CLASS TEST

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HIGHWAY

CIVIL ENGINEERING

Date of Test : 03/05/2025

ANSWER KEY

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

DETAILED EXPLANATIONS

1. (d)

Grade compensation, $\% = \dfrac{30+R}{R} \not> \dfrac{75}{R}$

$$= \frac{30+60}{60} \not> \frac{75}{60}$$

$$= 1.5 \not> 1.25$$

Compensated gradient $= 5 - 1.25$

$= 3.75\% < 4\%$

Adopt compensated gradient = 4%

Hence reduction in gradient = 1%

2. (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

3. (d)

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

Coefficient of lateral friction is useful in horizontal curve design.

4. (b)

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

Assuming, $L > S$

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

$= 555.56 > S$ (= 400 m) (OK)

5. (d)

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

$= 251.97 \simeq 252$ m

6. (d)

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

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

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

$$= \frac{125 \times 70}{4} = 2187.5 \simeq 2187 \text{ vph}$$

7. (c)

Equilibrium superlevation:

$$f = 0$$

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

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

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

8. (d)

In intersection design: Relative speed is dependent on the absolute speeds of the intersecting vehicles and the angles between them when the angle of merging is small, the relative speed will also be low. Relative speed increases, the judgement of drivers regarding time and distance is likely to be more inaccurate, thus increasing the possibility and severity of accidents.

9. (d)

Radius of relative stiffness (l)

$$l = \left[\frac{Eh^3}{12k\left(1-\mu^2\right)}\right]^{1/4}$$

where, E = Modulus of elasticity of concrete

μ = Poisson's ratio of concrete

h = Slab thickness

k = Modulus of subgrade reaction

10. (d)

Transition curve: Introduced between a straight and a circular curve.

Objects of providing transition curve:

(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.

11. (b)

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

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

Optimum cycle time, $$C_0 = \frac{1.5L+5}{1-Y} = \frac{1.5\times16+5}{1-0.6}$$

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

12. (a)

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

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

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

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

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

13. (c)

The spacing of expansion joint is given by

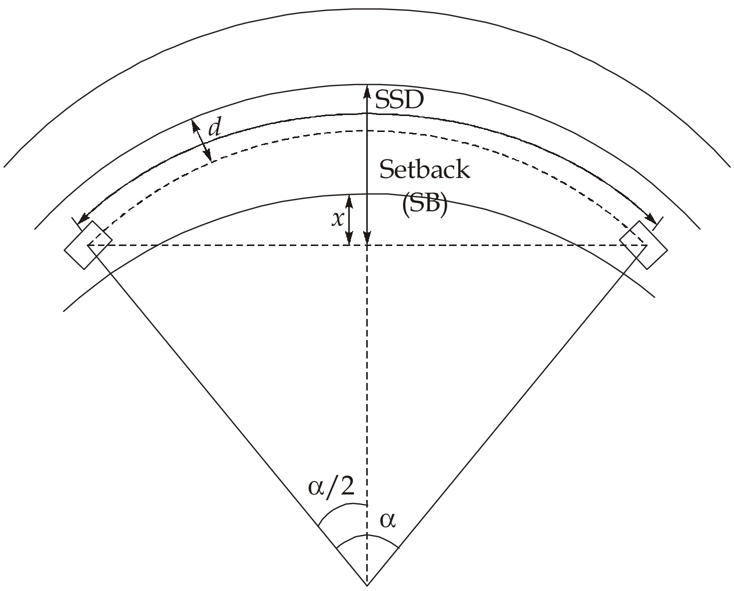
$$L_e = \frac{\delta'}{100C(T_2 - T_1)}$$

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

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

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

14. (d)



$R = 400$ m
$l = 225$ m
$S = 90$ m
$l > S$
$d = \dfrac{3.8}{2} = 1.9$ m

$\therefore$ L_c (225 m) $>$ SSD (90 m)

