CLASS TEST

S.No. : 02_IG_CE_A+C_040523

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HIGHWAY ENGINEERING

CIVIL ENGINEERING

Date of Test : 04/05/2023

ANSWER KEY

1.	(d)	7.	(c)	13.	(a)	19.	(c)	25.	(a)
2.	(a)	8.	(b)	14.	(b)	20.	(b)	26.	(a)
3.	(d)	9.	(a)	15.	(a)	21.	(a)	27.	(a)
4.	(d)	10.	(b)	16.	(b)	22.	(d)	28.	(c)
5.	(c)	11.	(a)	17.	(b)	23.	(c)	29.	(c)
6.	(c)	12.	(b)	18.	(a)	24.	(c)	30.	(c)

DETAILED EXPLANATIONS

1. (d)

Flexible progressive system: In the system it is possible to vary cycle length, cycle division and the time schedule at each intersection with the help of a computer.

Note:

Simultaneous system: All signals along the given road show some indications at same time.

Alternate system: Alternate signals show opposite indication along the route at same time. It is more satisfactory then simultaneous system.

Simple progressive system: A time schedule is made to permit as nearly as possible a continuous operation of group of vehicles along the main road at a reasonable speed.

2. (a)

Viscosity test: Viscosity is the general term for consistency and it is a measure of resistance of flow.

Ductility test: Used to measure the adhesiveness or elasticity of bitumen.

Penetration test: Determine hardness or softness of bitumen.

Softening point test: It is the temperature at which the substance attains a particular degree of softening under specified conditions of test.

3. (d)

$$R_{\text{ruling}} = \frac{V^2}{127(e+f)} = \frac{80^2}{127(0.07+0.13)}$$

$$= 251.97 \simeq 252 \text{ m}$$

4. (d)

$$\text{Jam density} = \frac{1000}{\text{Space headway}}$$

$$= \frac{1000}{8} = 125 \text{ veh/km}$$

$$\text{Maximum flow} = \frac{\text{Jam density} \times \text{Free speed}}{4}$$

$$= \frac{125 \times 70}{4}$$

$$= 2187.5 \simeq 2187 \text{ vph}$$

5. (c)

The spacing of expansion joint is given by

$$L_e = \frac{\delta'}{\alpha(T_2 - T_1)}$$

Given, $$\delta' = \frac{\text{Width of expansion joint}}{2} = \frac{2}{2} = 1 \text{ cm}$$

$$\therefore \quad L_e = \frac{1}{100 \times 10 \times 10^{-6}(50-20)}$$

$$= \frac{1}{100 \times 10 \times 10^{-6} \times 30} = 33.33 \text{ m}$$

6. (c)

Space headway, $S = 45t - 45t^2$

$$\therefore \quad \frac{dS}{dt} = 45 - 90t = 0$$

$$\Rightarrow \quad t = 0.5 \text{ hr} = 30 \text{ minutes}$$

$$\frac{d^2S}{dt^2} = -90 < 0$$

Thus t = 30 min will give maximum headway.

∴ Maximum space headway,

$$S_{max} = 45 \times 0.5 - 45 \times (0.5)^2 = 11.25 \text{ km}$$

7. (c)

Summit curve: Summit curves are vertical curves with convexity upward, the design of a summit curve is governed by consideration of sight distance.

8. (b)

$$\text{Running speed} = \frac{3.5}{(6-1.5)} \times 60 = 46.67 \text{ kmph}$$

9. (a)

10. (b)

As per IRC total number of volume about 3000 veh/hr can be considered as the upper limiting case and a volume of 500 veh/hr is the lower limit.

11. (a)

$$L = \left[0.278V_2t + (0.278V_2t_0 + 2S) + 0.278Vt_0\right] \quad \text{...(i)}$$

In this problem,

$$V_2 = 65 - 15 = 50 \text{ kmph}$$

$$t = 2 \text{ sec}$$

$$V = 65 \text{ kmph}$$

$$S = (0.2 \times 50 + 6) = 16 \text{ m}$$

$$t_0 = \sqrt{\frac{4 \times S}{a}} = \sqrt{\frac{4 \times 16}{3.28 \times \frac{5}{18}}} = 8.38 \text{ sec}$$

Substituting in (i),

$$L = [0.278 \times 50 \times 2 + (0.278 \times 50 \times 8.38 + 2 \times 16) + 0.278 \times 65 \times 8.38]$$

$$= 327.8 \text{ m} \simeq 328 \text{ m}$$

So, the nearest answer is option (a).

