CLASS TEST

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HIGHWAY

CIVIL ENGINEERING

Date of Test :12/06/2024

ANSWER KEY

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

DETAILED EXPLANATIONS

1. (c)

Curve (a) or (d) $\rightarrow$ For flow value

Curve (b) $\rightarrow$ Percent voids filled with bitumen (VFB)

Curve (c) $\rightarrow$ Percent voids in total mix

2. (d)

Radius of Horizontal curve = 75 m

$$\text{Grade compensation} = \frac{30+R}{R} \le \frac{75}{R}$$

$$= \frac{30+75}{75} = 1.4$$

and $$\frac{75}{R} = \frac{75}{75} = 1\%$$

So, Grade compensation = 1%

$\therefore$ Compensated gradient

= Ruling gradient – grade compensation

= 6% – 1% = 5%

3. (b)

$$R = \frac{v^2}{127(e+f)} = \frac{362}{127(0.1+0.15)} = 40.82$$

4. (b)

Assuming V volume passed in peak hour. And for minimum peak hour volume, all volume of that hour, was passed in 10 min only.

So, $$\text{Min PHF10 min} = \frac{V}{\left(\frac{60}{10}\right)\times V} = \frac{1}{6} = 0.167$$

5. (c)

The theoretical specific gravity of the mix is given by,

$$G_t = \frac{100}{\frac{50}{2.56}+\frac{38.20}{2.65}+\frac{4.70}{2.70}+\frac{7.10}{1.10}} = 2.37$$

6. (d)

For standard load of 2055 kg or 105 kg/cm^2, the penetration will be 5.0 mm

So, $$CBR = \frac{\text{Applied load}}{\text{Standard load}}\times 100$$

$$= \frac{52.5}{105}\times 100 = 50\%$$

7. (d)

Let the PCU of other vehicle be 'x'. As number of vehicles of both classes are equal, therefore, we have 500 vehicle of each class. The capacity of the road will remain equal to 1500 vehicle/hour under similar conditions.

$$\Rightarrow \quad 1500 = 500 \times 1 + 500 \times x$$

$$x = 2$$

8. (b)

Extra widening required $W_e = W_m + W_{ps}$

$$\Rightarrow \quad W_e = \frac{n\ell^2}{2R} + \frac{V}{9.5\sqrt{R}} \qquad (n = 2 \text{ for } 7.0 \text{ m pavement width})$$

$$\Rightarrow \quad W_e = \frac{2\times 7^2}{2\times 250} + \frac{70}{9.5\sqrt{250}} = 0.662\text{m}$$

9. (b)

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

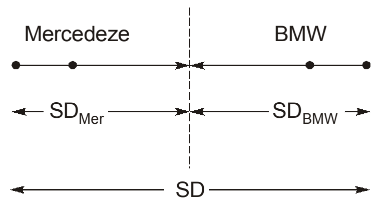
Assuming, $L > S$

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

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

10. (b)

11. (b)



$$\text{Stopping distance} = SD_{Mer} + SD_{BMW}$$

$$\text{Stopping distance for Mercedeze} = (0.278 V_{Mer})t + \frac{V_{Mer}^2}{254 f}$$

$$= 0.278\times 220\times 2 + \frac{220^2}{254\times 0.7\times 0.8}$$

$$= 462.59 \text{ m}$$

$$\text{Stopping distance for BMW} = 0.278\times 180\times 3 + \frac{180^2}{254\times 0.7\times 0.75} = 393.09 \text{ m}$$

$$\therefore \quad \text{Total stopping distance required} = 462.59 + 393.09$$

$$= 855.68 \text{ m}$$

12. (c)

