CLASS TEST

Sl. : 03_IG_CE_H+E+F_190423

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HIGHWAY ENGINEERING

CIVIL ENGINEERING

Date of Test : 19/05/2023

ANSWER KEY

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

DETAILED EXPLANATIONS

1. (d)

As per IRC, coefficient of longitudinal friction = 0.35 to 0.4.

Coefficient of lateral friction is useful in horizontal curve design.

2. (c)

The Nagpur road plane laid down two formulae for road length of different classes, considering the geographical, agricultural and population conditions, assumed the star and grid pattern of the road network.

An example of radial and circular pattern is the road network of Connaught Place in New Delhi.

3. (b)

Deviation angle, $N = \left|\frac{1}{75} - \left(-\frac{1}{50}\right)\right| = 0.0333$

Assuming, $L > S$

$$L = \frac{NS^2}{9.6} = \frac{0.0333 \times 400^2}{9.6}$$

$$= 555.56 > S (= 400 \text{ m}) \qquad \text{(OK)}$$

4. (b)

5. (c)

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

6. (b)

A metal hammer of weight 13.5-14.0 kg having a free fall from a height 38 cm is dropped 15 times in aggregate impact test.

So energy imparted = 14 × 38 × 15 = 7980 kg-cm

7. (b)

Marshall test is used for design of bituminous concrete mix i.e., option (b) is correct.

8. (b)

Rigid pavements are more affected by temperature variation than flexible pavements.

9. (c)

As per IRC, minimum length of transition curve in plain or rolling terrain

$$L_s = \frac{2.7V^2}{R} = \frac{2.7 \times 100^2}{180} = 150 \text{ m}$$

10. (c)

The spacing of expansion joint is given by

$$L_e = \frac{\delta'}{100C(T_2 - T_1)}$$

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

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

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

11. (d)

$$V = 80 - \frac{2}{3}K$$

Capacity, $$q = V \times K$$

$$= 80K - \frac{2}{3}K^2$$

For q to be maximum, $$\frac{dq}{dK} = 0$$

$$= 80 - \frac{4K}{3} = 0$$

$\therefore$ $$K = 60$$

$\therefore$ Maximum capacity, $$q = 80 \times 60 - \frac{2}{3} \times 60^2$$

$$= 4800 - \frac{2}{3} \times 3600 = 2400 \text{ veh/hr}$$

12. (a)

Off-tracking, $$\frac{l^2}{2R} = 0.1 \text{ m}$$

$\Rightarrow$ $$R = \frac{(6.6)^2}{2 \times 0.1} = 217.8 \text{ m}$$

Extra-widening, $$E_W = \frac{nl^2}{2R} + \frac{V}{9.5\sqrt{R}}$$

$$= 2 \times 0.1 + \frac{75}{9.5\sqrt{217.8}}$$

$$= 0.2 + 0.53 = 0.73 \text{ m}$$

13. (c)

Road	Length (km)	Total utility served by the road	Utility per unit length	Priority
P	500	100 × 1 + 70 × 2 + 50 × 4 + 20 × 8 + 50 × 2 + 20 × 10 = 900	$\frac{900}{500} = 1.8$	II
Q	600	200 × 1 + 120 × 2 + 30 × 4 + 10 × 8 + 60 × 2 + 25 × 10 = 1010	$\frac{1010}{600} = 1.683$	III
R	800	100 × 1 + 90 × 2 + 80 × 4 + 80 × 8 + 30 × 2 + 15 × 10 = 1450	$\frac{1450}{800} = 1.8125$	I
S	900	150 × 1 + 130 × 2 + 100 × 4 + 10 × 8 + 50 × 2 + 12 × 10 = 1110	$\frac{1110}{900} = 1.23$	IV

14. (d)

Population, agriculture and industrial development factors are utilized in deciding the best alignment.

15. (c)

Development allowance in first 20 years road plan = 15% of road length

Development allowance in second 20 years road plan = 5% of road length

16. (b)

Since the carriageway is divided i.e., dual carriageway.

