CLASS TEST

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HIGHWAY ENGINEERING

CIVIL ENGINEERING

Date of Test : 21/07/2022

ANSWER KEY

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

DETAILED EXPLANATIONS

1. (c)

In case of flexible pavement the no. of repetition to failure decrease with increase of stiffness.

3. (c)

$$\text{Curve resistance} = T(1-\cos\alpha) = 60\,(1-\cos 60°) = 30\text{ kN}$$

4. (c)

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

5. (a)

When the gradients are not equal, the lowest point lies on the side of flatter grade, and this point is at a distance $x = L\sqrt{\frac{n_1}{2N}}$ from the tangent point of the first grade n_1.

$$N = n_1 + n_2 = \left|\frac{-2}{100} - \frac{1}{100}\right| = 0.03$$

$$\therefore \quad x = 100\sqrt{\frac{0.02}{2\times 0.03}} = \frac{100}{\sqrt{3}} = 57.7\text{ m}$$

8. (d)

For mixed traffic conditon, super elevation is provided for 75% of design speed. Emergency escapes are provided on down grades so that in case of brake failure or system failure vehicle can be controlled.

9. (a)

Given: $n_a = 21,\ n_w = 350,\ V = 70$ kmph

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

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

10. (c)

$$\text{Capacity} = \text{Velocity} \times \text{Density}$$

$$C = u \times k = 65\,k - 0.65\,k^2$$

Now,

$$\frac{dC}{dk} = 65 - 1.3\,k = 0$$

$$k = \frac{65}{1.3} = 50$$

$$\therefore \quad \text{Capacity, } C = 65 \times 50 - 0.65 \times 50^2 = 1625\text{ veh/hr}$$

11. (a)

$$y_a = \frac{q_a}{S_a} = \frac{400}{1250} = 0.32$$

$$y_b = \frac{q_b}{S_b} = \frac{250}{1000} = 0.25$$

$$Y = y_a + y_b = 0.32 + 0.25 = 0.57$$

$$L = 2n + R = 2 \times 2 + 12 = 16 \text{ sec}$$

$$C_0 = \frac{1.5L+5}{1-Y} = \frac{1.5\times16+5}{1-0.57}$$

$$= \frac{29}{0.43} = 67.44 \text{ sec}$$

$$G_a = \frac{y_a}{Y}(C_0 - L) = \frac{0.32}{0.57}(67.44-16) = 28.88 \text{ sec}$$

$$G_b = \frac{y_b}{Y}(C_0 - L) = \frac{0.25}{0.57}(67.44-16) = 22.56 \text{ sec}$$

All red time for pedestrian crossing = 12 sec

Providing Amber times of 2.0 sec each for clearance, total cycle time

$$= 28.88 + 22.56 + 12 + 4 = 67.44 \approx 67.4 \text{ sec}$$

12. (b)

Length of transition curve based on rate of change of superelevation is given by,

$$L_S = \frac{v^3}{CR}$$

$$C = \frac{80}{75+V} = \frac{80}{75+80} = 0.5161 \text{ m/s}^3$$

As the value of C is $0.5 < C < 0.8$, we can apply the formula.

$$L_S = \frac{(0.278\times80)^3}{0.5161\times150} = 142.095 \text{ m}$$

According to IRC formula,

$$L_S = \frac{2.7V^2}{R} = \frac{2.7\times80^2}{150} = 115.2 \text{ m}$$

Maximum of the above two values is taken as length of transition curve,

i.e. $L_S = 142$ m

13. (c)

Expansion joint spacing = L_s

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

$$\delta' = \frac{1}{2}\times(\text{expansion joint gap}) = 1.25 \text{ cm}$$

$$\therefore \quad L_s = \frac{1.25}{100\times10^{-5}\times30} = 41.7 \text{ m}$$

Contraction joint spacing

$$L_c = \frac{2S_c\times10^4}{W.f} = \frac{2\times0.8\times10^4}{2400\times1.5} = 4.4 \text{ m}$$

