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HIGHWAY

CIVIL ENGINEERING

Date of Test : 24/09/2026

ANSWER KEY ➤

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

DETAILED EXPLANATIONS

1. (c)

Mean vehicular arrival rate, $v = 3$ veh/min

Probability that atleast 1 vehicle will arrive in any given 1 minute

$$\begin{aligned} &= P(n \geq 1) = 1 - [P(n = 0)] \\ &= 1 - \left[\frac{(vt)^n \cdot e^{-vt}}{n!} \right] = 1 - \left[\frac{(3 \times 1)^0 \cdot e^{-3 \times 1}}{0!} \right] = 1 - e^{-3} \\ &= 0.9502 \approx 0.95 \end{aligned}$$

2. (d)

Absolute ruling minimum radius,

$$\begin{aligned} R_{\text{ruling}} &= \frac{V^2}{127(e + f)} \\ &= \frac{(110)^2}{127 \times (0.07 + 0.15)} \\ &= \frac{12100}{127 \times 0.22} = 433 \text{ m} \end{aligned}$$

3. (d)

$$\text{Grade compensation} = \text{Minimum of } \begin{cases} \frac{30 + R}{R} = \frac{30 + 60}{60} = 1.5\% \\ \frac{75}{R} = \frac{75}{60} = 1.25\% \end{cases}$$

$$\therefore \text{Grade compensation} = 1.25\%$$

$$\text{Compensated gradient} = 5 - 1.25 = 3.75\% \text{ but } \nless 4\%$$

$$\therefore \text{Compensated gradient} = 4\%$$

$$\text{Grade compensation allowed} = 5 - 4 = 1\%$$

4. (a)

2.5 sec is 90th percentile of reaction time.

5. (c)

$$\begin{aligned} \frac{100}{G_t} &= \frac{45}{2.56} + \frac{40}{2.65} + \frac{5}{2.7} + \frac{10}{1.10} \\ \Rightarrow G_t &= 2.29 \approx 2.3 \end{aligned}$$

6. (d)

$$N = \frac{365[(1+r)^n - 1]}{r} A \times D \times F$$

where, A is number of commercial vehicle per day, F is vehicle damage factor,

D is lane distribution factor

Now, lane distribution factor for intermediate lane is 0.75.

$$\therefore N = \frac{365}{0.05} [(1.05)^{15} - 1] \times 1500 \times 0.75 \times 2.5 \times 10^{-6}$$

$$\Rightarrow N = 22.15 \text{ msa}$$

7. (b)

For thin bituminous surface in high rainfall area, the value of camber is 2.5%.
Hence, the radius beyond which no superelevation is required is given as

$$R = \frac{V^2}{225(\text{Camber})} = \frac{90^2}{225(0.025)} = 1440 \text{ m}$$

8. (a)

Total number of repetitions in terms of standard axle load of 80 kN

$$= 400 \times \left(\frac{50}{80}\right)^4 + 700 \left(\frac{60}{80}\right)^4 = 282.52$$

9. (a)

Speed (in km/hr) $U = 50 - 0.5k$

$$\Rightarrow U = 50 \left[1 - \frac{k}{\frac{50}{0.5}} \right]$$

Now, free flow speed, $V_f = 50 \text{ kmph}$

Jam density, $k_j = \frac{50}{0.5} = 100 \text{ veh/km}$

Capacity flow, $q_{\max} = \frac{V_f \cdot k_j}{4} = \frac{50 \times 100}{4} = 1250 \text{ veh/hr}$

Now, $q_{\max} = \frac{3600}{h}$

where h is average time headway in seconds

$$\therefore h = \frac{3600}{1250} = 2.88 \text{ sec}$$

Hence, the average time headway will be 2.88 sec.

10. (d)

$$\text{Stopping sight distance, SSD} = 0.278 \cdot V \cdot t_r + \frac{V^2}{254 \left[\eta f - \frac{G}{100} \right]}$$

where η is brake efficiency and G is descending gradient

$$\therefore \text{SSD} = 0.278 \times 80 \times 2.5 + \frac{80^2}{254 [0.4 \times 0.7 - 0.03]} = 156.39 \text{ m} \approx 157 \text{ m (say)}$$

$\therefore$ Provide stopping sight distance as 157 m.

