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ESE- 2020 (Prelims) - Offline Test Series Test- 5

CIVIL ENGINEERING

SUBJECT: GEOTECHNICAL ENGINEERING & TRANSPORTATION SOLUTIONS

01. Ans: (c)

Sol: e > 0 (void ratio)

$0 < n < 1$ (Porosity)

$0 \le S \le 1$ (Degree of saturation)

$w \ge 0$ (Water content)

02. Ans: (b)

Sol: e (natural) = 0.56

e_{max} (loosest) = 0.84

e_{min} (Densest) = ??

I_D = relative density = $\dfrac{e_{max} - e}{e_{max} - e_{min}} = 0.7$

$\Rightarrow \dfrac{0.84 - 0.56}{0.84 - e_{min}} = 0.7 \Rightarrow e_{min} = 0.44$

$\gamma_d(\text{densest state}) = \dfrac{G_s \gamma_w}{1 + e_{min}} = \dfrac{2.7 \times 10}{1 + 0.44}$

$= 18.75\ kN/m^3$

03. Ans: (c)

Sol: 1-Incorrect

I_f (flow index) and shear strength inversely related.

$2 - I_c$ (consistency) < 0

$I_c = \dfrac{W_L - W_N}{I_p} < 0 \Rightarrow W_L < W_N$

Soil is in liquid state correct.

3-Incorrect

Consistency limits are determined for soil passing 425 μ IS sieve .

04. Ans: (c)

Sol: K (Permeability) $\alpha \dfrac{1}{\mu(\text{vis cosity})}$

K α T (Temperature)

$K \propto \dfrac{1}{\text{Specific surface area}}$

Organic content decrease permeability

05. Ans: (d)

Sol: $\dfrac{aL}{At_1} \ell n \dfrac{8}{h} = \dfrac{aL}{At_2} \ell n \dfrac{h}{2}$

since soil sample is same a, L, A and K will be same

$\Rightarrow \dfrac{1}{3} \ell n \dfrac{8}{h} = \dfrac{1}{1.5} \ell n \dfrac{h}{2}$

$$\ell n\frac{8}{h} = 2\ell n\frac{h}{2}$$

$$\ell n\frac{8}{h} = \ell n\left(\frac{h}{2}\right)^2 \Rightarrow h^3 = 8 \times 4 = 32$$

$$h = 3.17 \text{ cm}$$

06. Ans: (d)

Sol:

1. Incorrect

   Space between two adjacent flow lines is known as flow channel.

2. Incorrect

   Flow nets are drawn for anisotropic soil after co-ordinate transformation.

3. Incorrect

   N_d = Number of potential drops

   = Number of equipotential lines –1

   = 7 –1 = 6

   $\Delta h = \frac{H}{Nd}$ = drop across two adjacent equipotential lines = $\frac{14}{6} = 2.33\,m$

07. Ans: (d)

Sol: $\frac{\Delta H}{H} = \frac{\Delta e}{1+e_o}$

e_o = initial void ratio

$\Delta e = e_1 - e_2$

$$\frac{c}{a} = \frac{e_1 - e_2}{1+e_1}$$

08. Ans: (a)

Sol: $\sigma_z = \frac{3Q}{2\pi z^2}$ $\left\{\left(\frac{r}{z}=0\right)\text{below point load}\right\}$

$$\approx 0.4775\frac{Q}{z^2}$$

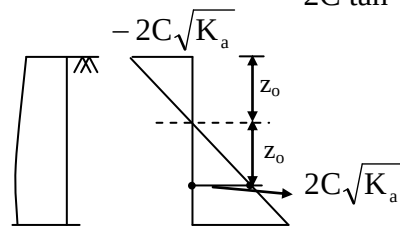
$$\sigma_z = 0.4775 \times \frac{50}{4}\text{kN/m}^2 \backsimeq 6 \text{ kN/m}^2$$