14. (b)

Overtaking sight distance for one way traffic = $d_1 + d_2$

$$d_1 = 0.278\, V_b \times t_R = 0.278 \times 50 \times 2 = 27.8 \text{ m}$$

$$d_2 = 0.278\, V_b T + 2S$$

$$S = 0.7\, V_b + 6 = 0.2\left(\frac{50 \times 1000}{3600}\right) + 6 = 16 \text{ m}$$

$$T = \sqrt{\frac{4s}{a}} = \sqrt{\frac{4 \times 16}{1}} = 8 \text{ sec}$$

$$d_2 = 0.278 \times 50 \times 8 + 2 \times 16 = 143.2 \text{ m}$$

$$\therefore \quad \text{OSD} = d_1 + d_2 = 27.8 + 143.2 = 171 \text{ m}$$

15. (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,

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

16. (a)

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

Traffic flow after 3 year,

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

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

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

$$\text{Equivalent axle load} = 365 \times 6643.72 \times \frac{\left[(1 + 0.065)^{15} - 1\right]}{\left(\frac{6.5}{100}\right)} \times 0.018 \times 1 = 1.05 \text{ msa}$$

17. (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

$$= \frac{\delta}{\alpha(T_2 - T_1)} = \frac{1.5\times10^{-2}}{10\times10^{-6}\times30} = 50 \text{ m}$$

18. (c)

Braking distance for travelling upgrade,

$$S_1 = \frac{V^2}{254(f+0.01n)}$$

Braking distance for travelling downgrade

$$S_2 = \frac{V^2}{254(f-0.01n)}$$

Give, $S_2 = 2S_1$

$$\Rightarrow \quad \frac{1}{(f-0.01n)} = \frac{2}{f+0.01n}$$

$$\Rightarrow \quad 2f - 0.02\,n = f + 0.01\,n$$

$$\Rightarrow \quad n = \frac{f}{0.03} = \frac{0.3}{0.03} = 10\%$$

19. (d)

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

$$= \frac{30+100}{100} \leq \frac{75}{100} = 1.3 \geq 0.75$$

As $1.3 > 0.75$

$\therefore$ Grade compensation $= 0.75$

Note : Here grade compensation is asked, not the compensated gradient, so no need to subtract it from the given grade.

20. (d)

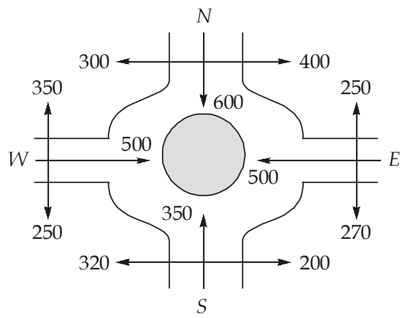
$$\text{Optimum signal cycle, } C_0 = \frac{1.5L+5}{1-(y_A+y_B)} = \frac{1.5\times10+5}{1-(0.15+0.45)} = 50 \text{ seconds}$$

Flow on road A = Green time of road A

$$\Rightarrow \quad G_A = \frac{y_A}{y}(C_0 - L) = \frac{0.15}{0.6}(50-10) = 10 \text{ seconds}$$

$$\text{Percent time flow on road } A = \frac{G_A}{C_0}\times100 = \frac{10}{50}\times100 = 20\%$$

21. (c)



$$p = \text{Weaving ratio} = \frac{b+c}{a+b+c+d}$$

where b and c are weaving traffic and a and d are non weaving traffic.