11. (a)

Braking duration, $t = 1.5 \text{ sec}$

Braking distance = 7.8 m

$$v = u + at$$

As final velocity, $v = 0$

$$\therefore u = -at \quad \dots(i)$$

$$\text{Also, } v^2 - u^2 = 2as$$

$$\Rightarrow -u^2 = -2as \quad \dots(ii)$$

Using (i) and (ii), we get

$$\Rightarrow a^2 t^2 = 2as$$

$$\Rightarrow a = \frac{2s}{t^2} = \frac{2 \times 7.8}{(1.5)^2}$$

Average skid resistance developed,

$$f = \frac{a}{g} = \frac{2 \times 7.8}{9.81 \times (1.5)^2} = 0.7068$$

$$\text{Brake efficiency} = \frac{0.7068}{0.8} \times 100 = 88.35\% \approx 88.4\%$$

12. (c)

Weight of specimen in air = 1240.1 gm

Weight of specimen coated with paraffin in air = 1272.4 gm

$$\begin{aligned} \text{Weight of paraffin wax} &= 1272.4 - 1240.1 \\ &= 32.3 \text{ gm} \end{aligned}$$

Weight of coated specimen in water = 671.1 gm

$$\Rightarrow \frac{1272.4 - 671.1}{1} = V_{\text{specimen}} + V_{\text{wax}} \quad [\rho_{\text{water}} = 1 \text{ gm/cc}]$$

$$G_{\text{specimen}} = 2.2 = \frac{W_{\text{specimen}}}{V_{\text{specimen}}}$$

$$\Rightarrow 2.2 = \frac{1240.1}{(1272.4 - 671.1) - V_{\text{wax}}}$$

$$\Rightarrow V_{\text{wax}} = 37.62 \text{ gm}$$

$$G_{\text{wax}} = \frac{\text{Weight of wax}}{V_{\text{wax}}} = \frac{32.3}{37.62} = 0.859 \approx 0.86$$

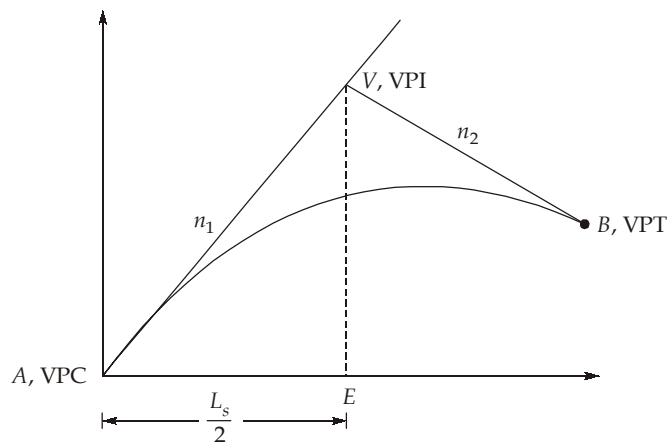
13. (b)

Assume $S < L$,

$$L = \frac{Ns^2}{(\sqrt{2H} + \sqrt{2h})^2}$$

$$N = n_1 - n_2 = 1.5 - (-0.5) = 2\%; H = 1.125 \text{ m}; h = 0.1 \text{ m}$$

$$L = \frac{0.02 \times 300^2}{(\sqrt{2 \times 1.125} + \sqrt{2 \times 0.1})^2} = 474.73 \text{ m} > 300 \text{ m} \quad \therefore \text{OK}$$



$$\begin{aligned}
 RL_A &= RL_V - \frac{L_s}{2} \times n \\
 &= 75 - \frac{474.73}{2} \times 0.015 = 71.44 \text{ m}
 \end{aligned}$$

$$\begin{aligned}
 \text{RL of VPT (RL of B)} &= RL_A + \frac{L_s}{2} (n_1 + n_2) \\
 &= 71.44 + \frac{474.73}{2} \frac{(1.5 - 0.5)}{100} = 73.81 \text{ m}
 \end{aligned}$$

14. (c)

Width of the pavement = $W + W_e$

$$W_e = \frac{nl^2}{2R} + \frac{V}{9.5\sqrt{R}}$$

Length of wheel base = 6.1 m (as per IRC)

$$W_e = \frac{2 \times (6.1)^2}{2 \times 280} + \frac{80}{9.5\sqrt{280}} = 0.636 \text{ m} \simeq 0.64 \text{ m}$$

 $\therefore$ Width of pavement = $7.0 + 0.64 = 7.64 \text{ m}$

$$\text{Distance between centre line of highway and centre line of inner lane} = \frac{W + W_e}{4} = \frac{7.64}{4} = 1.91 \text{ m}$$

