

Sol: **Isochrone**: line joining equal time of travel. Linear reservoir is one which storage is directly proportional to the discharge.

100. Ans: (c)

Sol:



$$R = \frac{\text{Volume of runoff}}{\text{Area of catchment}}$$

$$\frac{1}{100} = \frac{\frac{1}{2} \times 35 \times 60 \times 60 \times Q_p}{252 \times 10^6}$$

$Q_p = 40$ m^3/sec

Peak discharge of direct runoff hydrograph

$(Q_p)_{DRH} = (Q_p)_{UH} \times R = 40 \times 5$

$= 200$ m^3/sec

101. Ans: (d)

Sol: Buckling means the track has gone out of the original position or alignment due to prevention of expansion of rails in hot weather on account of temperature variations. This buckling may take place on tangent length and at curves.

102. Ans: (b)

Sol: Degree of Accuracy

$$= \frac{\text{Probable error}}{\text{Measured distance}}$$

$$= \frac{0.05}{584.65} = 1/11693 \simeq 1/11700$$

103. Ans: (d)

Sol: DO deficit

104. Ans: (a)

105. Ans: (d)

Sol: S = 0.278Vt + L

= 0.278 ×40 × 1 + 6 = 17.12 m

Theoretical capacity, $C = \frac{1000V}{S}$

$= \frac{1000 \times 40}{17.12}$

C = 2336 veh/hr/lane

106. Ans: (c) **107. Ans (c)**

108. Ans: (c)

Sol: $D^o = 3^o$

For BG track, G = 1.676 m

V = 100 kmph

$\therefore R = \frac{1719}{3^o} = 573 \text{ m}$

$e = \frac{GV^2}{127R} = \frac{1.676 \times 100^2}{127 \times 573} = 0.230 \text{ m}$

e = 23.0 cm

109. Ans: (b)

Sol: Hydrated minerals tend to expand many time their original volume of anhydrous minerals. Therefore, they become more porous and attain a lower density.

110. Ans (d) **111. Ans (b)**

112. Ans: (c)

Sol: One of the main objective of tunnel ventilation is to reduce temperature in tunnel situated at great depth.

113. Ans: (d)

114. Ans (c)

115. Ans (b)

Sol: Esp is used to control particulate matter.

116. Ans: (a)

Sol: By definition of spurs & groyves 1 and 2 options are correct silt deposition can be prevented, hence 3^{rd} cannot be the right

117. Ans: (a)

118. Ans: (b)

Sol: Lime, not exceeding 5%, is desirable in good brick earth, as it helps in preventing shrinkage of raw bricks. Hence, option (b) is the correct option.

119. Ans: (c) **120. Ans: (a)**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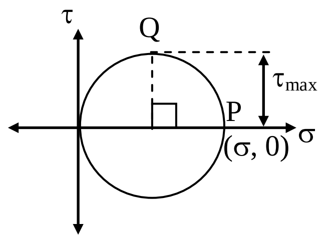
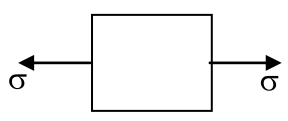
121. Ans: (d)

Sol: Mild steel is strong in tension but it is weak in shear. When a mild steel bar is subjected to tensile test, the state of stress on an element and Mohr circle can be represented as shown in the figure below.





Thus, is fails at 45° (in Mohr circle, at 2θ = 90°) to the axis of the rod where maximum shear stress occurs. Therefore statement (I) is false and statement (II) is true.

122. Ans: (d)

Sol: The slope deflection method is a stiffness method in which the joint displacements are found by applying the equilibrium conditions at each joint.

Statement (I) is false but statement (II) is true.

123. Ans: (c)

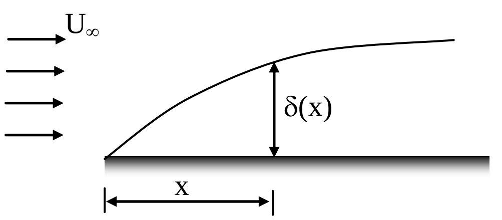
Sol: The time period of oscillation is given by

$$T = 2\pi\sqrt{\frac{k^2}{g\,GM}}$$

As 'GM' increases, 'T' decreases. Hence, statement (II) is false. If metacentric height is low, the time period of oscillation is high which increases the comfort of passengers.