12. (b)

$$L_c = 1200 \text{ m, SSD} = 250 \text{ m, } R = 350 \text{ m}$$

$\because$ $$L_c > \text{SSD}$$

$\Rightarrow$ $$\alpha = \frac{SSD}{(R-d)} \times \frac{180°}{\pi}$$

$\therefore$ $$\left(\frac{\alpha}{2}\right) = \frac{250 \times 180}{2\pi\left[350 - \left(3.5 + \frac{3.5}{2}\right)\right]} = 20.77°$$

$\therefore$ Set-back distance,

$$m = R - (R-d)\cos\frac{\alpha}{2}$$

$$= 350 - \left(350 - 3.5 - \frac{3.5}{2}\right)\cos 20.77°$$

$$= 27.65 \text{ m} \qquad \text{(from center line)}$$

$\therefore$ Distance from inner edge to obstruction = 27.65 – 7 = 20.65 m

13. (a)

Spacing between contraction joint is given by

$$L_C = \frac{2S_c}{wf} \times 10^4 = \frac{2 \times 0.8 \times 10^4}{2400 \times 1.5} = 4.44 \text{ m}$$

14. (b)

Amber time = 4 s; Reaction time = 1 s; Braking time = 4 – 1 = 3s

Now using, $$v = u + at$$

$\Rightarrow$ $$0 = u + at$$

$\Rightarrow$ $$a = -\frac{u}{t}$$

But $$u = 40 \text{ kmph} = \frac{40}{3.6} = 11.11 \text{ m/s}$$

$\therefore$ $$a = -\frac{11.11}{3} = -3.704 \text{ m/s}^2$$ (negative sign implies de-acceleration)

Using, $$F = ma$$

$\Rightarrow$ $$Wf = \frac{Wa}{g}$$

$\Rightarrow$ $$f = \frac{a}{g} = \frac{3.704}{9.81} = 0.378$$

15. (a)

$$y_N = \frac{q_N}{S_n} = \frac{900}{2500} = 0.36$$

$$y_S = \frac{q_S}{S_S} = \frac{500}{2000} = 0.25$$

$\therefore$ Maximum value of $\frac{q}{S}$ in N-S direction = 0.36

$$y_E = \frac{q_E}{S_E} = \frac{800}{3200} = 0.25$$

$$y_W = \frac{q_W}{S_W} = \frac{1000}{3000} = 0.33$$

$\therefore$ Max value of $\frac{q}{S}$ in E-V direction = 0.33.

Total lost time = 4 × 2 = 8 sec

$$C_0 = \frac{1.5L+5}{1-Y} = \frac{1.5\times 8+5}{1-(0.36+0.33)} = 54.84 \text{ sec}$$

16. (b)

17. (b)

The cumulative number of standard axle load,

$$N_S = \frac{365ADF\left[\left(1+\frac{r}{100}\right)^n - 1\right]}{\frac{r}{100}}$$

$\Rightarrow$

$$N_S = \frac{365\times 1250\times 0.5\times 3\left[\left(1+\frac{8}{100}\right)^{10} - 1\right]}{\frac{8}{100}}$$

$$= 9.91 \text{ msa}$$

18. (a)

Speed range (m/s)	Average speed (V_i) (m/s)	Volume of flow (q_i)	$V_i q_i$	q_i/V_i
6 - 10	8	2	16	0.25
11 - 15	13	1	13	0.077
16 - 20	18	4	72	0.22
21 - 25	23	0	0	0
26 - 30	28	5	140	0.179
		$\Sigma q_i = 12$	$\Sigma V_i q_i = 241$	$\Sigma q_i/V_i = 0.726$

$$\text{Space mean speed} = \frac{\Sigma q_i}{\Sigma\left(\frac{q_i}{V_i}\right)} = \frac{12}{0.726} = 16.53 \text{ m/s}$$

$$\text{Time mean speed} = \frac{\Sigma q_i V_i}{\Sigma(q_i)} = \frac{241}{12} = 20.08 \text{ m/s}$$

19. (c)