Given : Length of the curve = 180 m; Sight distance = 250 m

L.C < S.D

 $\therefore$ Set back distance from centre line of road,

$$m = R - (R - d) \cos \frac{\alpha}{2} + \left(\frac{S - L}{2} \right) \sin \frac{\alpha}{2}$$

$$L = (R - d) \alpha$$

$$\alpha = \left(\frac{180}{280 - 1.91} \right) \times \frac{180}{\pi} = 37.086^\circ$$

$$\begin{aligned}
 \therefore m &= 280 - (280 - 1.91) \cos \left(\frac{37.086}{2} \right) + \left(\frac{250 - 180}{2} \right) \sin \left(\frac{37.086}{2} \right) \\
 &= 280 - 278.09 \cos \left(\frac{37.086}{2} \right) + 35 \times \sin \left(\frac{37.086}{2} \right) \\
 &= 27.48 \text{ m}
 \end{aligned}$$

$$\begin{aligned}\text{Set back distance required from outer edge of pavement} &= (m + 2d) \\ &= (27.48 + 2 \times 1.91) = 31.3 \text{ m}\end{aligned}$$

15. (a)

$$\begin{aligned}\text{Effective green time} &= \text{Green time} + \text{Amber time} - \text{Startup loss} - \text{Clearance time} \\ &= 27 + 3.5 - 2.5 - 1.5 = 26.5 \text{ second}\end{aligned}$$

$$\begin{aligned}\text{Saturation flow} &= \frac{3600}{\text{Saturation time headway}} \\ &= \frac{3600}{2.5} = 1440 \text{ veh/hr}\end{aligned}$$

$$\begin{aligned}\text{Actual capacity} &= \text{Saturation flow} \times \frac{\text{Effective green time}}{\text{Cycle time}} \\ &= 1440 \times \frac{26.5}{60} = 636 \text{ veh/hr}\end{aligned}$$

16. (c)

By rate of change of centrifugal acceleration

$$C = \frac{80}{75 + V} = \frac{80}{75 + 100} = 0.457 < 0.5$$

$\therefore$

$$C = 0.5$$

$$L_s = \frac{0.0215V^3}{CR} = \frac{0.0215 \times (100)^3}{0.5 \times 400} = 107.5 \text{ m}$$

By rate of introduction of superelevation

$$\begin{aligned}L_s &= e \times W \times N \quad [\because \text{rotation about inner edge}] \\ &= 0.07 \times 7.6 \times 150 \\ &= 79.8 \text{ m}\end{aligned}$$

By IRC formula:

For plain terrain,

Minimum length of transition curve,

$$L_s = \frac{2.7V^2}{R} = \frac{2.7 \times 100^2}{400} = 67.5 \text{ m}$$

Adopting highest of the above three values,

$$L_s = 107.5 \text{ m}$$

17. (c)

Given : design speed, $v = 100 \text{ kmph} = 27.78 \text{ m/s}$

$$n_1 = -\frac{1}{30} \text{ and } n_2 = 0 \quad (\because \text{level stretch})$$

$$\text{Deviation angle, } N = \left| -\frac{1}{30} - 0 \right| = \frac{1}{30}$$

Length of valley curve for comfort condition:

$$L = 2 \left[\frac{Nv^3}{C} \right]^{1/2} = 2 \left[\frac{1}{30} \times \frac{(27.78)^3}{0.6} \right]^{1/2} = 69 \text{ m}$$

Length of valley curve for head light sight distance:

$$HSD = SSD = vt + \frac{v^2}{2gf}$$

$$= (27.78 \times 2.5) + \frac{(27.78)^2}{2 \times 9.81 \times 0.35} = 181.83 \text{ m}$$

Assumed $L > \text{HSD}$

$$L = \frac{Ns^2}{(1.5 + 0.035s)} = \frac{1 \times (181.83)^2}{30(1.5 + 0.035 \times 181.83)}$$

$$\Rightarrow L = 140.14 \text{ m} < \text{HSD}$$

$\therefore$ Assumption is wrong.

For, $L < \text{HSD}$

$$\begin{aligned} \text{i.e. } L &= 2s - \frac{1.5 + 0.035s}{N} \\ &= 2 \times 181.83 - \frac{1.5 + 0.035 \times 181.83}{\left(\frac{1}{30}\right)} \\ &= 127.74 \text{ m} < \text{HSD} \quad \therefore \end{aligned}$$

OK

The valley curve length based on HSD being higher than that based on comfort condition, the design length of valley curve is 127.74 m.

