## Solutions

1. Ans. B.
At Z = 0, stress should not be equal to zero because of available surcharge
And upto Z = h variation in stress should be linear.

2. Ans. A.
VPI is horizontally midway between VPC and VPT
VPC = VPI — L/2
⇒0=100—L/2
⇒L = 200m

3. Ans. D.

$$z = \frac{T_s - T_E}{\sigma}$$

$$T_s = T_E + 2\sigma = 200 + 1.64 \times 6.1 \quad z = \frac{T_s - T_E}{\sigma}$$

$$= 200 + 10.004 = 210.004 days$$

For 95% confidence level z = 1.64
$T_E$ = 200 days
$\sigma$ = 6.1days

$$T_s = T_E + 2\sigma = 200 + 1.64 \times 6.1$$

$$= 200 + 10.004 = 210.004 days$$

4. Ans. D.
Lump sum contract should be preferred when construction work is well-defined with all its drawings, specifications, quantities and estimates

5. Ans. D.
Given

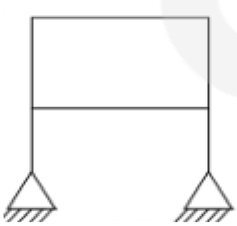
$$V = x^2 i + 2y^3 j + z^4 k$$

$$divv = \frac{\partial}{\partial x}(x^2) + \frac{\partial}{\partial y}(y^2) + \frac{\partial}{\partial z}(z^2)$$

$$= 2x + 6y^2 + 4z^3$$

$$div\, v|_{(1,2,3)} = 2 + 24 + 108 = 134$$

6. Ans. B.



Total degree of freedom = 3j-R
J= no. of joints = 6
R = no. of reactions = 2+2 = 4
DOF=3x 6-4 =18-4=14
When axial deformation are neglected total axial deformations = 8
Reduction in $D_k$ =14 —8 = 6

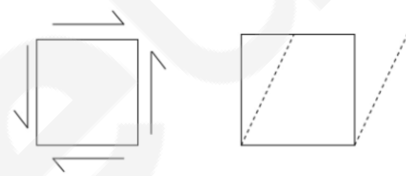
7. Ans. A.
As per Indian standard, day time noise level at residential area limited to 55 dB

8. Ans. A.
From zero air void line

$$\gamma_d = \frac{G.\gamma_w}{1 + wG}$$

9. Ans. C.
The safety of round about can be achieved by decreasing entry radius (decreases speed at entry) and increasing exit radius (increasing exit speed)

10. Ans. D.
Shear strain in an element is positive when the angle between two faces is reduced and negative when angle is increased.



Here since angle has increased, so shear strain should be negative.
$\gamma_{xy}$ = —0.0056 rad = 0.001k
So, -0.005 = 0.001 K
⇒ K = —0.50

11. Ans. D.
Resection is the method of orientation used when the table occupies a position not yet located in the map.

12. Ans. C.
The specific speed of pump

$$(N_s) = \frac{N\sqrt{Q}}{H^{3/4}} = \frac{N.Q^{0.5}}{H^{0.75}}$$

13. Ans. C.

$$\frac{\Delta T}{\Delta Z} = \frac{15 - 15.5}{60 - 10} = \frac{0.5}{50} = \frac{1.00°C}{100m}$$

$$\frac{\Delta T}{\Delta Z} = \frac{14.3 - 15.0}{130 - 60} = \frac{0.7}{70} = \frac{1.00°C}{100m}$$

So, Neutral

14. Ans. B.

$$\phi - index = \frac{P - R}{t}$$

$$1.5 = \frac{3.5 - R}{1} \Rightarrow R = 3.5 - 1.5 = 2cm / hr$$

15. Ans. B.

Equilibrium cant = $\frac{G.V^2}{127\ R}$

For Broad guage (G )= 1.676

$$e = \frac{1.676V^2}{127\ R}$$

$$= 0.01319\frac{V^2}{R}m$$

$$e = 1.319\frac{V^2}{R}cm$$

16. Ans. A.

given systems

$$3x_1 + 2x_2 = c_1$$

$$4x_1 + x_2 = c_2$$

Matrix From is $\begin{pmatrix} 3 & 2 \\ 4 & 1 \end{pmatrix}\begin{pmatrix} x_1 \\ x_2 \end{pmatrix} = \begin{bmatrix} c_1 \\ c_2 \end{bmatrix}$

