CLASS TEST

S.No.:01IGCE_DEF_01042024

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HIGHWAY

CIVIL ENGINEERING

Date of Test :01/04/2023

ANSWER KEY

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

DETAILED EXPLANATIONS

1. (c)

Grade compensation is minimum of :

(i) $$\frac{30+R}{R} = \frac{30+100}{100} = 1.3\%$$

(ii) $$\frac{75}{R} = \frac{75}{100} = 0.75\%$$

$\therefore$ Compensated gradient = Ruling gradient – grade compensation

$$= \frac{1}{20} - \frac{0.75}{100} = \frac{1}{23.53} \simeq \frac{1}{24}$$

2. (c)

3. (b)

$$\text{Bulk specific gravity} = \frac{1000}{1010-610} = 2.5$$

$$\text{Water absorption} = \frac{1010-1000}{1000} \times 100 = 1\%$$

4. (b)

IRC 37 : Tentative guidelines for design of flexible pavements.

5. (b)

The steel bar reinforcement in cement concrete pavement are not meant for increase in flexural strength. These reinforcement prevent cracking and allow wider spacing of joints.

6. (c)

For two way, two lane road, lane distribution factor = 0.75

$$\text{Cumulative standard axles} = \frac{365A \times \left[(1+r)^n - 1\right] L \times VDF}{r}$$

$$= \frac{365 \times 2000 \times \left[(1+0.15)^{10} - 1\right] \times 0.75 \times 2}{0.15 \times 10^6}$$

$\simeq$ 22 million standard axles (msa)

7. (a)

8. (b)

Spacing between contraction joints,

$$L_C = \left(\frac{2S_C}{\gamma_c \times f}\right)$$

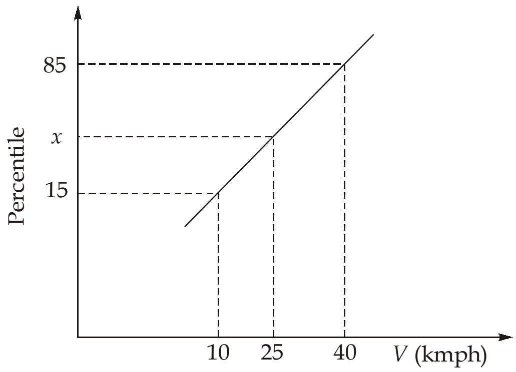
$$= \frac{2 \times 0.8 \times 10^4}{2400 \times 1.6} = 4.17 \text{ m}$$

9. (a)

Glycerine and dextrine are applied to the standard briquette for avoiding sticking of bitumen.

10. (b)

Given linear variation between percentile and speed, and thus the graph between these two quantities is shown below.



$$\text{Slope of line} = \frac{85-15}{40-10} = \frac{x-15}{25-10}$$

$$\Rightarrow \quad x = 50$$

$$\therefore \quad \text{25 kmph speed} = 50^{\text{th}} \text{ percentile speed}$$

$$\therefore \quad \text{Number of vehicles between 10 and 25 kmph} = \left(\frac{50-15}{100}\right)1000 = 350$$

11. (a)

Practical capacity of rotary (Q_P),

$$Q_P(\text{veh/hr}) = \frac{280w\left(1+\frac{\rho}{w}\right)\left(1-\frac{P_{\max}}{3}\right)}{\left(1+\frac{w}{L}\right)}$$

$$\therefore \quad Q_P \propto \left(1-\frac{P_{\max}}{3}\right)$$

$$\therefore \quad \frac{Q_{P_1}}{Q_{P_2}} = \frac{\left(1-\frac{P_{\max}}{3}\right)_1}{\left(1-\frac{P_{\max}}{3}\right)_2}$$

$$\Rightarrow \quad \frac{2500}{Q_{P_2}} = \frac{\left(1-\frac{0.45}{3}\right)}{\left(1-\frac{0.6}{3}\right)}$$

$$\Rightarrow \quad Q_{P_2} = 2352.94 \simeq 2353$$

12. (b)

Angle parking accommodates more vehicles per unit length of kerb and maximum vehicles can be parked when angle is 90°.

13. (c)

Velocity of slow moving vehicle,

$$V_B = 65 - 12 = 53 \text{ kmph}$$

Space headway, $S = 0.2\,V_B + l$

$$= 0.2 \times 53 + 6$$

$$= 16.6 \text{ m}$$

$$T = \sqrt{\frac{4S}{a}} = \sqrt{\frac{4 \times 16.6 \times 18}{2.86 \times 5}} = 9.14 \text{ sec}$$

$\therefore$ $d_1 = 0.278\ V_B t_R$

$\Rightarrow$ $d_1 = 0.278 \times 53 \times 2 = 29.47$ m

$$d_2 = 0.278 V_B T + \frac{1}{2} a T^2$$

$\Rightarrow$ $d_2 = 0.278 \times 53 \times 9.14 + \frac{1}{2} \times 2.86 \times \frac{5}{18} \times 9.14^2$

