CLASS TEST

S.No. : 01 IG_CE_B_11322

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HIGHWAY ENGINEERING

CIVIL ENGINEERING

Date of Test : 11/03/2022

ANSWER KEY

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

DETAILED EXPLANATIONS

1. (c)

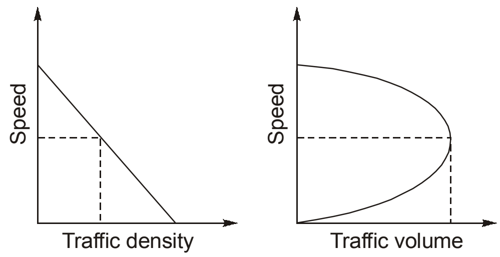
Given: $V = 120$ kmph, $e = 0.07$ and $f = 0.15$

We know that, $$e + f = \frac{V^2}{127R}$$

$$\Rightarrow \quad 0.07 + 0.15 = \frac{120^2}{127R_{min}}$$

$$R_{min} = 515.40 \text{ m} \simeq 516 \text{ m}$$

3. (b)



4. (a)

We know, $$\frac{\Delta}{2} = L\alpha\Delta T$$

$$\Rightarrow \quad \frac{2.5}{100 \times 2} = L \times 10 \times 10^{-6} \times 30$$

$$L = 41.67 \text{ m}$$

5. (c)

$$\text{Hourly expansion factor} = \frac{25000}{5000} = 5$$

6. (b)

$$\text{Rulling gradient} = 5\%$$

$$\text{Grade compensation} = \frac{30+R}{R} = \frac{30+50}{50} = 1.6\%$$

$$\text{Maximum limit of grade compensation} = \frac{75}{R} = \frac{75}{50} = 1.5\%$$

$$\text{Compensated gradient} = 5 - 1.5 = 3.5\%$$

but it should not be less than 4%

$$\text{So, provided gradient} = 4\%$$

7. (a)

For bituminous concrete pavement,

$$\text{Cross slope} = 2\%$$

then, rise of crown with respect to edges

$$= \frac{7}{2} \times \frac{1}{50} = 0.07 \text{ m}$$

8. (c)

Psychological widening is given by

$$= \frac{V}{9.5\sqrt{R}} = \frac{80}{9.5\sqrt{250}} = 0.532\text{ m}$$

9. (d)

$$\text{Density} = \frac{1000}{S} = \frac{1000}{40} = 25\text{ vehicle/km}$$

$$u = 70 - 0.7 \times 25 = 52.5\text{ km/hr}$$

11. (a)

With increase in bitumen content void content decreases.

12. (c)

$$\text{Space headway, } S = 0.278Vt + \frac{V^2}{254f} + L$$

$$= 0.278 \times 60 \times 2.4 + \frac{60^2}{254 \times 0.38} + 5$$

$$= 82.33\text{ m}$$

$$\text{Capacity, } C = \frac{1000V}{S} = \frac{1000 \times 60}{82.33}$$

$$= 728.77 \simeq 728\text{ vehicle/hour/lane}$$

13. (c)

$$N_s = \frac{A \times 365 \times \left(\left(1 + \frac{r}{100}\right)^n - 1\right) \times L.D.F \times V.D.F}{\left(\frac{r}{100}\right)}$$

$$= \frac{2000 \times 365 \times [(1.1)^{15} - 1] \times 0.75 \times 2.8}{\left(\frac{10}{100}\right)}$$

$$= 48.70\text{ msa}$$

14. (a)

$$V = 60\text{ kmph} = 16.66\text{ m/s}$$

We know that, SSD = 260 m

$$\therefore \quad \text{SSD} = Vt + \frac{V^2}{2g(\eta_b \times f - n\%)}$$

$$\Rightarrow \quad 260 = 16.66 \times 2.5 + \frac{16.66^2}{2 \times 9.81 \times (\eta_b \times 0.4 - n)}$$

$$\Rightarrow \quad 218.35 = \frac{16.66^2}{2 \times 9.81 \times (0.8 \times 0.4 - n)}$$

$$\Rightarrow \quad 0.32 - n = 0.064$$

$$\Rightarrow \quad n = 0.256$$

$$\therefore \quad n\,\% = 25.6\%$$

15. (d)

Overtaking criterion is not considered in horizontal transition curve design.