09. Ans: (b)

Sol: Safe depth of Unsupported cut or Critical depth $H_C = 2Zo$

Active Earth pressure = $2C\sqrt{K_a}$

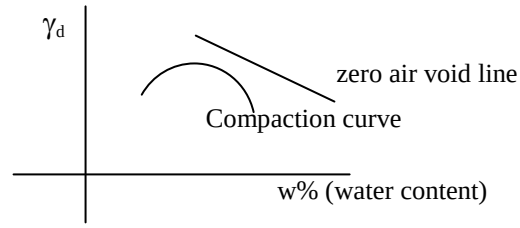
$$= 2C \tan\left(45 - \frac{\phi}{2}\right)$$



10. Ans: (b)

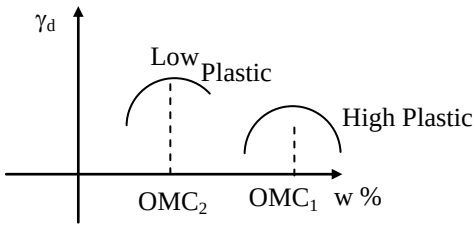
Sol:

1. True (Correct)



2. Incorrect, Drainage is considered only in vertical direction.

3. Correct



$OMC_1 > OMC_2$

11. Ans: (d)

Sol: After over burden correction

SPT value = $1.35 \times 20 = 27 > 15$

After Dilatancy correction

$$\text{SPT Value} = 15 + \frac{27-15}{2} = 15 + 6 = 21$$

12. Ans: (b)

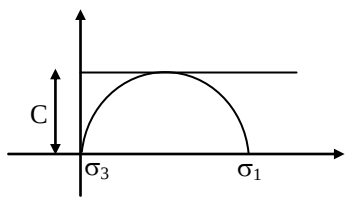
Sol: Degree of consolidation

$$U = \frac{\bar{u}_i - \bar{u}}{\bar{u}_i}$$

$$U = \frac{50-20}{50} = \frac{30}{50} = 0.6 \text{ or } 60\%$$

13. Ans: (d)

Sol: In Unconfined compression test



C ell pressure = $0 \Rightarrow \sigma_3 = 0$

$\sigma_1 - \sigma_3 = \sigma_1 - 0 = \sigma_1$

Deviator stress = Major principal stress

C = Cohesion $\neq 0$

14. Ans: (d)

15. Ans: (d)

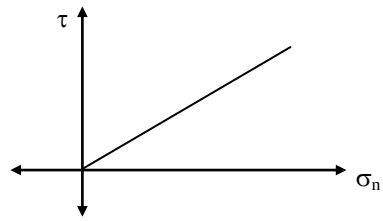
Sol: Wall yield towards soil

Passive earth pressure develops

$$`K_p = \frac{1+\sin\phi}{1-\sin\phi} = \frac{1+\sin 30}{1-\sin 30} = \frac{1+0.5}{1-0.5} = 3$$

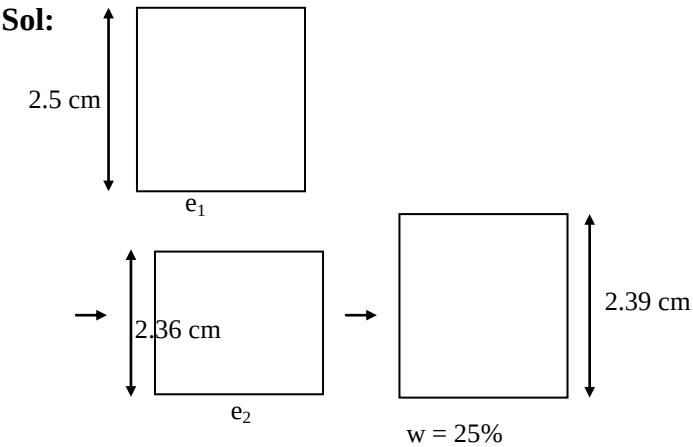
16. Ans: (b)