$\Rightarrow$ $d_2 = 134.67 + 33.18 = 167.85$ m

$d_3 = 0.278\ V_C T$

$\Rightarrow$ $d_3 = 0.278 \times 65 \times 9.14 = 165.16$ m

Safe length of overtaking zone

$$= d_1 + d_2 + d_3$$

$$= 362.48 \text{ m}$$

Desirable length of overtaking zone

$$= 5 \times 362.48$$

$$= 1812.4 \text{ m}$$

14. (c)

Based on head light sight distance,

Length of valley curve, $L_v = \dfrac{Ns^2}{1.5 + 0.035s}$

Assuming L_v > HSD, $L_v = \dfrac{\left|-\frac{1}{40} - \frac{1}{60}\right| \times 120^2}{1.5 + 0.035 \times 120}$

$L_v = 105.26$ m $\quad \not> HSD$

Hence the assumption is incorrect,

For $L_v < HSD$

$$L_v = 2S - \frac{1.5 + 0.035s}{N}$$

$$= 2 \times 120 - \frac{1.5 + 0.035 \times 120}{\left| -\frac{1}{40} - \frac{1}{60} \right|} = 103.2 \text{ m}$$

15. (c)

Angularity number, AN = 67% – % solid volume

$$= 67 - \left(\frac{V_a}{V_{cyl}} \times 100 \right)$$

$$= 67 - \left(\frac{\frac{3.9}{2.65}}{2.5} \times 100 \right)$$

= 67 – 58.87

= 8.13%

∴ AN = 8.00

16. (b)

λ = 280 veh/hr

Probability for 10 vehicles arriving within 2 minutes time interval

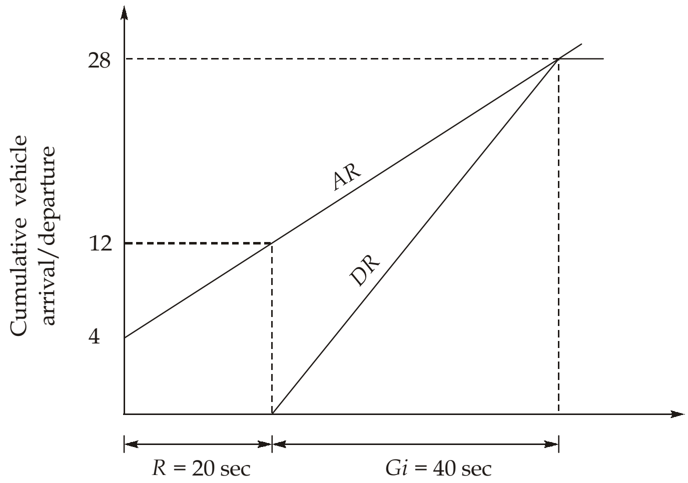
$$P(n, t) = \frac{(\lambda t)^n e^{-\lambda t}}{n!}$$

$$P\left(10, \frac{2}{60}\right) = \frac{\left(280 \times \frac{2}{60}\right)^{10} e^{-280 \times \frac{2}{60}}}{10!}$$

$$= \frac{5.016 \times 10^9 \times 8.84 \times 10^{-5}}{10!}$$

= 0.122

17. (c)



Let time after which uniform arrival and discharge line meets is at t sec after the red time.

$$\therefore \quad 4 + 24 \times \frac{(20+t)}{60} = 42 \times \frac{t}{60}$$

$$\Rightarrow \quad 4 \times 60 + 24 \times 20 + 24\,t = 42\,t$$

$$\Rightarrow \quad t = 40 \text{ sec}$$

Hence, both lines meet exactly at the end of cycle time (option (c) is correct)

Total vehicle discharge at the end of cycle time

$$= 42 \times \frac{40}{60} = 28$$

Option (b) is incorrect.

$$\text{Average delay per vehicle} = \frac{\text{Area between } AR \text{ and } DR}{\text{Cumulative vehicle at the end of cycle}}$$

$$= \frac{\frac{1}{2}[4+28] \times 60 - \frac{1}{2} \times 40 \times 28}{28}$$

$$= \frac{400}{28} = 14.28 \text{ sec}$$

18. (a)

$$\text{BI} = 630\ [\text{IRI}]^{1.12}$$

Here, IRI is in m/km, $\text{IRI} = 3465 \text{ mm/km} = 3.465 \text{ m/km}$

$$\text{BI} = 630\ [3.465]^{1.12} = 2534 \text{ mm/km}$$

19. (d)

$$V_v = \frac{G_t - G_m}{G_t} \times 100 = \frac{2.442 - 2.268}{2.442} \times 100$$

$$V_v = 7.12\%$$

$$V_b\ \% = G_m \times \frac{W_b\%}{G_b} = 2.268 \times \frac{5}{1.1} = 10.309\%$$

$$\text{VMA} = V_v + V_b = 7.12 + 10.309 = 17.429\%$$

$$\text{VFB} = \frac{V_b\%}{VMA\%} \times 100 = \frac{10.309}{17.429} \times 100 = 59.15\% \approx 59\%$$