16. (b)

$V_1 = 90$ kmph $= 25$ m/s $\quad V_2 = 60$ kmph $= 16.66$ m/s

$f = 0.40, \quad t = 2.5$ sec, $\quad \eta_b = 50\%$

$$\text{SSD} = vt + \frac{V^2}{2gf \cdot \eta_b}$$

$$\text{SSD}_1 = 25 \times 2.5 + \frac{25^2}{2 \times 9.81 \times 0.4 \times 0.5} = 221.77 \text{ m}$$

$$\text{SSD}_2 = 16.66 \times 2.5 + \frac{(16.66)^2}{2 \times 9.81 \times 0.4 \times 0.5} = 112.38 \text{ m}$$

Total distance required $= 221.77 + 112.38 = 334.15$ m

17. (a)

Assuming weight of specimen $= W$

Volume of specimen $= V$

$$\Rightarrow \quad V = V_{CA} + V_{FA} + V_b + V_a$$

$$V = \frac{0.7W}{2.8} + \frac{0.24W}{2.66} + \frac{0.06W}{1} + 0.08\,V$$

$$0.92V = 0.25W + 0.0902W + 0.06\,W$$

$$\frac{W}{V} = 2.298$$

$$\therefore \quad \frac{W}{V} = 2.298 \text{ gm/cm}^3$$

18. (d)

Space headway increases always but time headway first decreases and than starts increasing after an optimal value.

19. (c)

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

$$\lambda = \left(\frac{220}{60 \times 60}\right) \times \frac{\text{veh}}{\text{sec}} = 0.0611$$

$$\text{t} = 40 \text{ sec}; \quad x = 2$$

$$P(x = 2) = \frac{e^{-0.0611 \times 40} \times (0.0611 \times 40)^2}{2!} = 0.259$$

21. (d)

Normal flow on road A, q_a = 500 PCU/hr

Normal flow on road B, q_b = 300 PCU/hr

Saturation flow on road A, S_a = 1500 PCU/hr

Saturation flow on road B, S_b = 1000 PCU/hr

All red time, R = 16 sec

Number of phases, n = 2

$$y_a = \frac{q_a}{S_a} = \frac{500}{1500} = 0.33$$

$$y_b = \frac{q_b}{S_b} = \frac{300}{1000} = 0.3$$

$$Y = y_a + y_b = 0.33 + 0.3 = 0.63$$

Total lost time, $L = 2n + R = 2 \times 2 + 16 = 20$ sec.

Optimum cycle time, $C_o = \frac{1.5L+5}{1-Y} = \frac{1.5\times 20+5}{1-0.63} = 94.59 \simeq 95\,\text{sec}.$

22. (a)

Given: A = 5500 vehicles, $r = 6.5\%$ per annum, construction period = 3 years

Traffic flow after 3 year,

$$= 5500\times\left(1+\frac{6.5}{100}\right)^3 = 6643.72 \text{ cvpd}$$

$$\simeq 6644 \text{ cvpd}$$

$$\text{VDF} = \left(\frac{L}{L_s}\right)^4 = \left[\frac{3000}{8160}\right]^4 = 0.018, \text{ where } L = \frac{2500+3500}{2} = 3000 \text{ kg}$$

$$\text{Equivalent axle load} = 365\times 6643.72\times\frac{\left[(1+0.065)^{15}-1\right]}{\left(\frac{6.5}{100}\right)}\times 0.018\times 1$$

$$= 1.05 \text{ msa}$$

23. (b)

Given:
V = 100 kmph,
R = 400 m,
N = 150

Required superelevation,

$$\Rightarrow \quad e = \frac{V^2}{225R} = \frac{100^2}{225\times 400} = 0.11$$

$e \le 0.07$ for plain and rolling

Hence provide, $e = 0.07$

Since $R > 300$ m, extra widening is not required

Length of transition curve = to counter camber + to provide superelevation

$$= \left(\frac{h\%}{100}\cdot\frac{w}{2}+\frac{e\cdot w}{2}\right)\times 150$$

$$= \left(\frac{2}{100}\times\frac{7}{2}+0.07\times\frac{7}{2}\right)\times 150$$

$$= 47.25 \text{ m}$$

24. (a)

Assume S is less than L

$$L = \frac{NS^2}{4.4}$$

$$N_1 = \frac{1}{50} = 0.02$$

$$N_2 = -\frac{1}{40} = -0.025$$

$$\therefore \quad N = N_1 - N_2 = 0.02 - (-0.025) = 0.045$$

$$\therefore \quad L = \frac{0.045 \times 180 \times 180}{4.4} = 331.36 \text{ m}$$

Hence assumption is correct.
Equation of parabola is,

$$y = \frac{Nx^2}{2L} = \frac{0.045x^2}{2 \times 331.36} = 6.79 \times 10^{-5} x^2$$

25. (a)

