CLASS TEST

Sl. : 03 IGCE-I+J_07072023

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HIGHWAY ENGINEERING

CIVIL ENGINEERING

Date of Test : 07/07/2023

ANSWER KEY ➤

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

DETAILED EXPLANATIONS

1. (c)

As per IRC, the maximum permissible width of vehicle is 2.44 m and the desirable side clearance for single lane carriageway is 0.65 m. This require minimum lane width of 3.75 m for a single lane road.

2. (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

3. (c)

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

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

4. (b)

Deviation angle, $N = \frac{1}{75} + \frac{1}{50} = 0.0333$

Assuming, $L > S$

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

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

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.

7. (b)

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

9. (d)

Objectives of providing transition curve are:

(i) To introduce gradually the centrifugal force between the tangent points and beginning of circular curve, avoiding sudden jerk on the vehicle.

(ii) To enable the driver turn the steering gradually for comfort and safety.

(iii) It introduces superelevation and extra widening on curve gradually.

(iv) To improve aesthetic appearance of road.

10. (d)

Flexible progressive system: In the system it is possible to automatically 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.

11. (a)

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

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

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

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

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

12. (b)

Sum of critical flow ratio, $Y = y_a + y_b$

$$= \frac{600}{1500} + \frac{300}{1500} = 0.6$$

Optimum cycle time, $$C_0 = \frac{1.5L+5}{1-Y} = \frac{1.5\times 16+5}{1-0.6}$$

$$= 72.5 \text{ sec} \simeq 73 \text{ sec (say)}$$

13. (d)

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

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

14. (c)

Equilibrium superlevation:

$$f = 0$$

The superelevation required to balance the vehicle over a curve only with superelevation without considering friction.

$$e + f = \frac{v^2}{gR}$$

$$e_{eq} = \frac{v^2}{gR}$$

15. (d)

Grade compensation (in %) = $\frac{30+R}{R} \not> \frac{75}{R} = \frac{30+60}{60} \not> \frac{75}{60} = 1.5 \not> 1.25$

Compensated gradient = 5 – 1.25

= 3.75% < 4%

Adopt compensated gradient = 4%

Hence reduction in gradient = 1%

16. (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	IV
R	800	100 × 1 + 90 × 2 + 80 × 4 + 80 × 8 + 30 × 2 + 15 × 10 = 1450	$\frac{1450}{800}$ = 1.813	I
S	900	150 × 1 + 130 × 2 + 100 × 4 + 10 × 8 + 50 × 2 + 12 × 10 = 1110	$\frac{1110}{900}$ = 1.23	IV

17. (c)

For a particular vehicle on a high speed track.

$$\frac{e+f}{1-ef} = \frac{V^2}{127R}$$

$$\Rightarrow \quad \frac{e+0.15}{1-e\times 0.15} = \frac{180^2}{127\times 350}$$

$\Rightarrow$ e + 0.15 = 0.7289 – 0.109 e

$\Rightarrow$ 1.109e = 0.5789

$$\Rightarrow \quad e = 0.522 = \frac{1}{1.916}$$

$\therefore$ $N = 1.916 \simeq 1.92$

18. (b)

As we know,

Stopping sight distance, $\text{SSD} = 0.278Vt + \frac{V^2}{254(n_b \times f - 0.01n)}$

Where, n_b is the braking efficiency and n is descending gradient (in %).

$$\Rightarrow \quad 230 = 0.278\times 60\times 2.5 + \frac{60^2}{254(0.8\times 0.4 - 0.01n)}$$

$\Rightarrow$ $n = 24.5\%$

19. (a)

Velocity of slow moving vehicle, $V_B = 65 - 12 = 53$ kmph

Space headway, $S = 0.2\ V_B + l$ where l is length of vehicle

$= 0.2 \times 53 + 6$

$= 16.6$ 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

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

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

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

$d_3 = 0.278\ V_C T$

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

So, overtaking sight distance, OSD $= d_1 + d_2 + d_3 = 362.48$ m

20. (a)

Spacing between contraction joints

$$= \frac{2\sigma_s A_s}{bh\gamma_c f}$$

$$\text{Total area of steel} = \frac{\pi}{4} \times 10^2 \times \frac{4200}{260} = 1268.72 \text{ mm}^2 = 12.69 \text{ cm}^2$$

$$\text{Spacing} = \frac{2 \times 1400 \times 12.69}{420 \times 18 \times 2400 \times 10^{-6} \times 1.5} = 1305.56 \text{ cm} = 13.06 \text{ m} \simeq 13 \text{ m (say)}$$

21. (a)

Given, $h = 25$ cm, $E = 3 \times 10^5$ kg/cm^2, $\mu = 0.15$, $k = 6$ kg/cm^3

$$L = \left[\frac{Eh^3}{12k(1-\mu^2)}\right]^{1/4} = \left[\frac{3 \times 10^5 \times 25^3}{12 \times 6\{1-(0.15)^2\}}\right]^{1/4}$$

$\Rightarrow$ $L = 90.34$ cm

22. (c)

$$N_{S_1} = \frac{365 A_1\left[(1+r)^n - 1\right]}{r} \times F = \frac{365 \times 1800\left[\left(1+\frac{8}{100}\right)^{12} - 1\right]}{\frac{8}{100} \times 10^6} \times 4$$

$= 49.87$ msa

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

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

$$= 14.55$$

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

$$= 49.87 + 14.55$$

$$= 64.42 \text{ msa}$$

23. (b)

When friction is neglected, no stresses will be developed in the cement concrete pavement.

24. (c)

$$T_p = \sqrt{\frac{1.75P}{CBR\%} - \frac{P}{\pi p}}$$

Here T_p denotes thickness of pavement above the test layer whose CBR value is taken.

25. (a)

Condition for the prevention of overturning and sliding is

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

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

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

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

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

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

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

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

27. (a)

Practical capacity of a rotary is given by

$$Q_p = \frac{280\,w\left(1 + \dfrac{e}{w}\right)\left(1 - \dfrac{p_{\max}}{3}\right)}{1 + \dfrac{w}{L}}$$

Statement-I: True

As with increase in length of weaving section, practical capacity increases.

Statement-II: False

As with increase in weaving ratio, numerator decreases and practical capacity of rotary ultimately decreases.

28. (b)

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

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

29. (d)

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

Probability for 10 vehicles arriving within 2 minutes time interval

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

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

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

$$= 0.122$$

30. (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

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