Sol: CD test on NC clay



17. Ans: (b)

Sol:



w = 25%

$e_3 = wG_s$

$= 0.25 \times 2.72$

$= 0.68$

$$\frac{\Delta H}{H_f} = \frac{\Delta e}{1+e_f}$$

$$\frac{2.39-2.36}{2.39} = \frac{\Delta e}{1+e_3} = \frac{\Delta e}{1.68}$$

$\Delta e = 0.02 = e_3 - e_2$

$e_2 = e_3 - 0.02 = 0.68 - 0.02 = 0.66$

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18. Ans: (c)

Sol: $\frac{G_s - 1}{G_s} = \left(\frac{\gamma_{sub}}{\gamma_d}\right) = 0.63$

$S = 1$

$Se = WG$

$e = 2.7 \times 0.2 = 0.54$

$\Rightarrow G_s = 2.7$

$\gamma_{sat} = \left(\frac{G_s + e}{1+e}\right)\gamma_w$

$= \left(\frac{2.7 + 0.54}{1 + 0.54}\right) \times 1 = 2.1 g/cc$

19. Ans: (c)

Sol:

1. N_c, N_γ, N_q only dependent on ϕ, (incorrect)
2. Correct
3. Correct

20. Ans: (b)

Sol: Granular soil $C = 0$

(Sand)

$q_u = q\,N_q + 0.5\left(1 - 0.2\frac{B}{L}\right)N_\gamma \gamma \times B$

$\Rightarrow q_u = (2 \times 18)33 + 0.5\left(1 - 0.2 \times \frac{3}{6}\right)40 \times 18 \times 3$

$= 2160\ kN/m^2$

21. Ans: (a)

Sol: $K_a = \frac{1 - \sin 30°}{1 + \sin 30°} = \frac{1 - 0.5}{1 + 0.5} = \frac{1}{3}$

$H = 6$

$\gamma = 20\ kN/m^3$

Moment $= \left(\frac{1}{2}K_a \gamma H^2\right)\frac{H}{3}$

$= \frac{1}{6}K_a \gamma H^3 = \frac{1}{6} \times \frac{1}{3} \times 20 \times 6^3$

$= 240\ kNm/m$

22. Ans: (b)

Sol: Bulb diameter = 2.5 shaft diameter

23. Ans: (b)

Sol: Liquid limit (w_L) decreases

Plastic limit (w_P) increases

I_P (Plasticity Index) $= w_L - w_P$ decreases

24. Ans: (c)

Sol: $\left.\begin{matrix}\text{Gravel} = 200\ g \\ \text{Sand} = 100\ g\end{matrix}\right]$ coarse $= 300\ g$

Fine = 200 g

It is coarse grained and gravel (G)

Since silt (M) is more, soil is GM.

25. Ans: (b)

Sol: $Q_u = \frac{WH}{(S + C)}$

C = 2.5 cm = 25 mm for drop hammer

$1700 = \frac{50 \times 100}{(S + C)}$

$S + C = 2.94$ cm

$S = 2.94 - 2.5 = 0.44$ cm

S = Penetration per blow

For 5 blows Penetration = $0.44 \times 5 = 2.2$ cm

$= 22$ mm

26. Ans: (c)

Sol: $\frac{\sigma_1}{\sigma_3} = 4 \Rightarrow \sigma_1 = 4\sigma_3 = 4\times150 = 600$ kPa

Clayey soil $\Rightarrow \phi = 0$

$\sigma_1 = \sigma_3 \tan^2 45° + 2C \tan 45°$

$\Rightarrow 600 = 150 + 2C \Rightarrow 2C = 450$ kPa

When $\sigma_1 = 750$

$750 = \sigma_3 + 2C \Rightarrow \sigma_3 = 750 - 450 = 300$ kPa

$\sigma_1 - \sigma_3 = 750 - 300 = 2C = 450$ kPa

27. Ans: (a)

Sol:

1. Correct
2. Rankine theory assumes that retaining wall back is smooth and vertical - incorrect
3. Passive > Active > Rest (zero yield)
4. Incorrect

Bridge abutment designed for earth pressure at rest.