124. Ans: (c)

Sol:



$\delta(x) = \frac{5x}{\sqrt{Re_x}}$ for laminar boundary layer, on a flat plate.

$$= \frac{5x}{\sqrt{\frac{\rho V_\infty x}{\mu}}} \propto \sqrt{x}$$

i.e., $\delta^2 \propto x$ or $\delta^2 = kx$

Above equation shows that parabolic relation exists between δ and x but 'δ' is not directly proportional to 'x^2'.

125. Ans: (a)

126. Ans: (d)

Sol: To have economy in design of heavily loaded columns. The least radius of gyration is increased to maximum. To achieve this condition the rolled steel sections are kept away from centroidal axis of the column and are connected by some connecting system. The commonly used connecting system is lacing, battens or perforated plates. The battening of columns shall not be done where the columns are subjected in the plane of battens of eccentric loading.

127. Ans: (c)

Sol: Pore pressure will not increase in the case of gravel and coarse sands as these are highly permeable.

128. Ans: (d)

Sol: Tie bars are provided in column to prevent premature buckling of main reinforcement bars and to confine concrete in core. It also helps in holding the main reinforcement during the concreting.

When the ultimate load level is reached longitudinal bars yield irrespective of the provision of ties. However, in the absence of ties failure will be brittle caused by crushing and shearing of concrete accompanied by buckling o steel.

129. Ans: (d)

Sol: Lower grade steels have clearly defined and longer yield plateau. Hence plastic hinges formed will have larger rotation capacities leading to greater energy dissipation. Over strength (strength more than the design strength) of the locations of plastic hinges results in the section that is not yielding at the expected load levels. This results in the development of loads larger than the design loads for adjoining elements causing damage. Hence locations of potential plastic hinges should not have over strength. Statement I is not correct, Further, steels with lower grades have higher ultimate strengths i.e ratio of ultimate strength to yield strength is high. This is desirable as is results in increased length of plastic hinge and thereby increased plastic rotation capacity.

130. Ans: (a)

Sol: Flash set can be reduced by adding gypsum in to the cement, at the time of grinding cement clinker.

131. Ans: (b)

Sol: Vibration gives compact form of concrete. Excess of vibration causes segregation, by which cement slurry comes on to the top leaving honey combing on bottom face. The cement slurry deposited on surface is also not useful as it will not give proper strength.

132. Ans: (d)

Sol: Calcium chloride is an accelerator, which increases rate of hardening of ordinary Portland cement.

133. Ans: (c) **134. Ans: (b)**

135. Ans: (d) **136. Ans: (d)**

137. Ans: (d) **138. Ans: (b)**

139. Ans: (b)

Sol: SOR $(v_0) = \frac{Q}{SA}$

Statement I is correct

$v_0 \to (v_s)_{min}$

(v_s)= design settling velocity

if $v_s > u_0 \to \text{Obvious settle}$

$v_s = u_0 \to$ just settle

$v_s < u_0 \to particle\ escape$

Statement II is correct.

But statement II is not explanation of statement I.

140. Ans (c)

Sol: In India surface water is choosen as drinking water source. Statement (I) is correct.

Surface water is not better than ground water. The only problem with GW is, it is devoids of O_2. Thats why SW is chosen as drinking water source. Statement II is false.

141. Ans (a)

Sol: Statement (I) is correct.

Statement (II) is also correct and it is the correct explanation of statement (I).

142. Ans (c)

Sol: $Cl_2 + H_2O \xrightarrow{pH>5} HOCl + HCl - \text{Ionization}$

$HOCl \xleftrightarrow[pH<7.5]{}$

$H^+ + OCl^- - Hydrolizaton$

Statement I is correct

$HOCl + OCl^- \Rightarrow Free\ Cl_2$

They take part in disinfection not Cl^-

Statement (II) is false.

143. Ans: (d)

144. Ans: (b)

145. Ans: (d)

Sol: Marshall test is unconfined compression test.

146. Ans: (a)

147. Ans: (d)

Sol:

- Rotary intersection is useful if the total traffic entering from all the directions not exceeding 3000 per/hr.
- Rotary is used if crossing or weaving traffic is 50% of total traffic (or) fast moving traffic is 30% of total traffic.

  Both the statements are individually true but no relation between them.

148. Ans: (b)

149. Ans: (a)

150. Ans: (c)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AIR 6 RATIPALLI NAGESWAR EE
AIR 7 KARTIKEYA DUTTA E&T
AIR 7 TEKCHAND DESHWAL EE
AIR 7 ROHIT KUMAR CE
AIR 8 SURYASH GAUTAM E&T
AIR 8 RAVI TEJA MANNE EE
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