CLASS TEST

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HIGHWAY ENGINEERING

CIVIL ENGINEERING

Date of Test : 19/03/2023

ANSWER KEY

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

DETAILED EXPLANATIONS

1. (c)

Deviation angle, $N = |n_1 - n_2|$

$= |(-4.2 - 3.3)| = |-7.5\%|$ (valley) = 7.5%

Location of deepest point,

$$x = \left(\frac{n_1}{2N}\right)^{1/2} L_V = \left(\frac{4.2}{2 \times 7.5}\right)^{1/2} \times 280 = 148.16 \text{ m}$$

2. (c)

The deformation at the failure point expressed in units of 0.25 mm is called the Marshall flow value of the specimen.

3. (c)

$$\text{Daily expansion factor, DEF} = \frac{\text{Average traffic volume per week}}{\text{Average traffic volume per day}}$$

$$= \frac{250500}{32000} = 7.828$$

4. (b)

$$\text{Space mean speed} = \frac{nL}{\Sigma \text{time}} = \frac{4 \times 400 \times 10^{-3}}{\left(\frac{400}{25} + \frac{400}{35} + \frac{400}{42} + \frac{400}{48}\right) 10^{-3}} = 35.33 \text{ km/hr}$$

5. (b)

$$\text{Jam density} = K_j = \frac{1000}{7} \text{ veh/km}$$

$$\text{Maximum flow} = \left(\frac{V_{S_f} \times K_j}{4}\right) = \frac{84 \times \frac{1000}{7}}{4} = 3000 \text{ veh/hr}$$

6. (b)

CBR method, Group index method, McLeod and Burmister method are some of the methods which are used in the design of flexible pavements.

7. (a)

Viscosity test: Viscosity is the general term for consistency and it is a measure of resistance of flow.

Ductility test: Used to measure the adhesiveness or elasticity of bitumen.

Penetration test: Determine hardness or softness of bitumen.

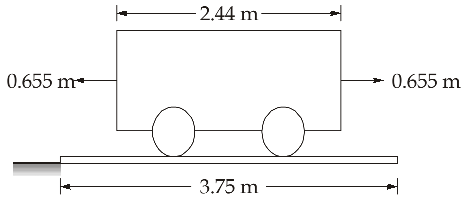
Softening point test: It is the temperature at which the substance attains a particular degree of softening under specified conditions of test.

8. (d)

$$R_{\text{ruling}} = \frac{V^2}{127(e+f)} = \frac{80^2}{127(0.07 + 0.13)} = 251.97 \text{ m} \simeq 252 \text{ m}$$

9. (c)

As per IRC, the maximum permissible width of vehicle is 2.44 m and the desirable side clearance for single lane carriageway is 0.655 m. This require minimum of lane width of 3.755 m for a single lane road.



Single lane

10. (c)

Summit curve: Summit curves are vertical curves with convexity upward. The design of a summit curve is governed by consideration of sight distance.

11. (a)

$$\text{ISD - SSD} = 93.2 \text{ m} \quad \text{(Headlight sight distance = Stopping sight distance)}$$

But $\quad \text{ISD} = 2\,\text{SSD}$

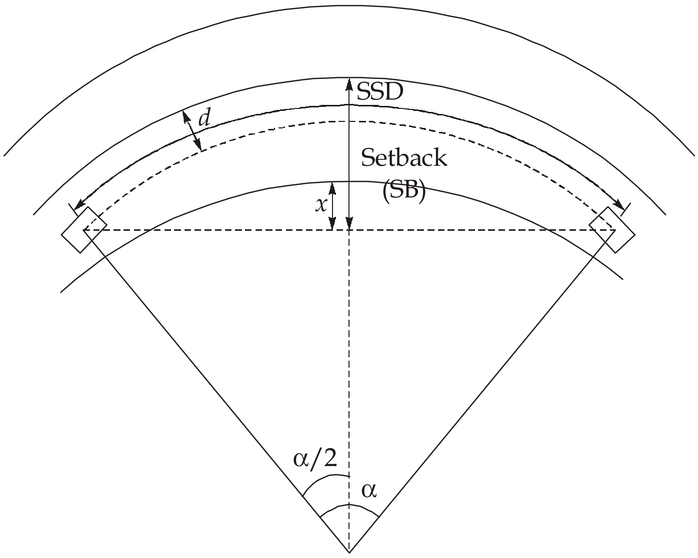
So, $\quad \text{SSD} = 93.2 \text{ m}$

$$\therefore \quad \text{SSD} = 0.278V \times t + \frac{(0.278 \times V)^2}{2gf}$$

