20BCE204

Term Assignment - 1

Geometric Design of Roads

1. Explain PIEV theory affecting the reaction time of driver, and its importance in road safety.

Ans → The PIEV theory is a conceptual framework used to explain the factors that affect a driver's reaction time and overall process of perceiving and responding to a potential hazard on road.

→ The acronym PIEV stands for Perception, Intellection, Emotion, Volition time. This theory is particularly relevant in understanding driver behaviour and its implications for road safety.

→ Perception Time : The time required for the sensations received by eyes or ears to be transmitted to brain through nervous system.

→ Intellection time : The time required for understanding the situation. It is also the time required for comparing the different thoughts and new sensations.

→ Emotion time : The time elapsed during emotional sensations and disturbances such as fear, anger, etc. It varies upon the problem involved.

→ Volition time : The time required for taking the final action.

→ The importance of PIEV theory in road safety lies in its ability to highlight the complex cognitive and sensory process that take place during critical moments leading up to a potential collision.

1) Driver Training : By understanding the PIEV stages, driver education programs can emphasize the importance of focused and alert driving. Drivers can be trained to anticipate and respond to hazards more effectively.

2) Road Design : Roadways can be designed in ways that enhance driver's ability to perceive and respond to hazards.

2. Calculate the safe-stopping sight distance on a level road stretch for design speed of 70 kmph for (a) two-way traffic on a two-lane road (b) two-way traffic on a single lane road.

Ans $v = 70 \times \frac{5}{18} = 19.44$ m/s

$f = 0.35 \qquad t = 2.5$ s

Safe stopping distance $SSD = vt + \frac{v^2}{2gf}$

$= 19.44(2.5) + \frac{(19.44)^2}{2 \times 9.8 \times 0.35}$

$= 48.61 + \frac{377.91}{6.86}$

$= 48.61 + 55.08$

$SSD = 104$ m

(a) two way traffic on two lane road

$SSD = 104$ m

(b) two way traffic on single road

$SSD = 2 \times 104$

$= 208$ m

3. Calculate the minimum sight distance required to avoid a head on collision of two cars approaching from the opposite directions at 80 and 50 kmph. Assume coefficient of friction of 0.7 and a brake efficiency of 50 percent.

Ans Minimum Sight distance = $SSD_{v_1} + SSD_{v_2}$

$v_1 = 80 \times \frac{5}{18} = 22.22 \text{ m/s}$

$v_2 = 50 \times \frac{5}{18} = 13.88 \text{ m/s}$

$f = 0.7$

efficiency $= 0.5$

$f_{actual} = 0.7 \times 0.5 = 0.35$

$SSD_{v_1} = v_1 t + \frac{v_1^2}{2gf}$

$= (22.22)(2.5) + \frac{(22.22)^2}{2 \times 9.8 \times 0.35}$

$= 55.55 + \frac{493.72}{0.7 \times 9.8}$

$= 55.55 + 71.9$

$SSD_{v_1} = 127.52$

$SSD_{v_2} = v_2 t + \frac{v_2^2}{2gf}$

$= 13.88(2.5) + \frac{(13.88)^2}{2 \times 9.8 \times 0.35}$

$= 34.7 + \frac{192.65}{0.7 \times 9.8}$

$= 34.7 + 28.08$

$SSD_{v_2} = 62.7$

$\therefore$ Minimum SSD $= SSD_{v_1} + SSD_{v_2}$

$= 128 + 63$

$= 191 \text{ m}$

4. Calculate the SSD on a highway at a descending gradient 3% for a design speed of 70 kmph. Assume other data as per IRC recommendation.

Ans

$$v = 70 \times \frac{5}{18} = 19.44 \text{ m/s}$$

$$n = 3 \qquad f = 0.35$$

$$SSD = vt + \frac{v^2}{2g\left(f - \frac{n}{100}\right)}$$

$$= (19.44)(2.5) + \frac{(19.44)^2}{2 \times 9.8\left(0.35 - \frac{3}{100}\right)}$$

$$= 48.6 + 377.91$$

$$= 48.6 + 60.25$$

$$SSD = 108.85 \text{ m}$$

$$= 109 \text{ m}$$

5. The speeds of overtaking and overtaken vehicle's are 80 and 50 kmph respectively On a two way traffic. Calculate safe overtaking sight distance.

