CLASS TEST

S.No. : 01_PT_CE_ABC_240922

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HIGHWAY ENGINEERING

CIVIL ENGINEERING

Date of Test : 26/09/2022

ANSWER KEY

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

DETAILED EXPLANATIONS

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

2. (d)

Radius of Horizontal curve = 75 m

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

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

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

So, Grade compensation = 1%

∴ Compensated gradient

= Ruling gradient – grade compensation

= 6% – 1% = 5%

3. (a)

$$\text{Capacity} = \frac{1000V}{S}$$

$$S = 0.2V + L$$

$$= 0.2 \times 60 + 6 = 18 \text{ m}$$

$$\text{Capacity} = \frac{1000\times 60}{18} \times 2 = 6666.7 \simeq 6700$$

The closest answer is 6800.

4. (b)

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

5. (c)

$$CBR_{2.5} = \frac{\text{Load sustained by specimen at 2.5 mm penetration}}{\text{Load sustained by standard aggregate at 2.5 mm penetration}} \times 100$$

$$= \frac{60}{1370} \times 100 = 4.379 \simeq 4.38\%$$

$$\text{CBR}_{5.0} = \frac{\text{Load sustained by specimen at 5.0 mm penetration}}{\text{Load sustained by standard aggregate at 5.0 mm penetration}} \times 100$$

$$= \frac{80}{2055} \times 100 = 3.89\%$$

6. (a)

Given:

$$n_a = 21,\ n_w = 350,\ V = 70 \text{ kmph}$$

$$T_w = T_a = \frac{8}{70} \text{ hr}$$

$$q = \frac{n_a + n_w}{T_a + T_w} = \frac{350 + 21}{\left(\frac{8}{70} + \frac{8}{70}\right)} \simeq 1624 \text{ vehicles/hr}$$

7. (c)

The theoretical specific gravity of the mix is given by,

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

8. (d)

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

9. (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

10. (c)

$$\frac{\Delta_{flexible}}{\Delta_{rigid}} = \frac{1.5}{1.18} = 1.27$$

11. (d)

12. (d)

13. (a)

Numbers of points of conflict:

Crossing : 4

Merging : 8

Weaving : 12

14. (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,

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

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

15. (d)

Given: $$V = 60 \text{ kmph} = \frac{60 \times 1000}{60 \times 60} = 16.67 \text{ m/s}$$

$$\text{SSD} = Vt + \frac{V^2}{2g\left(f + \frac{n\%}{100}\right)}$$

$$= 16.67 \times 2.5 + \frac{(16.67)^2}{2 \times 9.81 \times (0.36 + 0.02)}$$

$$= 78.948 \simeq 78.95 \text{ m}$$

$$\therefore \quad \text{ISD} = 2 \times \text{SSD} = 157.9 \text{ m}$$

16. (a)

$$L = 2\left[\frac{NV^3}{c}\right]^{1/2}$$

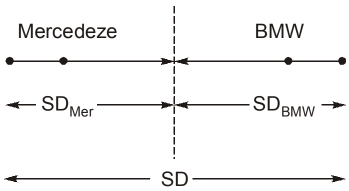
$$= 0.38\left[NV^3\right]^{1/2} \qquad \left[\because c = 0.6 \text{ m/s}^3\right]$$

$$N = -\frac{1}{45} - \left(\frac{1}{60}\right) = \frac{-7}{180}$$

$$\therefore \quad L = 0.38\left[\frac{7}{180} \times 75^3\right]^{1/2}$$

$$= 48.67 \text{ m}$$

17. (b)



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

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

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

$$= 462.59 \text{ m}$$

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

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

$$= 855.68 \text{ m}$$

18. (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

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

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

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

19. (d)

$$V_v = \frac{G_t - G_m}{G_t} \times 100$$

$$= \frac{2.464 - 2.318}{2.464} \times 100 = 5.925\%$$

$$\text{Voids filled with bitumen, } V_b = G_m \times \frac{W(\%)}{G_b}$$

$$= 2.318 \times \frac{5.5}{1.12} = 11.383\%$$

$$\text{VMA} = V_v + V_b$$

$$= 5.925 + 11.383 = 17.308\%$$

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

$$= \frac{11.383}{17.308} \times 100 = 65.767\% \simeq 65.77\%$$

20. (a)

21. (d)

$$\text{Deflection, } \Delta = \frac{1.5pa}{E_s}$$

where, p = Contact pressure due to wheel load = 0.5 MPa, a = Radius of contact area