The capacity of rotary, $$Q_P = \frac{280w\left(1+\frac{e}{w}\right)\left(1-\frac{p}{3}\right)}{\left(1+\frac{w}{L}\right)}$$

$$w = 15 \text{ m}, \; p = 0.6, \; L = 75 \text{ m}, \; e = 5 \text{ m}$$

$$\Rightarrow \quad Q_p = \frac{280 \times 15 \times \left(1+\frac{5}{15}\right)\left(1-\frac{0.60}{3}\right)}{\left(1+\frac{15}{75}\right)} = 3733.33 \simeq 3733 \text{ PCU/hr}$$

26. (c)

$$s = 0.2\,V_b + 6 = 0.2 \times 60 + 6 = 18$$

Given: $t_R = 2$ sec; $a = 3$ kmph/sec $= 3 \times \frac{5}{18} = 0.833 \text{ m/s}^2$

$$d_1 = 0.278\,V_b \times t_R = 0.278 \times 60 \times 2 = 33.36 \text{ m} \qquad ...(i)$$

$$T = \sqrt{\frac{4s}{a}} = \sqrt{\frac{4 \times 18}{0.833}} = 9.297 \text{ seconds}$$

$$d_2 = 0.278\,V_b \times T + \frac{1}{2}aT^2$$

$$= 0.278 \times 60 \times 9.297 + \frac{1}{2} \times 0.833 \times 9.297^2 = 191.073 \text{ m} \qquad ...(ii)$$

$$d_3 = 0.278\,V_c \times T$$

$$= 0.278 \times 80 \times 9.297 = 206.76 \text{ m} \qquad ...(iii)$$

Therefore, OSD on two–way traffic road is summation of (i), (ii) and (iii)

$$= d_1 + d_2 + d_3 = 33.36 + 191.073 + 206.76 \approx 431.20 \text{ m}$$

27. (a)

$$\text{Flow, } q = ku = 52\,k - 0.36\,k^2$$

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

$$\Rightarrow \quad 52 - 0.72\,k = 0$$

$$\Rightarrow \quad k = 72.222 \text{ veh/km}$$

$$\therefore \quad q_{max} = 52 \times 72.222 - 0.36 \times 72.222^2 = 1877.78 \text{ veh/hour}$$

Also for $v = A - Bk$, the maximum flow occurs at about half the mean free speed and is equal to $A^2/4B$, so directly

$$q_{max} = \frac{52^2}{4 \times 0.36} = 1877.78 \text{ veh/hour}$$

28. (c)

Design traffic is given by,

$$N = \frac{365 \times A\left[(1+r)^n - 1\right]}{r} \times \text{LDF} \times \text{VDF}$$

where,
A = traffic in year of completion of construction in terms of CVD
r = annual growth rate
n = design life in years
LDF = lane distribution factor
VDF = vehicle damage factor

$$\therefore \quad N = \frac{365 \times 2100 \times \left[(1+0.08)^{16} - 1\right]}{0.08} \times 3 \times 0.75$$

$$N = 522.98 \times 10^5 \text{ standard axles}$$

29. (c)

Mean rate of arrival per unit time,

$$\lambda = \frac{100}{3600} = \frac{1}{36} \text{ veh/second}$$

$$\text{Mean rate of service, } \mu = \frac{150}{3600} = \frac{1}{24} \text{ veh/hour}$$

$$\text{Traffic intensity, } \rho = \frac{\lambda}{\mu} = \frac{\left(\frac{1}{36}\right)}{\left(\frac{1}{24}\right)} = \frac{24}{36} = \frac{2}{3}$$

Average time spent by the vehicle in the system,

$$\bar{d} = \frac{1}{\mu(1-\rho)} = \frac{1}{\frac{1}{24} \times \left(1 - \frac{2}{3}\right)} = 72 \text{ seconds}$$

Average time spent by the vehicle in the queue,

$$\bar{w} = \frac{\rho}{\mu(1-\rho)} = \frac{\left(\frac{2}{3}\right)}{\frac{1}{24}\left(1 - \frac{2}{3}\right)} = \frac{2}{3} \times 72 = 48 \text{ seconds}$$

Total time spent in the system and in queue = 72 + 48 = 120 seconds.

30. (c)

$$\text{Group Index, GI} = 0.2\,a + 0.005\,ac + 0.01\,bd$$

Soil portion passing 0.075 mm sieve, $P = 45\%$

$$\text{LL} = 40\%, \quad \text{PI} = 15\%$$

$$a = P - 35 = 10 < 40$$

$$b = P - 15 = 30 < 40$$

$$c = \text{LL} - 40 = 0$$

$$d = \text{PI} - 10 = 5$$

$$\text{GI} = 0.2 \times 10 + 0 + 0.01 \times 30 \times 5$$

$$= 2 + 1.5 = 3.5$$

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