Ans $v_A = 80 \times \frac{5}{18} = 22.22 m/s$

$t = 2s$

$v_B = 50 \times \frac{5}{18} = 13.89 m/s$

$a = 0.99 m/s^2$

$v_c = v_A = 22.22 m/s$

$OSD = d_1 + d_2 + d_3$

$d_1 = v_b t = 2 v_b$

$d_2 = v_b T + 2S$

$d_3 = v_c T$

$d_1 = 13.89 \times 2$

$\boxed{d_1 = 27.78 m}$

$S = 0.7 v_B + 6$

$= 0.7(13.89) + 6$

$S = 15.723 m$

$d_2 = 13.89 \times (7.97) + 2(15.723)$

$T = \sqrt{\frac{4S}{a}} = \sqrt{\frac{4 \times 15.723}{0.99}}$

$= 7.97 s$

$d_2 = 110.7 + 31.446$

$\boxed{d_2 = 142.146 m}$

$d_3 = v_c T = 22.22(7.97) = \boxed{177.09 m}$

$OSD = d_1 + d_2 + d_3$

$= 27.78 + 142.146 + 177.09$

$\boxed{OSD = 347.019 m}$

6. Calculate safe Overtaking Sight Distance for a design speed of 96 km/hr. Assume all data suitably.

Only design speed given $= 96 \times \frac{5}{18} = 26.67 m/s$

$a = 1 m/s^2 \quad t = 2s$

$v_b = (96-16) = 80 \text{ kmph} = 80 \times \frac{5}{18}$

$= 22.22 \ m/s$

$OSD = d_1 + d_2 + d_3$

$= v_b t + (V_b T + 2S) + v_c T$

$S = 0.7 v_b + 6 \qquad T = \sqrt{\frac{4S}{a}} = \sqrt{\frac{4 \times 21.54}{1}}$

$= 0.7(22.2) + 6 \qquad T = 9.28 s$

$= 21.54 m$

$= (22.2)(2) + (22.22 \times 9.28 + 2(21.54)) + 26.6(9.28)$

$\boxed{OSD = 540 m}$

7. The radius of a horizontal curve is 100m. The design speed is 60 kmph and design co-efficient of lateral friction is 0.15.

(a) Calculate the super elevation required if full lateral friction is assumed to develop.

(b) Calculate the co-efficient of friction needed if no super elevation is provided.

Ans $R = 100\,m$ $\quad$ $V = 60\,kmph$

$f = 0.15$ $\quad$ $= 16.66\,m/s$

a) Super elevation

$$e + f = \frac{V^2}{127R}$$

$$= \frac{(60)^2}{127 \times 100}$$

$$e + 0.15 = 0.28$$

$$e = 0.13$$

b) Co-efficient of friction

$$f = \frac{V^2}{127R}$$

$$= \frac{(60)^2}{127 \times 100}$$

$$f = 0.28$$

8. While aligning a highway in a built-up area, it was necessary to provide a horizontal curve of radius 345m. The design speed is 75 kmph. Length of wheel base is 6m and width of pavement is 10.5 m. Design the following geometric features.
(i) Super elevation.
(ii) Extra widening of pavement
(iii) Length of transition curve

(i) $e_1 = \frac{V^2}{225R}$ $V = 75$ kmph
$R = 345$ m

$e_1 = \frac{75 \times 75}{225 \times 345}$
$= 0.072$
$\because 0.072 > 0.07$
$\therefore e = 0.07$

(ii) Extra widening of pavement W_e

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

l = length of wheel base = 6 m
n = no. of lanes = 3
$R = 345$ m
$V = 75$ kmph

$$W_e = \frac{3 \times (6)^2}{2 \times 345} + \frac{75}{9.5\sqrt{345}} = 0.156 + 0.425$$

$$\boxed{W_e = 0.58 \text{ m}}$$

(iii) Length of Transition Curve

1) Rate of change of centrifugal acceleration

$$C = \frac{80}{75+V} = \frac{80}{150} = 0.52$$

$$\therefore 0.5 \leq C \leq 0.8$$

$$L_s = \frac{0.0215\, V^2}{CR}$$

$$= \frac{0.0215 \times (75)^2}{0.52 \times 345} = 50.55\,m$$

2) $B = W + We$

$= 10.5 + 0.5815$

$= 11.08$

$e = 0.07$

$E = eB = 0.07 \times 11.08$

$= 0.775\ m$

3) $L = \frac{2.7 V^2}{R} = 44.02\ m$

$\therefore$ Length of Transition Curve = max of (1), (2), (3)

$= 50.55\ m$

$\approx 51\ m$