Speed Range	Mean	Frequency	$V_i q_i$	$\frac{q_i}{V_i}$
2 – 6	4	2	8	0.5
7 – 11	9	5	45	0.555
12 – 14	13	1	13	0.0769
15 – 19	17	8	136	0.47
Total		16	202	1.60

$$\text{Time mean speed, } V_t = \frac{\Sigma q_i V_i}{\Sigma q_i} = \frac{202}{16} = 12.625$$

$$\text{Space mean speed, } V_s = \frac{\Sigma q_i}{\Sigma\left(\frac{q_i}{V_i}\right)} = \frac{16}{1.6} = 10$$

$$\text{Ratio of time mean speed to space mean speed} = \frac{12.625}{10} \simeq 1.26$$

13. (d)

14. (d)

15. (a)

16. (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,

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

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

17. (a)

Numbers of points of conflict:

Crossing : 4
Merging : 8
Weaving : 12

18. (c)

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

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

$$= 48.70 \text{ msa}$$

19. (d)

The mean time headway, $x = \bar{t} = \frac{T}{N} = \frac{1800}{200} = 9$ sec

Total number of headways counted = 200 – 1 = 199

$$P(h \le t) = 1 - e^{-(t/\bar{t})}$$

$$\therefore \quad P(h \le 18) = 1 - e^{-(18/9)} = 1 - e^{-2}$$

$$= 1 - 0.1353 = 0.8647$$

∴ Number of headways less than 18 seconds

$$= 199 \times 0.8647 = 172$$

20. (b)

Free mean speed, V_{sf} = 100 km/hr

Average spacing between vehicles = 6.1 m

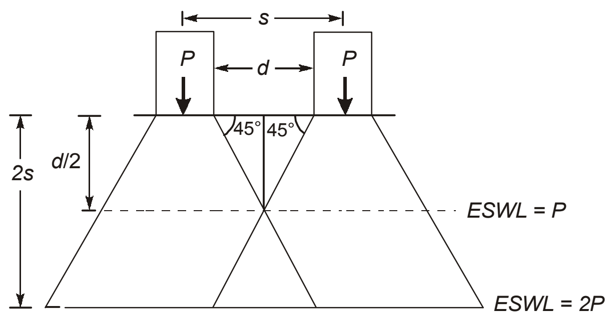
$$\text{Jam density, } K_j = \frac{1000}{6.1} = 163.93 \text{ veh/km}$$

$$\therefore \quad \text{Maximum flow} = \left(\frac{V_{sf} \times K_j}{4}\right) = \frac{100 \times 163.93}{4} = 4098.4 \text{ veh/hr}$$

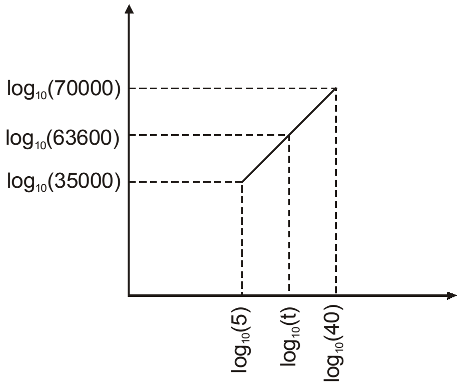
∴ Maximum flow capacity will be 4099 veh/hr.

21. (c)

d = 10 cm
P = 35 kN or 35000 N
s = 20 cm



ESWL of $\frac{d}{2}$ depth i.e. at 5 cm = 35000 N. ESWL at $2s$ depth i.e. at 40 cm = 2 × 35000 = 70000 N



By interpolation,

$$\Rightarrow \quad \log_{10}(63600) = \log_{10}(35000) + \frac{\log_{10}(70000) - \log_{10}(35000)}{\log_{10}(40) - \log_{10}(5)} \times (\log_{10}(t) - \log_{10}(5))$$

$$\Rightarrow \quad t = 30 \text{ cm}$$

22. (d)