AX=B

Characteristic equations of above systems is

$$|A - \lambda I| = 0$$

$$\begin{vmatrix} 3-\lambda & 2 \\ 4 & 1-\lambda \end{vmatrix} = 0$$

By expanding $\lambda^2 - 4\lambda - 5 = 0$

17. Ans. D.

$N_f$ = No. of flow channels = No. of flow lines -1= 5-1= 4

$N_d$ = No. of equipotential drops= no. of equipotential lines-1 = 11-1=10

$$q = k.h\frac{N_f}{N_d}$$

$$= 10^{-6} \times 4 \times \frac{4}{10}$$

$$= 1.6 \times 10^{-6}\, m3/s$$

$$q = 1.6\ cm^3 / sec.\ per.\ m.\ width$$

18. Ans. D.

The grade compensation

$$\frac{30+R}{R} = \frac{30+50}{50} = 1.6\%$$

Maximum grade compensation

$$= \frac{75}{R} = \frac{75}{50} = 1.5\%$$

Grade compensation = 1.5

19. Ans. C.

$0 \le \text{B} \le 1$

A can be negative for heavily OC clays and dense sands

A can be positive and greater than 1 for sensitive clays, NC clays, lightly OC clays.

20. Ans. C.

For the given condition,

Target mean strength = characteristic strength = 25 MPa

21. Ans. B.

In plate load test,

The ultimate bearing capacity does not depends upon width of footing

$$q_{uf} = q_{uP} = 180kPa$$

22. Ans. C.

Horton's infiltration capacity

$$f = f_e + (f_o - f_e)e^{-\propto t}$$

$f_e$ = ultimate infiltration capacity = 25 mm/hr

$f$ = Initial infiltration capacity = 200 mm/hr

f = Infiltration capacity = 90 mm/hr

$$f = f_e + (f_o - f_e)e^{-\propto t}$$

$$90 = 25 + (200 - 25)e^{-\propto \times 1}$$

$$175e^{-\propto} = 65$$

$$e^{-\propto} = 0.371$$

$$\propto = 0.9915;\ \ \propto = 0.99 / hour$$

23. Ans. B.

Given first three are already heads. If the coin is tossed again, the outcome does not depend on previous outcomes.

Probability getting head $== \frac{1}{2} = 0.5$

(Or)

Probability of first three is heads

$$= P(H \times H \times H \times H) = \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} = \frac{1}{16}$$

Probability of fourth time head is

$$= P(H \times H \times H \times H) = \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} = \frac{1}{16}$$

Given condition is that (H.H.H) is already realized

The required probability = $\frac{1/16}{2/8} = 0.5$

24. Ans. B.

ASP host heterotrophic aerobic organisms.

25. Ans. C.

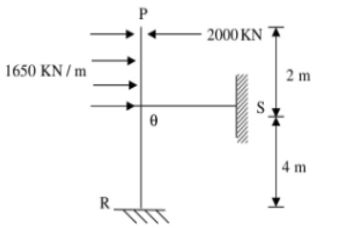
$w = f(x, y)$ where x and y are functions of t.

By Chain Rule

$$\frac{dw}{dt} = \frac{\partial w}{\partial x}.\frac{dx}{dt} + \frac{\partial w}{\partial y}.\frac{dy}{dt}$$

26. Ans. D.
Moment at

$$\theta, M_\theta = 2000\times2-1650\times\frac{(2)^2}{2}$$ =700KN-m anticlockwise




$$K\theta R=\frac{uEI}{4}=EI,$$

$$K\theta S=\frac{uEI}{4}=EI$$

$$\because M\theta \quad K\theta.\theta_\theta$$

$$\therefore \theta_\theta=\frac{M\theta}{K\theta}=\frac{700\times10^6\times1000}{2\times2.5\times10^{47}\times10^8}$$