$\therefore$ Setback distance, $\text{SB} = R - (R-d)\cos\dfrac{\alpha}{2}$

$$\frac{\alpha}{2} = \frac{SSD}{(R-d)} \times \frac{180}{2\pi}$$

$$= \frac{90}{(400-1.9)} \times \frac{180}{2\pi} = 6.48°$$

$$SB = 400 - (400 - 1.9) \times \cos 6.48°$$

$$= 4.443 \text{ m}$$

Setback distance from mid of the inner lane (x)

$$= 4.443 - 1.9 = 2.543 \text{ m}$$

15. (c)

$$N = \frac{365A[(1+r)^n - 1] \times F \times D}{r}$$

$$= \frac{365 \times 6000 \times [(1+0.075)^{18} - 1] \times 1.65 \times 0.6}{0.075 \times 10^6} \text{ msa}$$

$$= 77.352 \text{ msa}$$

16. (a)

Spacing between contraction joints

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

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

$$\text{Spacing} = \frac{2 \times 1400 \times 12.69}{420 \times 18 \times 2400 \times 10^{-6} \times 1.5}$$

$$= 1305.56 \text{ cm} = 13.06 \text{ m} \simeq 13 \text{ m (say)}$$

17. (c)

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

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

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

18. (c)

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

Equivalent radius of resisting section:

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

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

19. (d)

A tangent at the junction of convex and concave curve meets the x-axis and 1.5 mm. Standard penetrations are considered as (1.5 + 2.5) = 4 mm and (1.5 + 5) = 6.5 mm.

$$\text{CBR\%} = \max\begin{cases}\dfrac{P_{4,\text{mm}}}{1370}\times 100\\ \dfrac{P_{6.5\text{ mm}}}{2055}\times 100\end{cases}$$

$$= \max\begin{cases}\dfrac{50}{1370}\times 100 = 3.649\%\\ \dfrac{70}{2055}\times 100 = 3.406\%\end{cases}$$

$$\text{CBR\%} = 3.649\%$$

20. (a)

The distance of the lowest point on the valley curve from its first tangent point is given by

$$x = L\left(\frac{n_1}{2N}\right)^{1/2}$$

$$N = |n_1 - n_2|$$

$$n_1 = \frac{-5}{100},\ n_2 = \frac{3}{100}$$

$$N = \left|-\frac{5}{100} - \frac{3}{100}\right| = \frac{8}{100} = 0.08$$

$$\therefore \quad x = 250\left(\frac{5/100}{2\times 0.08}\right)^{1/2} = 139.75 \text{ m}$$

21. (b)

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

Now using, $v = u + at$

$\Rightarrow \quad 0 = u + at$

$\Rightarrow \quad a = -\dfrac{u}{t}$

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

$\therefore \quad a = -\dfrac{11.11}{3} = -3.703 \text{ m/s}^2$ (negative sign implies de-acceleration)

Using, $F = ma$

$\Rightarrow \quad Wf = \dfrac{Wa}{g}$

$\Rightarrow \quad f = \dfrac{a}{g} = \dfrac{3.703}{9.81} = 0.377$

22. (b)

$$V_V = \frac{G_t - G_m}{G_t} \times 100 = \frac{2.563 - 2.424}{2.563} \times 100 = 5.42\%$$

$$V_b = G_m \times \frac{W_b(\%)}{G_b} = 2.424 \times \frac{7}{1.1} = 15.43\%$$

$$VMA = V_b + V_v = 15.43 + 5.42 = 20.85\%$$

$$\therefore \quad VFB = \frac{V_b(\%)}{VMA} \times 100 = \frac{15.43}{20.85} \times 100 = 74\%$$

23. (b)