Now, $$\text{Contact area} = \frac{\text{Wheel load}}{\text{Type pressure}}$$

$$= \frac{50 \times 10^3 \text{ N}}{0.5} = 100 \times 10^3 \text{ mm}^2$$

But $$\text{Area} = \pi \times a^2$$

$$= 100 \times 10^3$$

$$\therefore \quad a = \sqrt{\frac{100 \times 10^3}{\pi}} = 178.41 \text{ mm}$$

$$E_s = 20 \text{ MPa}$$

So, $$\Delta = \frac{1.5 \times 0.5 \times 178.41}{20} = 6.69 \text{ mm}$$

22. (b)

$$\text{Traffic flow, } q = uk$$

$$= 60k - 0.75k^2$$

For maximum q,

$$\frac{dq}{dk} = 0$$

$$\Rightarrow \quad \frac{dq}{dk} = 60 - 1.5k = 0$$

$$\Rightarrow \quad k = 40$$

$$\therefore \quad u = 60 - 0.75 \times 40 = 30 \text{ km/h}$$

$$\therefore \quad q = 30 \times 40 = 1200 \text{ veh/h}$$

23. (c)

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

w = 15 m, p = 0.6, L = 75 m, e = 5 m

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

24. (a)

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

where, λ = Average rate of arrival,
t = time interval
n = Number of vehicles

$P(n)$, is the probability of n events (vehicle arrival) in some time interval t.

$$\Rightarrow \quad \lambda = \frac{200}{30\times 60} = \frac{1}{9} \text{ vehicle/sec}$$

Now probability that the headway (into arrival time) greater than or equal to 5 sec is

$$P(n=0) = \frac{\left(\dfrac{1}{9}\times 5\right)^0 \times e^{-\left(\frac{1}{9}\times 5\right)}}{0!} = e^{-\frac{5}{9}} = 0.573$$

25. (b)

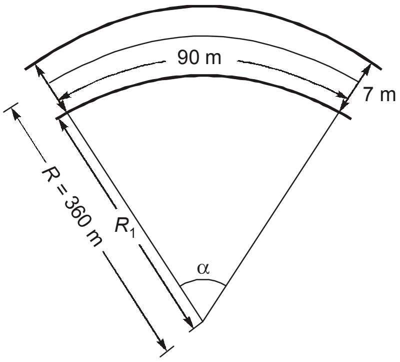
We know that, $C_0 = \dfrac{1.5L+5}{1-Y}$

L = 9 sec

$$Y = \frac{800}{2000} + \frac{900}{3000} = 0.7$$

$$C_0 = \frac{1.5\times 9+5}{1-0.7} = 61.67 \simeq 62 \text{ sec}$$

26. (b)



$\Rightarrow$ We know that, $R_1\alpha$ = SSD,

$$R_1 = 360 - \frac{3.5}{2} = 358.25 \text{ m}$$

$$358.25 \times \alpha = 90$$

$$\alpha = 0.251 \text{ radian} = 14.39°$$

For set back distance

We know, $$m = R - (R-d)\cos\frac{\alpha}{2}$$

$$= 360 - (360 - 1.75)\cos\left(\frac{14.39}{2}\right)$$

$$m = 4.57 \text{ m}$$

Set back distance from center line of inner lane = $m - d$ = 4.57 – 1.75 = 2.82 m

27. (c)

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

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

$$= 48.70 \text{ msa}$$

28. (c)

During stoppage number of vehicle passes = 40

Stoppage time = 10 min

$$\text{Stream flow } (q) = 40 \times \frac{60}{10} = 240 \text{ veh/hr}$$

$$\eta_y = \text{Number of overtaking vehicles} - \text{Number of overtaken vehicle}$$

$$= 70 - 25 = 45$$

$\Rightarrow$ We know that,
$$\eta_y = q[t_w - \bar{t}\,]$$

$$\bar{t} = t_w - \frac{\eta_y}{q} = \left(\frac{25}{60}\right) - \left(\frac{45}{240}\right) = 0.2292 \text{ hr}$$

$$\text{Average speed} = \frac{12}{0.2292} \simeq 52.36 \text{ km/hr}$$

29. (a)

Axle load (kN)	Mean Axle load (kN)	Load factor $(L/80)^4$	Repeation (N)	
20-30	25	9.536×10^{-3}	2000	19.072
30-40	35	0.0366	1000	36.60
40-50	45	0.100	1500	150
50-60	55	0.223	500	111.5
			$\Sigma N_s = 5000$	317.172

$$\text{Vehicle damage factor} = \frac{317.172}{2100} \simeq 0.15$$

30. (b)

Maximum expansion allowed,

$$\delta = \frac{3}{2} = 1.5 \text{ cm} = 1.5 \times 10^{-2} \text{ m}$$

$$\Delta T = T_2 - T_1 = 30°\text{C}$$

Coefficient of thermal expansion,

$$\alpha = 10 \times 10^{-6}/°\text{C}$$

$\therefore$ Spacing of expansion joint, L

$$= \frac{\delta}{\alpha(T_2 - T_1)} = \frac{1.5 \times 10^{-2}}{10 \times 10^{-6} \times 30} = 50 \text{ m}$$

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