18. (a)

Given: $E_1 = 120 \text{ MN/m}^2 = 120 \text{ N/mm}^2$

and $E_2 = 12 \text{ MN/m}^2 = 12 \text{ N/mm}^2$

$$\frac{E_1}{E_2} = \frac{120}{12} = 10, \text{ tyre pressure} = 0.5 \text{ MN/m}^2 = 0.5 \text{ N/mm}^2$$

$$\text{Radius of contact area, } a = \left[\frac{\text{Wheel load}}{p \times \pi} \right]^{1/2}$$

$$\Rightarrow a = \left[\frac{40 \times 10^3}{0.5 \times \pi} \right]^{1/2} = 159.577 \text{ mm}$$

$$\text{Now, } \Delta = \left(\frac{1.5 \times p \times a}{E_2} \right) \times F$$

$$\Rightarrow F = \left(\frac{\Delta \times E_2}{1.5 \times p \times a} \right) = \frac{(0.5 \times 10) \times 12}{1.5 \times 0.5 \times 159.577}$$

$$\Rightarrow F = 0.50$$

$\therefore$ From the given table, thickness of top layer

$$= 1.0 \text{ a}$$

$$= (1.0 \times 159.577) \text{ mm}$$

$$= 15.9577 \text{ cm} \simeq 16 \text{ cm}$$

19. (d)

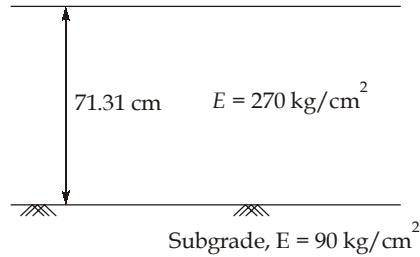
Thickness of pavement required above the subgrade

$$T_p = \left(\sqrt{\left(\frac{3Pxy}{2\pi E_s \Delta} \right)^2 - a^2} \right) \left(\frac{E_s}{E_p} \right)^{1/3}$$

$$a = \sqrt{\frac{P}{p\pi}}$$

$$\therefore T_p = \left(\sqrt{\left(\frac{3 \times 4080 \times 1.5 \times 0.8}{2\pi \times 90 \times 0.25} \right)^2 - \left(\frac{4080}{6 \times \pi} \right)} \right) \times \left(\frac{90}{270} \right)^{1/3}$$

$$\Rightarrow T_p = 71.31 \text{ cm}$$



To provide 5 cm of wearing course,

$$\frac{5}{T_{\text{sub}}} = \left(\frac{270}{9000} \right)^{1/3}$$

$$\Rightarrow T_{\text{sub}} = 16.09 \text{ cm}$$

Remove 16.09 cm of sub-base and provide 5 cm of wearing course of modulus of elasticity 9000 kg/cm².

$$\text{Remaining thickness} = 71.31 - 16.09 = 55.22 \text{ cm}$$

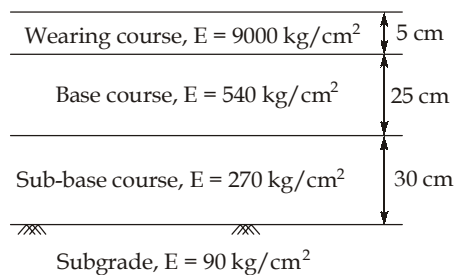
To provide 20 cm of base course,

$$\frac{20}{T_{\text{sub}}} = \left(\frac{270}{540} \right)^{1/3}$$

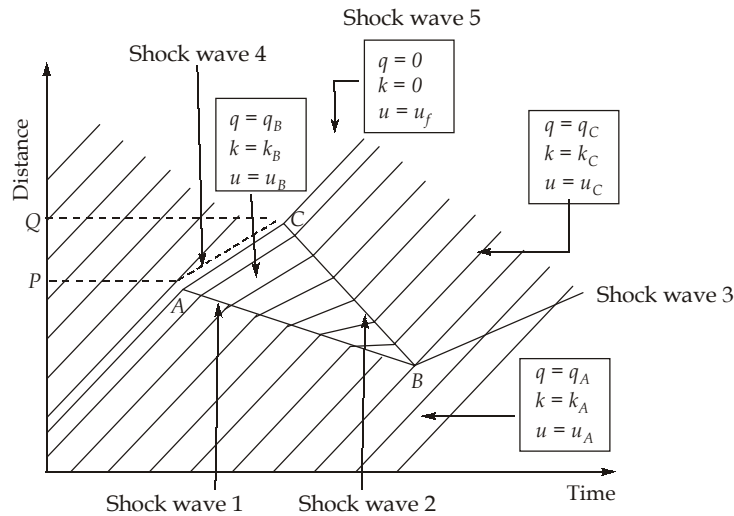
$$\Rightarrow T_{\text{sub}} = 25.2 \text{ cm}$$