Maximum of both direction traffic will be taken i.e.,

$$A = 2400 \text{ cvpd}$$

$$N_s = \frac{365ADF\{(1+r)^n - 1\}}{r \times 10^6} \times LSF$$

$$= \frac{365 \times 2400 \times 0.6 \times 3.0\{(1+0.07)^{15} - 1\}}{0.07 \times 10^6}$$

$$= 39.62 \text{ msa}$$

17. (d)

Time	Volume	HEF	Volume × HEF
8:00 - 9:00	500	14.5	7250
9:00 - 10:00	350	17.6	6160
10:00 - 11:00	200	15.3	3060
11:00 - 12:00	150	18.1	2715
			Σx = 19185

$$\text{Average daily traffic} = \frac{\Sigma x}{4} = \frac{19185}{4} = 4796.25$$

$$\text{Weekly average daily traffic} = \frac{4796.25 \times DEF}{7} = \frac{4796.25 \times 5.7}{7} = 3905.52$$

Annual average daily traffic, AADT = 3905.52 × 1.35 = 5272.45

18. (b)

$$\lambda = 280 \text{ veh/hr}$$

Probability for 10 vehicles arriving within 2 minutes time interval

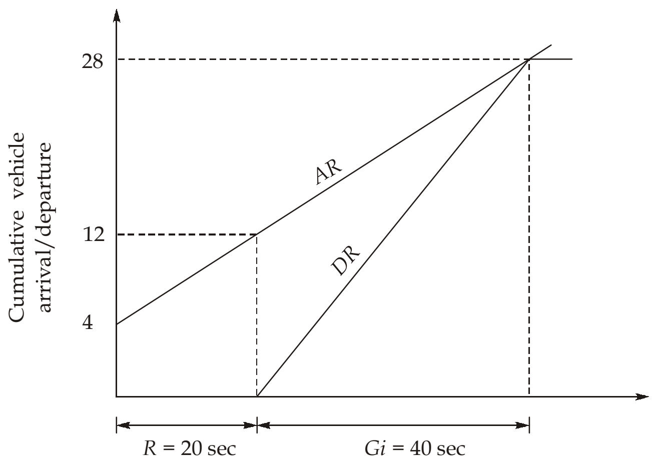
$$P(n,\ t) = \frac{(\lambda t)^n e^{-\lambda t}}{n!}$$

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

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

$$= 0.122$$

19. (a)



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

Total vehicle discharge at the end of cycle time

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

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

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

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

20. **(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, $$a = \frac{V^2}{R}$$

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

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

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

$$= 32.55 \text{ m}$$

21. **(a)**

$$\text{Effective green time} = \text{Green time + Amber time – Startup loss – Clearance time}$$

$$= 27 + 3.5 - 2.5 - 1.5 = 26.5 \text{ second}$$

$$\text{Saturation flow} = \frac{3600}{\text{Saturation time headway}}$$

$$= \frac{3600}{2.5} = 1440 \text{ veh/hr}$$

$$\text{Actual capacity} = \text{Saturation flow} \times \frac{\text{Effective green time}}{\text{Cycle time}}$$

$$= 1440 \times \frac{26.5}{60} = 636 \text{ veh/hr}$$

22. **(b)**

The cumulative number of standard axle load,

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

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

$$= 9.91 \text{ msa}$$

23. **(b)**

24. **(a)**

Spacing between contraction joint is given by

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

25. **(b)**

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

26. **(b)**

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

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

$\therefore$ 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

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

27. **(c)**

Given: P = 4100 kg, $E = 3 \times 10^5$ kg/cm², h = 15 cm, k = 3 kg/cm², a = 15 cm, μ = 0.15

Equivalent radius of resisting section:

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

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

28. **(a)**

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

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

($\therefore K = 8 \times 10^6$ kg/m³ = 8 kg/cm³)

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

Warping stress at corner is given by

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

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

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

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

$$S_{tc} = \frac{2.8\times10^5\times10\times10^{-6}\times12}{3(1-0.15)}\sqrt{\frac{15.96}{94.74}}$$

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

29. (a)

Condition for the prevention of overturning and sliding is

$$\frac{V^2}{gR} < \min\left\{\begin{array}{l}\frac{b}{2h}\\ f\end{array}\right.$$

$$\frac{b}{2h} = \frac{0.8}{2\times0.6} = 0.67$$

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

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

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

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

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

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

30. (a)

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

Here,

$$ESWL = 62 \text{ kN}$$

$$P = 35 \text{ kN}$$

$$Z = 30 \text{ cm}$$

$$S = 20 \text{ cm}$$

$$d = ?$$

Substitute all the values in eq. (i)

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

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

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