$$=0.0175rad$$

$$=1.003^o \simeq {}^o$$

27. Ans. D.
Radius of relative stiffness

$$(\ell \quad \left[\frac{Eh^3}{12K(1-\mu^2)}\right]^{1/4}$$

$$\frac{\ell}{\ell} \quad \frac{\left[\frac{Eh^3}{2K(1-\mu^2)}\right]^{1/4}}{\left[\frac{E(0.5h)^3}{12\times2K(1-\mu^2)}\right]^{1/4}}=\left[\frac{2}{(0.5)^3}\right]^{1/4}$$

$$=(2^4)^{1/4}=2$$

28. Ans. C.
Given sub critical depth =2x super critical depth
y= super critical depth
Sub critical depth = 2 y

$$y_1+\frac{Q_1^2}{2gA_1^2}=y_2+\frac{Q_1^2}{2gA_2^2}$$

$$2y+\frac{Q^2}{2gB^2(2y)^2}=y+\frac{Q^2}{2g.B^2y^2}$$

$$y=\frac{Q^2}{2g.B^2}\left[\frac{-1}{(2y)^2}+\frac{1}{y^2}\right]$$

$$y=\frac{2^2}{2\times9.81\times1}\left[-\frac{1}{4}+1\right]\frac{1}{y^2}\Rightarrow y^3=0.153$$

$$\Rightarrow 0.534$$

Super critical depth (y) = 0.5347
Sub critical depth = 2y=2 x 0.5347 = 1.0694m

29. Ans. A.

$$\frac{T_1}{J}=\frac{\tau}{r}$$

$$T=\frac{\tau}{r}J$$

$$=\frac{125}{\left(\frac{100}{2}\right)}\left[\frac{\pi}{32}(D_o^4-D_i^4)\right]$$

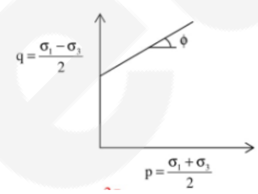
$$=\frac{125\times2}{100}\left[\frac{\pi}{32}(100^4-50^4)\right]$$

$$=23009711.82N-m$$

$$=23.009kN-m$$

30. Ans. D.
Walls of one brick thick are measured in Square meters not in cubic meters

31. Ans. A.



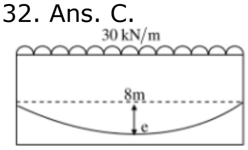

$$\sigma_1=\sigma_3\Rightarrow P=\frac{2\sigma_1}{2}=2, q=0$$

$\therefore$ lies on P.axis

If $\sigma_1>\sigma_3\Rightarrow P=\frac{\sigma_1+\sigma_3}{2}>0, q=\frac{\sigma_1-\sigma_3}{2}>0$

p & q are positive

32. Ans. C.




Maximum moment = $Pe$

$$\frac{w\ell}{8}$$

$$e=\frac{w\ell}{8P} \quad \frac{8^2}{8\times1600}=0.15m$$

33. Ans. D.

$$0.0673{d_1}^2=5 \Rightarrow d_1=8.62\ Km$$

$$0.0673{d_2}^2=40=d_2=24.38\ Km$$

Therefore distance of observer from light house

$$d=d_1+d_2$$

$$=8.62+24.38$$

$$=33km$$

34. Ans. A.

$$A = \begin{pmatrix} 1 & 5 \\ 6 & 2 \end{pmatrix} B = \begin{pmatrix} 3 & 7 \\ 8 & 4 \end{pmatrix}$$

$$AB^T = \begin{pmatrix} 1 & 5 \\ 6 & 2 \end{pmatrix}\begin{pmatrix} 3 & 8 \\ 7 & 4 \end{pmatrix}$$

$$= \begin{bmatrix} 38 & 28 \\ 32 & 56 \end{bmatrix}$$

35. Ans. C.
Strain up to linear elastic behavior is

$$\in = \frac{\delta}{\ell} \quad 2.5 \quad = \frac{1}{800}$$

Strain energy $= \frac{1}{2} \times f_y \times \in \times V$

$$= \frac{1}{2} \times 250 \times \frac{1}{800} \times \left(2000 \times \frac{\pi}{4} \times 8^2\right)$$