$\therefore$ Remove 25.2 cm of sub-base course to provide 20 cm of base course of modulus of elasticity 540 kg/cm².

$$\text{Remaining thickness of sub-base} = 55.22 - 25.2 = 30.02 \text{ cm}$$

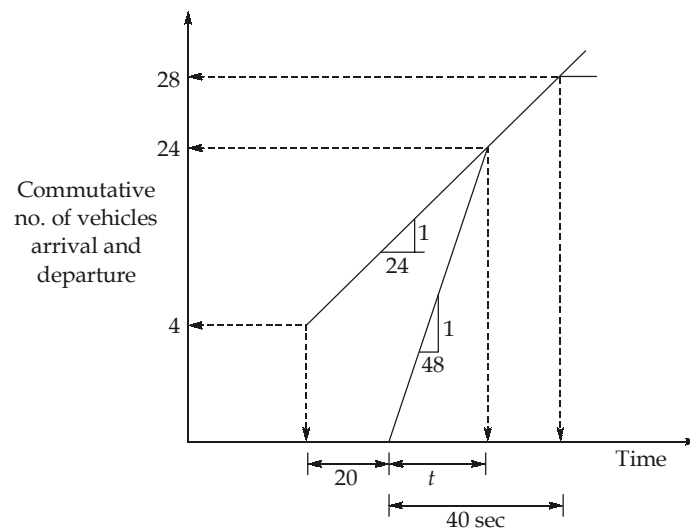


20. (d)



- The shock wave is the movement of the point that demarcates the two stream conditions. Therefore, there are five shockwaves in the given situation.
- Line AB is platoon forming shockwave. It starts at P and at the time when the slow moving vehicle enters the stream.
- Line BC is the platoon dissipating shock wave. It starts at Q (i.e. where slow moving vehicle leaves the stream).

21. (b)



$$4 + 24 \times \left(\frac{20+t}{60} \right) = 48 \left(\frac{t}{60} \right)$$

$$\Rightarrow 240 + 24(20+t) = 48t$$

$$\Rightarrow 720 = 24t$$

$$\Rightarrow t = 30 \text{ sec}$$

$$\text{Number of vehicles discharged in 30 sec} = 48 \times \frac{30}{60} = 24 \text{ vehicles}$$

$$\text{Total number vehicles arrival in one cycle} = 4 + 24 \times \left(\frac{60}{60} \right) = 28 \text{ vehicles}$$

$$\begin{aligned}\text{Average delay} &= \frac{\text{Area between arrival and departure per cycle time}}{\text{Cumulative number of vehicles arrival per cycle time}} \\ &= \frac{\left(\frac{4+24}{2}\right) \times 50 - \frac{1}{2} \times 30 \times 24}{28} = 12.14 \text{ sec.}\end{aligned}$$

22. (b)

$$\begin{aligned}q_A &= 400 \text{ PCU/hr}, q_B = 300 \text{ PCU/hr} \\ s_A &= 1600 \text{ PCU/hr}, s_B = 1200 \text{ PCU/hr}\end{aligned}$$

$$y_A = \frac{q_A}{s_A} = \frac{400}{1600} = 0.25$$

$$y_B = \frac{q_B}{s_B} = \frac{300}{1200} = 0.25$$

$$y = y_A + y_B = 0.25 + 0.25 = 0.5$$

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

$$\text{Optimum cycle time, } C_0 = \frac{1.5L + 5}{1 - y} = \frac{1.5 \times 20 + 5}{1 - 0.5} = 70 \text{ sec}$$

23. (b)

Stopping sight distance (SSD) is given as

$$SSD = 0.278Vt_r + \frac{V^2}{254f}$$

where t_r is reaction time and f is coefficient of longitudinal friction,

$$SSD = 0.278 \times 80 \times 2.5 + \frac{80^2}{254(0.35)} = 127.59 \text{ m}$$

Assume length of valley curve (L_V) > SSD (S)

$$\text{Now, } L_V = \frac{NS^2}{2[h + S \tan \alpha]}$$

Where, L_V = Length of valley curve (in m)

$$N = \text{Deviation angle} = \left| -\frac{1}{15} - \frac{1}{20} \right| = 0.1167$$

h = Average height of headlight = 0.5 m

S = Stopping sight distance = 127.59 m

α = Beam angle = 2°

$$L_V = \frac{0.1167 \times (127.59)^2}{2[0.5 + 127.59 \cdot [\tan 2^\circ]]} = 191.68 \text{ m} \approx 192 \text{ m (say)}$$

$\therefore L_V > SSD$ Hence OK

Hence, provide length of valley curve as 192 m.