For North-East:

$$a = 400; \quad b = (600 + 300) = 900;$$
$$c = 500 + 200 = 700; \quad d = 250$$

$$\therefore \quad p = \frac{900+700}{400+900+700+250} = 0.71$$

22. (b)

Given, $V = 40$ km/hr $= 11.11$ m/s

$$\text{Braking distance on flat road} = Vt + \frac{V^2}{2gf} = 46 \text{ m} \quad \text{...(i)}$$

$$\text{Braking distance on descending road} = Vt + \frac{V^2}{2g(f_b - n\%)} = 60 \text{ m} \quad \text{...(ii)}$$

Subtracting (i) from (ii),

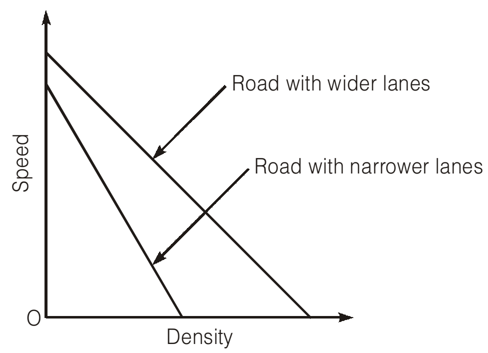
$$\Rightarrow \quad \frac{V^2}{2g}\left(\frac{1}{f_b - n\%} - \frac{1}{f}\right) = 14$$

$$\Rightarrow \frac{(11.11)^2}{2 \times 9.81} \times \left(\frac{1}{0.40 \times 0.9 - n} - \frac{1}{0.40}\right) = 14$$

$$0.40 - (0.40 \times 0.9 - n) = (2.22)(0.40)(0.4 \times 0.9 - n)$$
$$0.40 \times 0.1 + n = 0.32 - 0.89n$$
$$1.89n = 0.32 - 0.040$$
$$n = 0.1481 = 14.81\%$$

24. (b)

Both free flow speed and jam density will be lesser in the case of the narrow lane width road than in the case for a wide lane width road. Further the speed at any given density is expected to be lower on the narrow road. This is because individual drivers will drive at a lesser speed at a given distance headway than they would have done on the wider road possibly due to a higher perception of threat to ones safety on the narrow road.



25. (b)

	Corner (kg/cm^2)	Edge (kg/cm^2)	Interior (kg/cm^2)
Wheel load	25 (T) 25 (C)	28 (T) 28 (C)	23 (C) 23 (T)
Warping stress (summer)	8 (C) 8 (T)	9 (C) 9 (T)	10 (C) 10 (T)
Warping stress (winter)	6 (T) 6 (C)	7 (T) 7 (C)	8 (T) 8 (C)
Frictional stress (summer)	0	5 (C)	5 (C)
Frictional stress (winter)	0	4 (T)	4 (T)

Tension is critical in concrete slab,
So, combinations are:

At corner (top) = 25 + 6 = 31 kg/cm^2
At edge (top) = 28 + 7 + 4 = 39 kg/cm^2
at interior (bottom) = 23 + 10 + 4 = 37 kg/cm^2

∵ Warping stress depends on daily variation.

26. (d)

$$\text{Total lost time} = 2n + R = 2 \times 2 + 8 = 12 \text{ sec}$$

$$C_0 = \frac{1.5L+5}{1-\left(\frac{q_1}{s}+\frac{q_2}{s}\right)} = \frac{1.5\times 12+5}{1-\left(\frac{800}{2500}+\frac{1200}{3000}\right)} = 82.14 \text{ sec} \approx 85 \text{ sec}$$

28. (d)

$$\frac{t_1}{t_2} = \left(\frac{c_2}{c_1}\right)^{1/5}$$

$$\therefore \quad c_2 = \left(\frac{10}{7.5}\right)^5 \times 60 = (1.33)^5 \times 60 \simeq 250$$

29. (b)

Worst combination of stresses in summer will be at the bottom of pavement

= load stress + warping stress – frictional stress
= 30 + 8 – 7
= 31 kN/m^2

30. (b)

Camber is provided to drain rain water from the surface of pavement. Therefore higher the absorbing capacity of surface, lower will be the camber required to drain water quickly. So correct sequence in order of steepness of camber is

Cement Concrete roads < Bituminous high speed roads < WBM roads < Gravel roads.

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