$$= 5000\pi$$

$$= 15707.963 Nmm$$

36. Ans. A.
P: d = 60t, Q: d = $60t^2$
Distance at any time t between P and Q is given by d(t) = 60t - $60t^2$
For space headway to be maximum

$$\frac{d^2}{dt^2}(d(t)) = 0$$

$$\Rightarrow 60t - 120t = 0$$

$$\Rightarrow t = 1/2 hour$$

$$so, d(1/2) = 60 \times 1/2 - 60 \times \left(\frac{1}{2}\right)^2$$

$$= 30 - 15 = 15km$$

So, space headway would be max at t = 30 minutes

37. Ans. A.
given

$$I = \int_0^1 \frac{(\sin^{-1} x)^2}{\sqrt{1+x^2}} dx$$

$$= \frac{(\sin^{-1} x)^3}{3}\Bigg|_0^1 \left( \because \quad f^1(x)dx = \frac{f^{n+1}}{n+1} \right)$$

$$= \frac{1}{3}\left[(\sin^{-1})^3 - \sin^{-1} 0\right] = \frac{1}{3}\left[\left(\frac{\pi}{2}\right)^3 - 0\right] = \frac{\pi^3}{24}$$

38. Ans. C.
Detention time of a circular tank is given by

$$t^d = \frac{d^2(0.011d + 0.785H)}{Q}$$

$$So, \frac{d^2(0.011d + 0.785H)}{Q} = \frac{3}{20}$$

$$\Rightarrow \frac{d^2(0.011d + 0.785 \times 3)}{1000} = \frac{3}{20}$$

$$\Rightarrow 0.011d^3 + 2.355d^2 - 150 = 0$$

$\Rightarrow d = 7.83m = 8m$ (Rounded to nearest integer)

39. Ans. A.
Case-I: Undrained condition

$$F.O.S = \frac{Resisting\ shear\ stress}{Actual\ shear\ stress}$$

$$= \frac{80}{50} = 1.6$$

Case-I: Drained condition

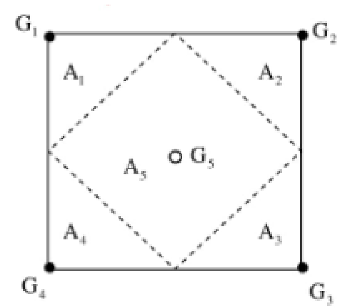
$$F.O.S = \frac{\overline{\sigma} \tan\phi + 'c'}{50}$$

$$= \frac{[2 \times 18 + 4(20 - 9.81] \times tan 18° + 20}{50}$$

$$= 0.9$$

40. Ans. A.
By thiesen polygon method

$$P_{avg} = \frac{\sum P_i A_i}{\sum A_i}$$




$$A_5 = \left(\frac{25}{\sqrt{2}}\right)^2 = 312.5km^2$$

$$A_1 = A_2 = A_3 = A_4 = \frac{625 - 312.5}{4} = 78.125km^2$$

$$P_{avg} = \frac{G_1A_1 + G_2A_2 + G_3A_3 + G_4A_4 + G_5A_5}{A}$$

$$= \frac{300 \times 78.125 + 285 \times 78.125 + 272 \times 78.125 + 288 \times 312.5}{625}$$