24. (d)

Speed (kmph)	Average speed (kmph)	No. of vehicles	Cummulative no. of vehicles	Cummulative vehicles
20 – 30	25	40	40	5.71%
30 – 40	35	50	90	12.86%
40 – 50	45	100	190	27.14%
50 – 60	55	150	340	48.57%
60 – 70	65	200	540	77.14%
70 – 80	75	100	640	91.43%
80 – 90	85	60	700	100%

The upper value of speed limit (i.e 85th percentile speed) is marked on the sign board

$$V_{85} = 65 + \left(\frac{75 - 65}{91.43 - 77.14} \right) \times (85 - 77.14)$$

$$V_{85} = 70.5 \text{ kmph} \approx 70 \text{ kmph}$$

Hence, 70 kmph speed is marked on the sign board.

25. (c)

$$p_{1-2} = \frac{b + c}{a + b + c + d}$$

$$a = V_{12} = 500$$

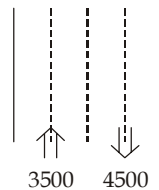
$$b = V_{13} + V_{14} = 450 + 150 = 600$$

$$c = V_{32} + V_{42} = 600 + 1000 = 1600$$

$$d = V_{43} = 700$$

$$p_{1-2} = \frac{600 + 1600}{500 + 600 + 1600 + 700} = 0.647$$

26. (c)



Total commercial vehicles, $A = 3500 + 4500 = 8000$ cvpd

Rate of growth of traffic, $r = 8\%$

Lane distribution factor, $D = 0.55$

$$\text{Vehicle damage factor, } VDF = \left(\frac{14500}{8170} \right)^4 = 9.9216$$

Design life, $n = 10$ yrs

Number of cumulative standard axle (in msa)

$$N_{\text{design}} = \frac{365 \cdot A \left[\left(1 + \frac{r}{100} \right)^n - 1 \right] D \times (VDF)}{\left(\frac{r}{100} \right) \times 10^6} \text{ msa}$$

$$= \frac{365 \times 8000 \left[\left(1 + \frac{8}{100} \right)^{10} - 1 \right] 0.55 \times (9.9216)}{\left(\frac{8}{100} \right) \times 10^6} \text{msa}$$

$$= 230.83 \text{ msa}$$

27. (b)

Total cross-sectional area of steel (A_{st}) in one direction along the slab width

$$A_{st} = (\text{number of bars}) \times \frac{\pi}{4} \cdot d^2$$

where d is diameter of bars,

$$\therefore A_{st} = \left(\frac{3}{0.4} \right) \times \frac{\pi}{4} \times 1^2 = 5.89 \text{ cm}^2$$

$$\sigma_{st} = 1400 \text{ kg/cm}^2$$

Now, spacing between contraction joints (L) is given as

$$L = \frac{2 \cdot \sigma_{st} \cdot A_{st}}{f \times \gamma_c \times B \times h}$$

$$= \frac{2 \times 1400 \times 5.89}{1.5 \times 2400 \times 3 \times 0.25} = 6.108 \text{ m} \approx 6 \text{ m}$$

28. (c)

Deviation angle,

$$N = n_1 - n_2$$

$$= (-4.2 - 3.3) = -7.5\% \text{ (valley)}$$

Location of deepest point,

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

29. (c)

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

$$= \frac{280 \times 15 \times \left(1 + \frac{5.2}{15} \right) \left(1 - \frac{0.69}{3} \right)}{1 + \frac{15}{82}}$$

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

30. (c)

Mean vehicular arrival rate, $v = 3 \text{ veh/min}$

Probability that atleast 1 vehicle will arrive in any given 1 minute

$$= P(n \geq 1) = 1 - [P(n = 0)] = 1 - \left[\frac{(vt)^n \cdot e^{-vt}}{n!} \right] = 1 - \left[\frac{(3 \times 1)^0 \cdot e^{-3 \times 1}}{0!} \right] = 1 - e^{-3}$$

$$= 0.9502 \approx 0.95$$