28. Ans: (a)

Sol: $Se = WG_s$

$S = 1$

$e = 0.35 \times 2.7 = 0.945$

Critical hydraulic gradient

$$i_c = \frac{G_s - 1}{1+e} = \frac{2.7-1}{1.945} = 0.874$$

FOS (Piping) $= \frac{i_c}{i} \Rightarrow i = \frac{i_c}{FOS} = \frac{0.874}{2.5}$

$= 0.35$

29. Ans: (c)

Sol: Colluvial - Gravity

Loess (Aeolian Soil) - wind

Lacustrine - deposited at bottom of lake

Alluvial - Running water (river)

30. Ans: (b)

Sol: Area ratio $= \frac{\frac{\pi}{4}d_o^2 - \frac{\pi}{4}d_i^2}{\frac{\pi}{4}d_i^2} = \frac{d_o^2 - d_i^2}{d_i^2} = 0.44$

$\Rightarrow \frac{d_o^2 - 50^2}{50^2} = 0.44$

$\Rightarrow d_o = 60$ mm (outer diameter)

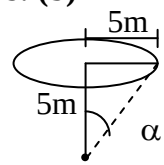
Outer radii = 30 mm (b)

31. Ans: (c)

Sol: Imaginary condition.

32. Ans: (b)

Sol:



$\alpha = 45° = \tan^{-1}\frac{5}{5} = \tan^{-1}1$

$\sigma_z = q(1 - \cos^3\alpha)$

$= \frac{5\times10^4}{\left(\frac{\pi}{4}\times10^2\right)}\left[1 - \cos^3 45\right] = 412\ \text{kN/m}^2$

33. Ans: (b)

Sol: r = 3 m

z = 5 m

$\frac{r}{z} = 0.6 < 1.52$

σ_z(Boussinesq) > σ_z (Westergaard)

34. Ans: (a)

Sol:

A	H	32K
B	H	8K
C	H	K

$$K_H = \frac{\sum K_i H_i}{\sum H_i} = \frac{KH + 8KH + 32KH}{3H} = \frac{41}{3}K$$

$$K_v = \frac{\sum H_i}{\sum \frac{H_i}{K_i}} = \frac{3H}{\frac{H}{K} + \frac{H}{8K} + \frac{H}{32K}}$$

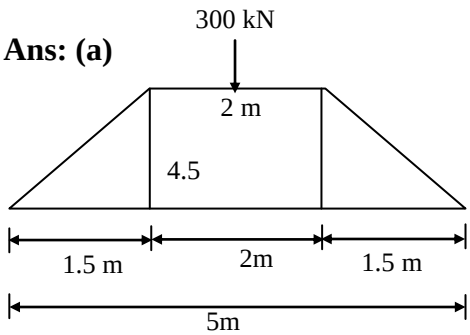
$$= \frac{3K}{\frac{1}{32}[32+4+1]} = \frac{3\times 32}{37}K = \frac{96K}{37}$$

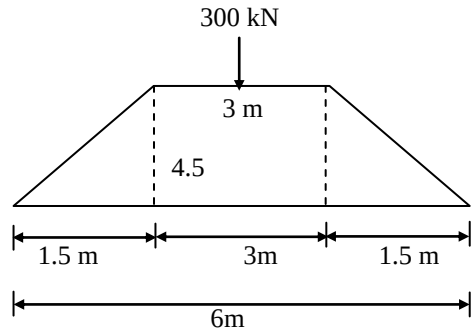
$$\frac{K_H}{K_V} = \frac{\left(\frac{41K}{3}\right)}{\left(\frac{96K}{37}\right)} = \frac{41\times 37}{3\times 96} = 5.3$$

35. Ans: (c)

36. Ans: (a)

Sol:

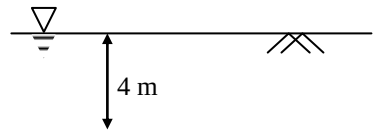




$$\sigma_z = \frac{300}{5\times 6} = 10\,kN/m^2$$

37. Ans: (a)

Sol: Before:

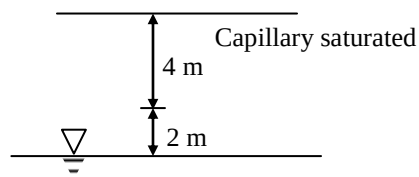


$\overline{\sigma} = \gamma_{sat} \times 4 - \gamma_W \times 4$

$= (18.6 - 10) \times 4$

$= 34\ kN/m^2$

After



$\overline{\sigma} = \gamma_{sat} \times 4 - (-\gamma_w \times 2)$

$= 18.5\times 4 + 10 \times 2$

$= 94\ kN/m^2$

Change = 94 – 34 = 60 kN/m^2

(or)

change = $6\gamma_w = 60\ kN/m^2$

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38. Ans: (c)

Sol:

- In saturation system, the best layout is chosen from the proposal that yields maximum utility per unit length. Hence all the road proposals need not have same length.
- This method is used to find the best layout from the alternate proposals and also to phase the road development plan.
- Population units depend on the population count i.e

< 500	unit : 0.25
501 to 1000	unit: 0.5 etc

39. Ans: (b)

Sol: In alignment of hilly roads

- More number of hill drains are preferred to provide adequate drainage to the roads.
- Since the construction of cross drainage structure is not economical, its number should be kept minimum
- Resisting length is the effective length considering the total work done against resistance. i.e ineffective rise and fall should be kept minimum. Hence resisting length has to be minimum.

40. Ans: (c)

Sol: Barrier kerbs prevent the vehicle from leaving the pavement and entering into shoulder.

Note:

Vehicles can cross the pavement when Low kerbs and semi barrier kerbs are provided.

41. Ans: D

Sol:

- Coefficient of friction decreases with increase in temperature.
- Type of aggregates used in surface course affects the skid resistance of the pavement.
- Friction coefficient decreases with skid speed which depends on speed of vehicle and brake efficiency.

42. Ans: (b)

Sol: For a parabolic camber: $y = \frac{2x^2}{nW}$

In the region of heavy rainfall with thin bituminous surface, camber is 1 in 40

Height of crown

$y = \frac{2 \times 3.5^2}{40 \times 7}$ = 0.0875m = 8.75 cm

In the region of heavy rainfall with CC surface, camber is 1 in 50

Height of crown $y = \frac{2 \times 3.5^2}{50 \times 7} = 0.07\text{m} = 7\text{m}$

Difference in camber = 7-8.75= -1.75cm

43. Ans: (b)

Sol: Absolute minimum sight distance is the stopping sight distance

Stopping sight distance = $vt + \frac{v^2}{2g(f \pm 0.01n)}$

Hence it is maximum for roads with down gradient.

On a two way road , minimum stopping sight distance is 2xSSD. Hence the critical case is for a two way road with down gradient.

44. Ans: (c)

Sol: As per IRC specification, ruling design speed (kmph) = minimum design speed (kmph) + 16

i.e V = 84 + 16 = 100kmph

For plain terrain e = 0.07 and f = 0.15

Ruling minimum radius of curve

$$= \frac{V^2}{127(e+f)}$$

Substituting the values $R_{rul,\,min}$ = 358m

45. Ans: (a)

Sol: Deviation angle $N = -\left(\frac{1}{25}\right) - \frac{1}{25} = -0.08$

Equation of valley curve : $y = kx^3$

$k = \frac{2N}{3\ell^2}$; N = 0.08, L =200m

Substituting the values $k = 1.33 \times 10^{-6}$

46. Ans : (c)

Sol: Centre to centre distance between the vehicles = 6.5+1.5 = 8m

Jam density = $\frac{1000}{8}$ = 125 veh/lane

Maximum flow = $\frac{100 \times 125}{4}$

= 3125 veh/hr/lane

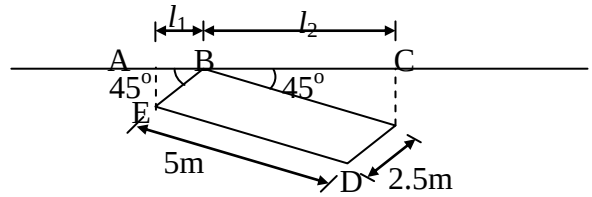
On a 2 lane one way road: maximum flow = 2×3125 = 6250veh/hr

47. Ans: (c)

Sol: In simple progressive system , various signal phases, in a given stretch give green indications in accordance with time schedule to allow continuous operation of vehicles at a planned speed. The phases and intervals at each signal may be different but each signal unit works as a fixed time signal with equal signal cycle length.