Length of transition curve for satisfactory rate of change of centrifugal acceleration

$$L_S = \frac{v^3}{C \cdot R_C}$$

$$C = \frac{80}{75+V} = \frac{80}{75+40} = 0.70 \text{ m/s}^3 \qquad (0.5 \le C \le 0.8)$$

$$L_S = \frac{0.215 \times 40 \times 40 \times 40}{0.70 \times 60} = 32.65 \text{ m}$$

$$e = \frac{(0.75 \times V)^2}{127R} = \frac{0.75 \times 0.75 \times 40 \times 40}{127 \times 60} = 0.12$$

This is high and should be restricted to 0.07

Checking the safety against transverse skiding.

$$\Rightarrow \quad f = \frac{V^2}{127R} - e = \frac{40^2}{127 \times 60} - 0.07 = 0.14 < 0.15$$

$$\text{Extra widening on curve} = \frac{nl^2}{2R_C} + \frac{V}{9.5\sqrt{R_C}} = 2 \times \frac{6^2}{2 \times 60} + \frac{40}{9.5\sqrt{60}}$$

$$= 0.6 + 0.54 = 1.14, \text{ say } 1.2 \text{ m}$$

Pavement width = 7.0 + 1.2 = 8.2 m

Total raising of pavement = 0.07 × 8.2 = 0.57 m

Given that raising of pavement for superelevation is done by rotation about centre-line,

$$\text{Length of transition} = \frac{0.57}{2} \times 60 = 17.1 \text{m}$$

Higher value is adopted, therefore, length of transition curve is 32.65 m ≃ 32.7 m.

23. (a)

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

Here, λ = Number of vehicles

= 250 vehicles/hr

$$P(2, 25) = \frac{e^{\frac{-250\times 25}{3600}}\left(\frac{250}{3600}\times 25\right)^2}{2!} = 0.266 \simeq 0.27$$

24. (b)

Width of weaving section, W = 15 m

Average entry width, e = 8.1 m

Length of weaving section between channelizing islands,

L = 40 m

Proportion of weaving traffic is given by

$$p = \frac{\text{Crossing traffic on the weaving section}}{\text{Total traffic on the weaving section}}$$

$$\Rightarrow \quad p = \frac{1200}{2400} = 0.5$$

The capacity of the roundabout may be given as:

$$Q = \frac{280\,W\left(1+\frac{e}{W}\right)\left(1-\frac{p}{3}\right)}{1+\frac{W}{L}}$$

$$= \frac{280\times 15\left(1+\frac{8.1}{15}\right)\left(1-\frac{0.5}{3}\right)}{1+\frac{15}{40}} = 3920 \text{ PCU per hour}$$

25. (a)

Cycle time, C = 65 sec

Green time, G_i = 25 sec

Yellow time, Y_j = 4 sec

Saturation headway, h = 2.5 sec/veh

Start-up loss time = 2 sec

Clearance time = 2 sec

Effective green time, $g = G_i + Y_j - t_L$

$= 25 + 4 - (2 + 2) = 25$ sec

Green ratio $= \frac{25}{65}$

Actual capacity per lane $= \frac{3600}{2.5}\times\frac{25}{65} = 553.846 \simeq 553$ veh/hr/lane

26. (d)

Given: $h = 15$ cm

Modulus of elasticity of concrete cement,

$$E = 2.4 \times 10^5 \text{ kg/cm}^2$$

$$\text{Poisson's ratio, } \mu = 0.14$$

We know that,

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

$$= \left[\frac{2.4\times10^5\times(15)^3}{12\times3.5\times\left[1-(0.14)^2\right]}\right]^{1/4} = 66.598 \text{ m} \simeq 66.6 \text{ m}$$

27. (a)

$$e_{eq} = \frac{V^2}{127R}$$

28. (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

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

$$\text{Weekly average daily traffic} = \frac{4796.25\times DEF}{7} = \frac{4796.25\times5.7}{7} = 3905.52$$

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

29. (c)

Equilibrium superlevation:

$$f = 0$$

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

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

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

30. (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

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