$$= 287.375mm$$

41. Ans. A.

$y = xInx$

$\frac{dy}{dx} = x.\frac{1}{x} + Inx$

$Given that \theta = 45^0 \Rightarrow \text{Tan}\,\theta = 1$

$\frac{dy}{dx} = \text{Tan}\,\theta = 1$

$i.e \Rightarrow x.\frac{1}{x} + Inx = 1 + Inx = 1$

$x = 1, y = 0$ *satisfies*

$\therefore$ *A is correct*

42. Ans. A.

head loss

$(h_f) = \frac{fLQ^2}{12d^5}$

$f = \frac{64}{R_e} = \frac{64}{800} = 0.08$

$h_f = \frac{800 \times (0.01)^2}{12 \times (0.1)^5} \times 1000$

$= 66.67$ *per km*

43. Ans. A.

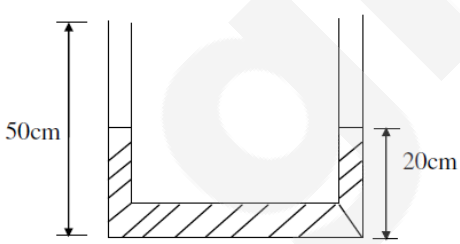
P - Le chattier test - soundness of OPC

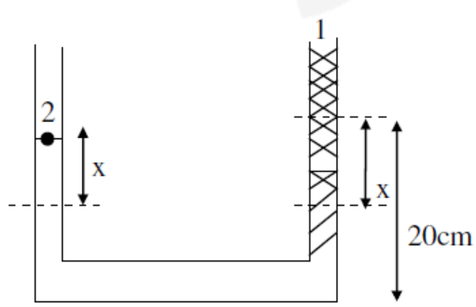
Q - Vee-Bee test — consistency or workability of concrete

R - Blaine air permeability test - Fineness of OPC

S - The vicat apparatus — consistency and setting time of OPC

44. Ans. C.




$50cm^3 0.5 \times 0.5 \times \ell$

$\ell$

$P_1 + (1000 \times 9.81 \times 0.2) - (13000 \times 9.81 \times 2x)$

$= P_2 P_1 = P_2$

$1000 \times 9.81 \times 0.2 = 13600 \times 9.81 \times 2x$

$x = \frac{100}{13600} = 7.35 \times 10^{-3} m = 0.735cm$

*New height* $= 20 + x = 20 + 0.735$

$= 20.735cm$

45. Ans. D.

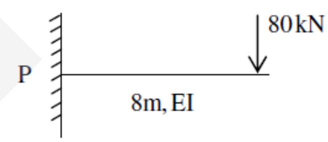
Total hardness as

$CaCo_3 = \left[Ca^{+2} \times \frac{50}{20}\right] + \left[Mg^{2+} \times \frac{50}{12.2}\right]$

$= \left[60 \times \frac{50}{20}\right] + \left[36.6 \times \frac{50}{12.2}\right]$

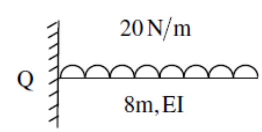
$= 150 + 150 = 300 mg/L$ *as* $CaCo_3$.

46. Ans. C.



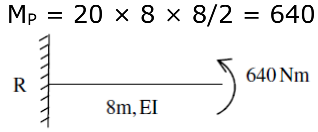

$S_P$ = 80 N

$M_P$ = 80 × 8 = 640 Nm




$S_Q$ = 20 × 8 = 160 N

$M_P$ = 20 × 8 × 8/2 = 640 Nm

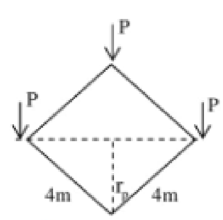



$S_R$ = 0

$M_R$ = 640 Nm

$S_P < S_Q > S_R$ $M_P = M_Q = M_R$

47. Ans. A.



$$r=\frac{4}{\sqrt{2}}=2\sqrt{2}=2.82$$

$$\sigma_x=4\times\frac{3Q}{2\pi z^2}\left[\frac{1}{1+\left(\frac{r}{z}\right)^2}\right]^{5/2}$$

$$=4\times\frac{3\times5000}{2\pi\times5^2}\left[\frac{1}{1+\left(\frac{2.82}{5}\right)^2}\right]^{5/2}$$