48. Ans: (c)

Sol: For a 45^o parking



Length of parking required = L = $l_1 + l_2$

l_1 = BE sin 45^o

$= \frac{2.5}{\sqrt{2}}$

l_2 = DE cos 45 = $\frac{5}{\sqrt{2}}$

$\therefore$ L = $l_1 + l_2 = \frac{7.5}{\sqrt{2}} = 5.3$ m

49. Ans: (b)

Sol: Minimum weaving length in a rotary is 4 times the width of weaving section.

50. Ans: (a)

Sol: Both capacity and volume measure the traffic flow. However, volume represents the actual rate of flow corresponding to the variations in traffic demand. Capacity corresponds to the maximum flow at certain level of service.

51. Ans: (d)

Sol: Effective green time = actual green time + yellow time – lost time

= 28 + 4 – 3 = 29 sec

52. Ans: (b)

Sol: Accident records are maintained by location files, spot maps, condition diagram and collision diagram etc,

53. Ans: (a)

Sol: In the traffic planning process, the following stages are involved:

- **Inventory:** Collect information related to travel characteristics, transportation facilities, land use etc
- Trip generation : Estimate the number of trips produced in a zone
- Trip distribution: Distribute the trips generated in each zone to any other zone
- Model split: Determine the proportion of trips shared between private and public transportation system
- Traffic assignment
- Plan preparation.

54. Ans: (d)

Sol: Bituminous materials are used in road construction due to its excellent binding properties, water proof characteristics, durability and relatively low cost.

55. Ans: (c)

Sol: Aggregate crushing value

= 100 × weight of the material passing through 2.36 mm sieve/total weight of the aggregate.

56. Ans: (c)

Sol: Bitumen content = 9%. Hence aggregates

= 91%

$$\frac{100}{G_{th}} = \frac{W_{agg}}{G_{agg}} + \frac{W_{bit}}{G_{bit}}$$

$$\frac{100}{G_{th}} = \frac{91}{2.6} + \frac{9}{1}$$

Theoretical specific gravity = 2.27

Air voids = $\frac{G_{th} - G_{act}}{G_{th}} \times 100$

$3 = (2.27 - G_{act}) \times \frac{100}{2.27}$

$G_{act} = 2.201$

57. Ans: (b)

Sol: Cutback bitumens are of three types

(a) Rapid Curing (RC)

(b) Medium curing (MC)

(c) Slow curing (SC)

Cutback bitumen is designated with rate of curing and a numeral beside it ranging from 0 to 5. Ex: MC-3

0 indicates lowest viscosity and 5 indicates highest viscosity. Hence MC-5 has highest viscosity.

58. Ans: (b)

Sol: Rigidity factor is the ratio of contact pressure to tyre pressure. If the tyre pressure is 7kg/cm^2, the rigidity factor is 1. If it is more than 7kg/cm^2, then rigidity factor is less than 1.

59. Ans: (d)

Sol: For a rigid plate:

Deflection = $1.18pa/E_s$

$0.5 = 1.18 \times 1.25 \times 15/ E_s$

$E_s = 44.25 kg/cm^2$

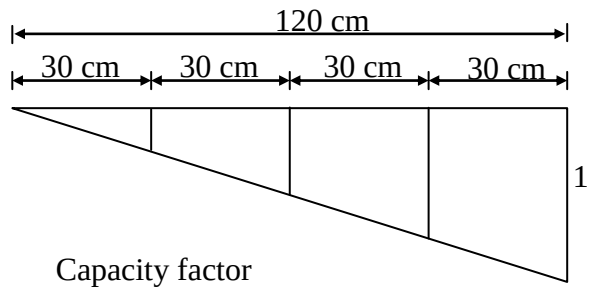
60. Ans: (a)