For soil sample,

$$\text{Group index, G.I.} = 0.2a + \frac{0.2}{40}ac + \frac{0.2}{20}bd$$

a = (% passing through 75 μ sieve) – 35
b = (% passing through 75 μ sieve) – 15
c = (Liquid limit)% – 40
d = (Plasticity index)% – 10

$$a = 60 - 35 = 25\% \text{ but } \ngtr 40\%$$
$$\Rightarrow \quad a = 25\%$$
$$b = 60 - 15 = 45\% \text{ but } \ngtr 40\%$$
$$\Rightarrow \quad b = 40\%$$
$$c = 40 - 40 = 0\% \text{ but } \ngtr 20\%$$
$$\Rightarrow \quad c = 0\%$$
$$d = (40 - 15) - 10 = 15\% \text{ but } \ngtr 20\%$$
$$\Rightarrow \quad d = 15\%$$
$$\therefore \quad \text{G.I.} = 0.2 \times 25 + \frac{0.2}{40} \times 25 \times 0 + \frac{0.2}{20} \times 40 \times 15$$
$$= 11$$

20. **(b)**

We know,

Radius of relative stiffness, $l = \left[\dfrac{Eh^3}{12k\left(1-\mu^2\right)}\right]^{1/4}$

l = Radius of relative stiffness, cm
E = Modulus of elasticity of cement concrete, kg/cm^2 = 3 × 10^5 kg/cm^2
h = Slab thickness, cm = 20 cm
k = Modulus of subgrade reaction = 0.375 kg/cm^2/deflection

$$= \frac{0.375}{0.125} = 3 \text{ kg/cm}^3$$

$$\therefore \quad l = \left[\frac{3 \times 10^5 \times 20^3}{12 \times 3 \times \left(1 - 0.15^2\right)}\right]^{1/4} = 90.88 \text{ cm}$$

∴ Radius of relative stiffness is 90.88 cm.

21. **(a)**

Effective green time = Green time + Amber time – Startup loss – Clearance time
= 27 + 3.5 – 2.5 – 1.5 = 26.5 second

$$\text{Saturation flow} = \frac{3600}{\text{Saturation time headway}}$$
$$= \frac{3600}{2.5} = 1440 \text{ veh/hr}$$
$$\text{Actual capacity} = \text{Saturation flow} \times \frac{\text{Effective green time}}{\text{Cycle time}}$$
$$= 1440 \times \frac{26.5}{60} = 636 \text{ veh/hr}$$

22. (d)

Theoretical specific gravity, G_t

$$= \frac{w_1 + w_2 + w_3 + w_4}{\frac{w_1}{G_1} + \frac{w_2}{G_2} + \frac{w_3}{G_3} + \frac{w_4}{G_b}}$$

$$= \frac{45 + 40.8 + 4.2 + 10}{\frac{45}{2.65} + \frac{40.8}{2.72} + \frac{4.2}{2.60} + \frac{10}{1.10}}$$

$$= 2.34$$

Effective specific gravity of aggregates (coarse + fine) is given by

$$G' = \frac{(45 \times 2.65) + (40.8 \times 2.72)}{45 + 40.8}$$

$$= 2.68$$

23. (c)

$$N_{S_1} = \frac{365 A_1 \left[(1+r)^n - 1\right]}{r} \times F$$

$$= \frac{365 \times 1800 \left[\left(1 + \frac{8}{100}\right)^{12} - 1\right]}{\frac{8}{100} \times 10^6} \times 4$$

$$= 49.87 \text{ msa}$$

$$N_{S_2} = \frac{365 A_2 \left[(1+r)^n - 1\right]}{r} \times F_2$$

$$= \frac{365 \times 300 \left[(1 + 0.08)^{12} - 1\right]}{0.08 \times 10^6} \times 7$$

$$= 14.55$$

$\therefore$ $$N_s = N_{S_1} + N_{S_2}$$

$$= 49.87 + 14.55$$

$$= 64.42 \text{ msa}$$

24. (c)

If α is the rate of change of radial acceleration, the radial acceleration (a) attained during the time the vehicle passes over the transition curve is given by

$$a = \alpha t = \alpha \times \frac{L}{V}$$

Radial acceleration, $$a = \frac{V^2}{R}$$

$\therefore$ $$\alpha \times \frac{L}{V} = \frac{V^2}{R}$$

$$\Rightarrow \qquad L = \frac{V^3}{\alpha R}$$

$$\Rightarrow \qquad L = \frac{\left(\frac{45 \times 1000}{60 \times 60}\right)^3}{0.25 \times 240}$$

$$= 32.55 \text{ m}$$

25. (a)