$$\Rightarrow \quad 93.2 = 0.278 \times 65 \times 2.5 + \frac{(0.278 \times 65)^2}{2 \times 9.81 \times f}$$

$$\Rightarrow \quad f = 0.3465 \simeq 0.35$$

12. (d)



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

$$\therefore \quad L_c \text{ (225 m)} > \text{SSD (90 m)}$$

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

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

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

$$= 4.443 \text{ m}$$

Setback distance from mid of the inner lane (x)

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

13. (c)

Assume $L > \text{SSD}$

$$L = \frac{NS^2}{\left(\sqrt{2h_1} + \sqrt{2h_2}\right)^2} = \frac{NS^2}{2\left(\sqrt{h_1} + \sqrt{h_2}\right)^2}$$

$$N = n_1 - n_2 = \frac{1}{55} - \left(-\frac{1}{50}\right) = 0.0382$$

$$S = 190 \text{ m}$$

h_1 = height of driver's eye

h_2 = height of object

$$\therefore \quad L = \frac{0.0382 \times 190^2}{2\left(\sqrt{1.15} + \sqrt{0.21}\right)^2}$$

$$\Rightarrow \quad L = 294.304 \text{ m} > 190 \text{ m} \quad \text{(Safe)}$$

14. (a)

Spacing between contraction joints

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

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

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

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

15. (c)

$$\text{Capacity of rotary} = \frac{280w\left(1 + \frac{e}{w}\right)\left(1 - \frac{P}{3}\right)}{1 + \frac{w}{l}} = \frac{280 \times 15 \times \left(1 + \frac{5.2}{15}\right)\left(1 - \frac{0.69}{3}\right)}{1 + \frac{15}{82}}$$

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

16. (a)

Effective green time = Green time + Amber time – Startup loss – Clearance time

= 27 + 3.5 – 2.5 – 1.5 = 26.5 second

$$\text{Saturation flow} = \frac{3600}{\text{Saturation time headway}}$$

$$= \frac{3600}{2.5} = 1440 \text{ veh/hr}$$

$$\text{Actual capacity} = \text{Saturation flow} \times \frac{\text{Effective green time}}{\text{Cycle time}}$$

$$= 1440 \times \frac{26.5}{60} = 636 \text{ veh/hr}$$

17. (a)

Vehicle Damage Factor (VDF),

$$= 0.08\left[\frac{20}{8.2}\right]^4 + 0.16\left[\frac{18}{8.2}\right]^4 + 0.36\left[\frac{16}{8.2}\right]^4 + 0.15\left[\frac{12}{8.2}\right]^4 + 0.25\left[\frac{8}{8.2}\right]^4$$

$$= 2.831 + 3.715 + 5.218 + 0.688 + 0.226$$

$$= 12.678$$

$$N_s = \frac{365A\left[(1+r)^n - 1\right]\times D\times F}{r}\times\frac{1}{10^6}$$

$$= \frac{365\times 6000\left[(1+0.08)^{20} - 1\right]\times 1.3\times 12.676}{0.08}\times\frac{1}{10^6}$$

$$= 1651.7 \simeq 1652 \text{ msa}$$

18. (d)

Theoretical specific gravity, $G_t = \dfrac{w_1 + w_2 + w_3 + w_4}{\dfrac{w_1}{G_1} + \dfrac{w_2}{G_2} + \dfrac{w_3}{G_3} + \dfrac{w_4}{G_b}}$

$$= \frac{45 + 40.8 + 4.2 + 10}{\dfrac{45}{2.65} + \dfrac{40.8}{2.72} + \dfrac{4.2}{2.60} + \dfrac{10}{1.10}} = 2.34$$