Sol: $\frac{a}{h} = \frac{28}{15} = 1.8667$

if a >1.724h, then equivalent radius of resisting section = a = 28cm

61. Ans: (b)

Sol: The dowel bars are effective in load transfer for a distance of 1.5 times of radius of relative stiffness. Assuming linear variation , the capacity factor for single dowel bar is 1 under the load and zero at a distance of 1.5L = 1.5 x 80 = 120cm.



Capacity factor

$= 1 + \frac{120-30}{120} + \frac{120-60}{120} + \frac{120-90}{120} + \frac{120-120}{120}$

$= 2.5$

62. Ans: (a)

Sol: Shear failure is due to excessive loading or inadequate shear strength

Frost heaving is localized heaving based on ground water and climatic conditions.

Alligator cracking is observed in flexible pavements due to relative movement of pavement layers.

Shrinkage cracks develop because of curing in cement concrete pavements.

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ESE 2020/2021
General Studies &
Engineering Aptitude

GATE 2020/2021
Computer Science &
Information Technology

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63. Ans: (b)

Sol: Minimum grade of concrete for prestressed sleepers is M50. During derailment, concrete sleepers are heavily damaged.

Since concrete sleepers are poor conductors of electricity, they are suitable for track circuiting.

64. Ans: (c)

Sol: Hangar is a building where maintenance and repair of aircraft is carried out.

65. Ans: (c)

Sol: Length of the transition curve is maximum of

(a) 7.2e = 7.2*15 = 108m

(b) $0.073eV_{max} = 0.073 \times 15 \times 80 = 87.6m$

(c) $0.073DV_{max} = 0.073 \times 7.5 \times 80 = 43.8m$

e is the actual superelevation in cm, D is cant deficiency in cm. For BG track maximum value of D is 7.5cm.

66. Ans: (b)

Sol: Needle beam method is used for soft soils

67. Ans: (d)

Sol: Setting out of tunnel is the marking of centerline or alignment .

It involves:

(a) Setting out tunnel on ground surface

(b) Transfer of centerline from surface to underground

(c) Underground setting out

(d) Underground levelling

68. Ans: (c)

Sol: As per IRC maximum spacing of contraction joints in reinforced CC pavements is 14 m and in unreinforced CC pavements is 4.5 m.

69. Ans: D

Sol: In case of a hump, the problem of sight distance does not arise as it is a relatively small summit but sharp. In this case, the main criteria is discomfort to passengers , hence the suitable curve is transition curve on either side of the hump with a level strip in between.

70. Ans: (a)

Sol: Due to the presence of different classes of vehicles, evaluating the characteristics of mixed traffic flow is difficult. Hence the vehicles of a particular class are converted to one common unit called as passenger car unit. PCU is a measure of relative space requirement of a vehicle class relative to that of a standard passenger cars under similar conditions.

Hence PCU of a vehicle is the ratio of capacity of roadway when there are only passenger cars to the capacity of similar roadway when there are vehicles of that vehicle class only.

71. Ans: (d)

Sol: Super elevation to be provided on a railway track depends on maximum speed, average speed and radius of the curve.

72. Ans: (c)

Sol: Seal coat is used to seal the top of the asphalt, preventing water from penetrating the surface of the pavement and protecting the top layer of asphalt from oxidation and wear caused by exposure to the sun and air.

It also seals the small cracks that can turn into large cracks and prevents water from seeping down to the base material. Hence it is used in pavements which are not impervious.

73. Ans: (c)

Sol: Statement I correct (True)

Flat portion indicates gap gradation (a range of particle sizes missing) statement II incorrect (false).

74. Ans: (b)

Sol: Both are correct but no co-relation.

75. Ans: (a)

Sol: There won't be sufficient time for water to drain out. So undrained conditions are applied.