$$=191.36kPa$$

48. Ans. B.

$$y\ =L_o\ [1-e^{-K_pxt}]$$

$$\frac{y}{L_o}=\ 0.68$$

$$\frac{y}{L_o}=1-e^{-K_pxt}$$

$$0.68=1-e^{-K_px5}$$

$$e^{-K_px5}=1-0.68=0.32$$

$$K_D=0.2276\approx0.23/day$$

49. Ans. A.

The point bearing resistance of piles in sandy soils

$$Q_P=A_b.\sigma_v^{'}.N_q$$

As the area at base $(A_b)$

and $N_q$ are same for

both the piles given,

$$Q_P\ \infty\sigma_v^{'}$$

For dry sand condition,

$$\sigma_v^{'}=\sigma_v=20\times\gamma$$

For submerged condition,

$$\sigma_v^{'}=20\times\gamma^{'}$$

$$\text{Since,..}\gamma^{'}=\frac{\gamma}{2}$$

$$\therefore QP_2\approx0.5QP_1$$

$(\text{or})$ $QP_1\ >\ QP_2$ by about 100%

50. Ans. B.

For rice,

$$Duty\ =\ \frac{8.64B}{\Delta}=\frac{8.6\times150}{1.30}=996.923$$

$$Q=\frac{A}{D}=\frac{2500}{996.923}=\ 2.5077$$

*For wheat*

$$Q\ =\frac{A}{D}=Q.D=\ 2.5077\times\frac{8.64\times120}{0.5}=5200ha$$

51. Ans. B.

Dry weight = Total weight —M.C

| Component | % mass | M.C | Dry wt (%) | Energy content | Total Energy |
|---|---|---|---|---|---|
| Food Waste | 20 | 70 | 6 | 2500 | 50,000 |
| Paper | 10 | 4 | 9.6 | 10000 | 1,00,000 |
| Cardboard | 10 | 4 | 9.6 | 8000 | 80,000 |
| Plastics | 10 | 1 | 9.9 | 14000 | 140000 |
| Garden Trimmings | 40 | 60 | 16 | 3500 | 140000 |
| Wood | 5 | 20 | 4 | 14000 | 70000 |
| Tin Cans | 5 | 2 | 4.9 | 100 | 500 |
| | | | 60 | | 580500Kj |

Unit energy = $\frac{580500}{100}=5805\ kJ/kg$

Moisture content =100 —60 = 40%

Energy on dry basis

$$=\frac{100\ \times5805}{100-40}\ =9675\ kJ/kg$$

So, different of energy

$$=\ 9675-5805=3870\ kJ/kg$$

52. Ans. A.

given $y''-4y'+3y\ =2t-3t^2$

$$\Rightarrow\left(D^2-4D+3\right)y\ =\left(2t-3t^2\right)$$

By the definition of particular solution

$$y_p=\frac{1}{D^2-4D\ +\ 3}\left(2t-3t^2\right)$$

$$\Rightarrow(D^2-4D\ +\ 3)y_p=2t-3t^2$$

verifying options, option (a) satisfies,

$$\left(D^2-4D+3\right)\left(-2-2t-t^2\right)$$

$$=-2+8+8t-6\ \text{-}6t-3t2=2t-3t^2$$

∴ (A) is constant

<u>Alternate solution:</u>

Given

$$y''-4y'+3y\ =2t-3t^2$$

$$(D^2-4D\ +\ 3)y=2t-3t^2$$

Particular Solution =

$$y_p=\frac{1}{D^2-4D\ +\ 3}\left(2t-3t^2\right)$$

$$=\left[\frac{\frac{-1}{2}}{D-1}+\frac{\frac{1}{2}}{D-3}\right](2t-3t^2)$$

$$=\frac{1}{2}\left[\frac{1}{1-D}+\frac{1}{3-D}\right]2\left(t-\frac{3}{2}t^2\right)$$

$$=\left[(1-D)^{-1}-\frac{1}{3}\left(1-\frac{D}{3}\right)^{-1}\right]\left(t-\frac{3}{2}t^2\right)$$

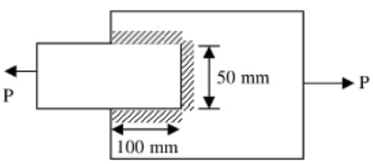
$$=(1+D+D^2+D^3+..)\left(t-\frac{3}{2}t^2\right)\frac{-1}{3}$$

$$\left(1+\frac{D}{3}+\frac{D^2}{9}+..\right)\left(t-\frac{3}{2}t^2\right)$$

$$\left[t-\frac{3}{2}t^2+1-3t-3\right]\frac{-1}{3}\left[t-\frac{3}{2}t^2+\frac{1-3t}{3}+\frac{1}{9}(-3)\right]$$

$$=-2-2t-\frac{3}{2}t^2-\frac{t}{2}+\frac{1}{2}t^2-\frac{1}{9}+\frac{t}{3}+\frac{1}{9}=-2-2t-t^2$$