20. (c)

(i) Length of national highway $= \frac{\text{Area}}{50} = \frac{13400}{50} = 268 \text{ km}$

(ii) Length of state highway,

(a) Length of state highway $= \frac{13400}{25} = 536 \text{ km}$

(b) Length of state highway $= 62.5 \times 12 - \frac{13400}{50} = 482 \text{ km}$

Adopt length of state highway (higher of the above two criteria) = 536 km

(iii) Length of major district road $= \max\begin{cases} \frac{13400}{12.5} = 1072 \text{ km} \\ 90 \times 12 = 1080 \text{ km} \end{cases} = 1080 \text{ km}$

21. (a)

Design speed of a road is independent of type of material used in the pavement.

22. (b)

$$y_A = \frac{q_A}{S_A} = \frac{450}{1250} = 0.36$$

$$y_B = \frac{q_B}{S_B} = \frac{250}{1050} = 0.238$$

$$Y = y_A + y_B = 0.36 + 0.238 = 0.598$$

Total lost time = 2 × 3 = 6 seconds (as it is two phase signal)

$$\text{Optimum cycle time, } C_o = \frac{1.5L + 5}{1 - Y} = \frac{1.5 \times 6 + 5}{1 - 0.598} = 34.83 \text{ seconds}$$

$$G_B = \frac{y_B}{Y}(C_o - L) = \frac{0.238}{0.598}(34.83 - 6) = 11.47 \text{ sec}$$

23. (c)

$$\frac{\alpha}{2} = \frac{180 L_C}{2\pi(R - d)} = \frac{180 \times 180}{2\pi(400 - 1.9)} = 12.95°$$

$\because$ $\quad$ SSD > L_C

∴ Set back distance from the centre line of pavement,

$$m = R-(R-d)\cos\frac{\alpha}{2}+\left(\frac{S-L_C}{2}\right)\sin\frac{\alpha}{2}$$

$$= 400 - (400 - 1.9)\cos 12.95 + \left(\frac{300-180}{2}\right)\sin 12.95$$

$$= 12.025 + 13.446 = 25.47 \text{ m}$$

Set back distance from inner edge $= m - 2d = 25.47 - 2 \times 1.9$

$$= 21.67 \text{ m} \simeq 22 \text{ m}$$

24. (a)

$$\frac{t_1}{t_2} = \left(\frac{C_2}{C_1}\right)^{1/5}$$

$$\Rightarrow \quad C_2 = \left(\frac{10}{8}\right)^5 \times 65 = 198.36$$

25. (b)

26. (b)

Traffic flow equation, $u = 80 - 0.7k$

∵ Flow, $q = u \times k = 80k - 0.7k^2$

For maximum flow, $\frac{dq}{dk} = 0$

$$\Rightarrow \quad 80 - 1.4k = 0$$

$$\Rightarrow \quad k = \frac{80}{1.4} = 57.14$$

∴ Maximum flow, $q_{max} = 80\,(57.14) - 0.7\,(57.14)^2 \simeq 2286$ vph

Alternatively,

For an equation, $q = ak - bk^2$

$$q_{max} = \frac{a^2}{4b} = \frac{(80)^2}{4\times 0.7} \simeq 2286 \text{ vph}$$

27. (c)

$$N = \left|+\frac{1}{50}-\left(-\frac{1}{50}\right)\right| = \frac{1}{25}$$

Assume, $L_s > \text{OSD}$

$$L_s = \frac{NS^2}{9.6} = \frac{\frac{1}{25}\times 620^2}{9.6} = 1601.67 \text{ m} > 620 \text{ m} \quad \text{OK}$$

But it is suggested that the length of vertical summit curve is restricted to 500 m.

So, let's provide intermediate sight distance instead of overtaking sight distance.

$$ISD = 2 \times SSD = 2 \times 160 = 320 \text{ m}$$

Assume, $L_S > ISD$

$$L_S = \frac{NS^2}{9.6} = \frac{\frac{1}{25} \times 320^2}{9.6} = 426.67 \text{ m} > 320 \text{ m and} < 500 \text{ m} \qquad \text{OK}$$

$\therefore$ Provide $L_s \simeq 427$ m

28. (c)

$$y = \frac{Nx^2}{2L}$$

It is maximum when $x = \frac{L}{2}$

$$\therefore \quad y = \frac{N}{2L}\left(\frac{L}{2}\right)^2$$

$$= \frac{NL}{8} = \frac{[g_1 - (-g_2)]}{100} \times \frac{L}{8} = \frac{(g_1 + g_2)L}{800}$$

29. (a)

30/40 grade means penetration value of bitumen is in the range of 30 to 40 at standard test conditions.

$\therefore$ 30/40 grade is more stiffer than 80/100 grade.

For hot climate, due to high temperature, comparatively stiff bitumen should be preferred.

30. (b)

Informatory signs are used to guide the road users along route.

Regulatory signs are meant to inform the road users of certain laws, regulations and prohibitions.

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