Effective specific gravity of aggregates (coarse + fine) is given by

$$G' = \frac{(45\times 2.65) + (40.8\times 2.72)}{45 + 40.8} = 2.68$$

19. (d)

$$L = 2\left[\frac{NV^3}{C}\right]^{1/2} = 0.38\left[NV^3\right]^{1/2} \qquad \text{(where } C = 0.6 \text{ m/s}^3\text{)}$$

$$N = \frac{1}{50} - \left(-\frac{1}{60}\right) = \frac{1}{50} + \frac{1}{60} = 0.03667$$

$\therefore$ $$L = 0.38\left[0.03667\times 75^3\right]^{1/2}$$

$\Rightarrow$ $$L = 47.26 \text{ m}$$

20. (a)

Given, $h = 25$ cm, $E = 3\times 10^5$ kg/cm^2, $\mu = 0.15$, $k = 6$ kg/cm^3

$$L = \left[\frac{Eh^3}{12k\left(1-\mu^2\right)}\right]^{1/4} = \left[\frac{3\times 10^5\times 25^3}{12\times 6\left\{1-(0.15)^2\right\}}\right]^{1/4}$$

$\Rightarrow$ $$L = 90.34 \text{ cm}$$

21. (c)

$$N_{S_1} = \frac{365A_1\left[(1+r)^n - 1\right]}{r}\times F = \frac{365\times 1800\left[\left(1+\dfrac{8}{100}\right)^{12} - 1\right]}{\dfrac{8}{100}\times 10^6}\times 4$$

$$= 49.87 \text{ msa}$$

$$N_{S_2} = \frac{365A_2\left[(1+r)^n - 1\right]}{r} \times F_2 = \frac{365 \times 300\left[(1+0.08)^{12} - 1\right]}{0.08 \times 10^6} \times 7$$

$$= 14.55$$

$$\therefore \quad N_s = N_{S_1} + N_{S_2} = 49.87 + 14.55 = 64.42 \text{ msa}$$

22. (b)

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

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

Optimum cycle time, $C_0 = \dfrac{1.5L+5}{1-Y} = \dfrac{1.5 \times 16 + 5}{1-0.6}$ = 72.5 sec $\simeq$ 73 sec (say)

23. (c)

Equilibrium superlevation:

$$f = 0$$

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

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

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

24. (c)

$$\text{SSD} = 0.278Vt + \frac{V^2}{254(Kf+n)}$$

where, $K = 0.6$, $f = 0.7$ and $n = 0.025$

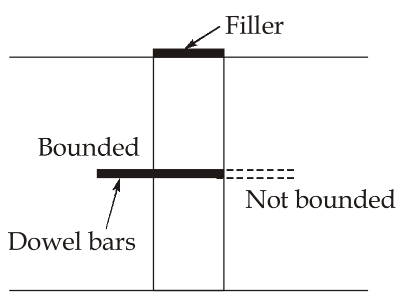
$$\therefore \quad \text{SSD} = 0.278 \times 100 \times 2.5 + \frac{100^2}{254(0.6 \times 0.7 + 0.025)} = 69.5 + 88.47$$

$$= 157.97 \text{ m} \simeq 158 \text{ m}$$

25. (c)

At the expansion joint, dowel bars are provided which develops bending, bearing and shearing stresses and helps in load transfer.

Sometime dowel bars also provided at contraction joint.



Longitudinal joints are provided along the length of pavement, we generally provides tie bars at the longitudinal joint.

26. (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. As 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.

27. (b)

Marshall test is used for design of bituminous concrete mix i.e., option (b) is correct.

28. (a)

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

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

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

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

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

29. (c)

Space headway, $S = 45t - 45t^2$

$\therefore \quad \frac{dS}{dt} = 45 - 90t = 0$

$\Rightarrow \quad t = 0.5 \text{ hr} = 30 \text{ minutes}$

$\frac{d^2S}{dt^2} = -90 < 0$

Thus t = 30 min will give maximum headway.

$\therefore$ Maximum space headway,

$$S_{max} = 45 \times 0.5 - 45 \times (0.5)^2 = 11.25 \text{ km}$$

30. (c)

The spacing of expansion joint is given by

$$L_e = \frac{\delta}{2\alpha\Delta T}$$

$$= \frac{2\times 10}{2\times 10\times 10^{-6}\times(50-20)} = 33333.33 \text{ mm} = 33.33 \text{ m}$$

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