Speed of overtaking vehicle, V = 80 kmph = 22.22 m/sec

Speed of overtaken vehicle,

$$V_b = 50 \text{ kmph} = 13.89 \text{ m/sec}$$

Average acceleration during overtaking,

$$a = 0.95 \text{ m/sec}^2$$

Overtaking sight distance for two way traffic,

$$\text{OSD} = d_1 + d_2 + d_3$$
$$= (V_b t + V_b T + 2S + VT)$$
$$d_1 = V_b t = 13.89 \times 2.5 = 34.7 \text{ m}$$
$$d_2 = V_b T + 2S$$
$$S = 0.7V_b + 6 = 0.7 \times 13.89 + 6 = 15.723 \text{ m}$$
$$T = \sqrt{\frac{4S}{a}} = \sqrt{\frac{4 \times 15.723}{0.95}} = 8.136 \text{ sec}$$
$$d_2 = 13.89 \times 8.136 + 2 \times 15.723 = 144.5 \text{ m}$$
$$d_3 = VT = 22.22 \times 8.136 = 180.8 \text{ m}$$
$$\text{OSD} = d_1 + d_2 + d_3 = 34.7 + 144.5 + 180.8 = 360 \text{ m}$$

Now, minimum length of overtaking zone = 3 × OSD = 3 × 360 = 1080 m

Also, desirable length of overtaking zone = 5 × OSD = 5 × 360 = 1800 m

24. (a)

Given,

Average arrival rate, λ = 260 veh/hr

$$= \frac{260}{3600} \text{ veh/sec}$$

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

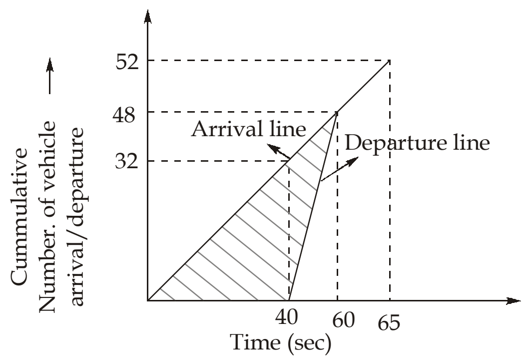
$$P(x = 0) = \frac{e^{-\left(\frac{260}{3600} \times 3\right)} \cdot \left(\frac{260}{3600} \times 3\right)^0}{0!} = 0.805$$

25. (c)

$$R = 1350 \text{ m}$$
$$V = 110 \text{ kmph}$$
$$L_T = \frac{V^3}{CR} = \left(\frac{110^3 \times \frac{5^3}{18^3}}{0.3 \times 1350}\right) = 70.44 \text{ m}$$

$$\therefore \quad \text{Shift} = \frac{L_T^2}{24R} = \frac{(70.44)^2}{24 \times 1350}$$
$$= 0.153 \simeq 0.15 \text{ m}$$

26. (a)



In 40 sec, number of vehicles arrived = 40 × 0.8 = 32 vehicles
In 40 sec to 60 sec, number of vehicle departure = 20 × 2.4 = 48 vehicles
In 65 sec (cycle time), number of vehicles arrived = 65 × 0.8 = 52 vehicles

$$\text{So, Average delay per vehicle} = \frac{\text{Area between arrival curve \& departure curve}}{\text{Cummulative number of vehicle arrival / cycle time}}$$

$$\Rightarrow \quad D_T = \frac{\frac{1}{2}[48 \times 60 - 48 \times 20]}{52 \times 60} = 0.307 \text{ min}$$

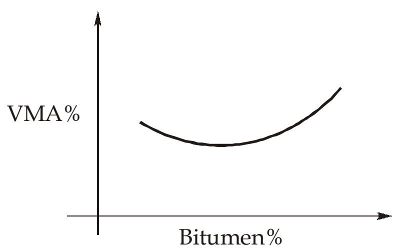
27. (c)

At normal temperature, bitumen is semi-solid

At high temperature, bitumen like a viscous liquid

At very low temperature, bitumen is as brittle as glass.

28. (c)



VMA slowly decreases with the increase in bitumen content, then remains constant over a range and finally increases at a high bitumen content.

29. (a)

II. Operational in relatively large area.

IV. Right-turn traffic has to travel extra distance.

30. (d)

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