Condition for the prevention of overturning and sliding is

$$\frac{V^2}{gR} < \min\begin{cases}\frac{b}{2h}\\ f\end{cases}$$

$$\frac{b}{2h} = \frac{0.8}{2 \times 0.6} = 0.67$$

$$f = \frac{F}{N} = \frac{5}{40} = 0.125$$

So, $$\frac{V^2}{gR} = 0.125$$

$$\Rightarrow \qquad V^2 = 0.125 \times 250 \times 9.81$$

$$\Rightarrow \qquad V^2 = 306.5625$$

$$\Rightarrow \qquad V = 17.51 \text{ m/s}$$

$$\Rightarrow \qquad V = 63.04 \text{ kmph}$$

26. (a)

$$\frac{\log(ESWL) - \log(P)}{\log(2P) - \log(ESWL)} = \frac{\log Z - \log \frac{d}{2}}{\log 2S - \log Z} \qquad \text{...(i)}$$

Here, ESWL = 62 kN

P = 35 kN

Z = 30 cm

S = 20 cm

d = ?

Substitute all the values in eq. (i)

$$\frac{\log 62 - \log 35}{\log 70 - \log 62} = \frac{\log 30 - \log \frac{d}{2}}{\log 40 - \log 30}$$

$$\Rightarrow \qquad d = 15.47 \text{ cm}$$

27. (a)

Radius of relative stiffness, $$l = \left[\frac{Eh^3}{12K(1-\mu^2)}\right]^{1/4}$$

$$\Rightarrow \quad l = \left[\frac{2.8 \times 10^5 \times 30^3}{12 \times 8 \times (1 - 0.15^2)}\right]^{1/4}$$

($\because$ $K = 8 \times 10^6$ kg/m^3 = 8 kg/cm^3)

$$\Rightarrow \quad l = 94.74 \text{ cm}$$

Warping stress at corner is given by

$$S_{tc} = \frac{E\alpha T}{3(1-\mu)}\sqrt{\frac{a}{l}}$$

$$P = \pi a^2 p$$

$$\Rightarrow \quad 4000 = \pi a^2 \times 5$$

$$\Rightarrow \quad a = 15.96 \text{ cm}$$

$$S_{tc} = \frac{2.8 \times 10^5 \times 10 \times 10^{-6} \times 12}{3(1-0.15)}\sqrt{\frac{15.96}{94.74}}$$

$$= 5.41 \text{ kg/cm}^2$$

28. (c)

$$\text{SSD} = 0.278Vt + \frac{V^2}{254(f \pm n)}$$

For a vehicle on ascending gradient

$$\text{SSD}_1 = 278Vt + \frac{V^2}{254(f + n)}$$

$$= 0.278 \times 85 \times 2.5 + \frac{85^2}{254(0.36 + 0.025)}$$

$$\Rightarrow \quad = 132.95 \text{ m}$$

For a vehicle coming from opposite direction i.e., descending gradient

$$\text{SSD}_2 = 278Vt + \frac{V^2}{254(f - n)}$$

$$= 0.278 \times 85 \times 2.5 + \frac{85^2}{254(0.36 - 0.025)}$$

$$\Rightarrow \quad = 143.98 \text{ m}$$

For a one lane, two way road

$$\text{SSD} = \text{SSD}_1 + \text{SSD}_2$$

$$= 132.95 + 143.98$$

$$= 276.93$$

29. (c)

$$\text{Capacity of rotary} = \frac{280w\left(1+\frac{e}{w}\right)\left(1-\frac{P}{3}\right)}{1+\frac{w}{l}}$$

$$= \frac{280\times15\times\left(1+\frac{5.2}{15}\right)\left(1-\frac{0.69}{3}\right)}{1+\frac{15}{82}}$$

$$= 3681.5 \simeq 3681 \text{ PCU/hr}$$

30. (c)

Given: $P = 4100$ kg, $E = 3 \times 10^5$ kg/cm^2, $h = 15$ cm, $k = 3$ kg/cm^2, $a = 15$ cm, $\mu = 0.15$

Equivalent radius of resisting section:

$$b = \sqrt{1.6a^2 + h^2} - 0.675h \qquad [a < 1.724h = 1.724 \times 15 = 25.86 \text{ cm}]$$

$$= \sqrt{1.6(15)^2 + (15)^2} - 0.675 \times 15 = 14.06 \text{ cm}$$

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