53. Ans. A.



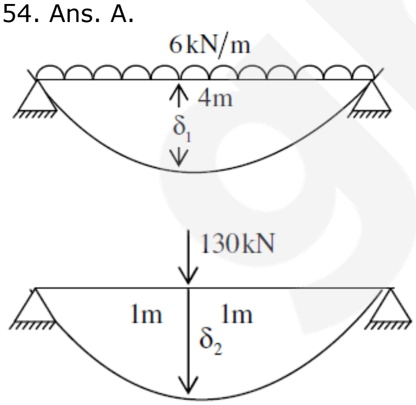

Maximum load taken by plate =150 x 50 x 8 = 60KN

$= k.s\ left.\tau$

Maximum load taken by weld = 0.7 x 6 x (100 +100 + 50) x 110 =115.5KN

So, permissible load = min. Of {60KN, 115.51CN} = 60KN

54. Ans. A.




$$\delta_1=\frac{5}{384}\frac{wL^4}{EI}=\frac{5}{384}\times\frac{6\times4^4}{1000}=\frac{1}{50}=0.02m$$

$$\delta_2=\frac{wL^4}{48EI}=\frac{130\times2^3}{48\times1000}=\frac{13}{600}=0.02m$$

$$\delta_2=\delta_1$$

55. Ans. A.

For Tower B,

Radial distance of top of tower, r = 6 cm Length of image, d=2 cm

Height of tower, $h_2$ =80 m

$\because \quad \frac{h_2}{\ \ -h_1}$

$$\Rightarrow H-h_1=\frac{r.h_2}{d}=\frac{6\times80}{2}=240m$$

For Tower A,

$\because \quad \frac{h_2}{\ \ -h_1}$

$r = 4cm,\ d=1.5\ cm,\ H-h_1=240\ m$

$\Rightarrow h_2=90\ m$

56. Ans. B.

Through means including every possible detail, parts or complete or absolute.

57. Ans. C.

In order to verify this propositions we have to turn to card 2 and blue from given 4 cards as proposition says it has even an one side opposite is red. Vice-verse might or might not be true so, answer (C) as all other options are eliminated.

58. Ans. B.

Required probability= $\frac{8}{36}=\frac{2}{9}$

59. Ans. B.

$$\frac{\left(\frac{16}{25}\right)^{x+2}}{\left(\frac{3}{5}\right)^{2x+4}}\times81=144$$

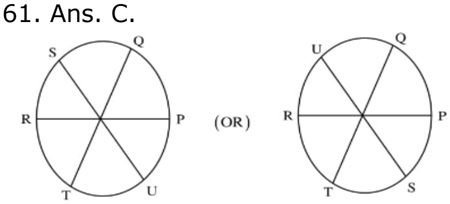
$$\Rightarrow\left(\frac{4}{3}\right)^{2x+4}\times81=144\Rightarrow\left(\frac{4}{3}\right)^{2x}.\frac{4^4}{3^4}\times81=144$$

$$\Rightarrow\left(\frac{4}{3}\right)^{2x}=\frac{9}{16}\Rightarrow x=-1$$

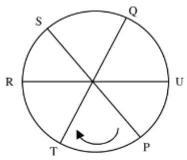
60. Ans. B.

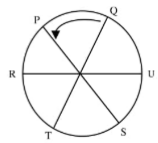
Conditional tense type (3 had+ third verb +would have + third verb)

61. Ans. C.




P <---> U Now, P & U switch seats; then there are 2 possibilities




62. Ans. A.
People coming out in the same order in which they enter indicates that the centre operates on a first come first serve basis.

63. Ans. C.
: "Kalimpong is at a lower elevation than Darjeeling" & "Siliguri is at a lower elevation than Gangtok" can be easily inferred from the given paragraphs.

64. Ans. D.
Let cycling speed=C; and walking speed=W

$$C\left(\frac{1}{2}\right)+W\left(\frac{3}{2}\right)=19....(1)$$

$$C+W=26.....(2)$$

On solving (1) & (2), we get W=6 km/hr

65. Ans. D.
(i). is incorrect as its has more directly.
(ii). is incorrect as it stayed for maximum duration on ground floor.

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