UNIVERSITY OF RUHUNA

Faculty of Engineering

Mid-Semester 6 Examination in Engineering: November 2014

Module Number: CE6236 Module Name: Highway Engineering Design

[Two Hours]

[Answer all questions. Each question carries **FIVE** marks]

All Standard Notations denote their regular meanings

Q1. a) Prove that the ground profile needs to be a parabola in order to have a constant rate of change in the gradient of a vertical curve.

[1.0 Mark]

b) Prove that the vertical line through the PI will bisect the horizontal length of a vertical curve.

[1.5 Marks]

c) Two tangents of -4% and +3% are to be connected using a parabolic curve. Maximum allowable rate of change in the gradient is set at 0.02 %/m. PI is at an elevation of 206 m above MSL. Calculate the following:

i. Horizontal length of the curve;
ii. Elevation of starting point of the curve;
iii. Elevation of ending point of the curve;
iv. Elevation of midpoint of the curve; and
v. Place where the minimum elevation of the curve occurs with respect to the starting point.

[2.5 Marks]

Q2. a) Describe 4 advantages of using a transition curves on horizontal curves.

[1.0 Mark]

b) A "6 degree curve" (100m arc definition) has been selected for a horizontal curve on expressway with 120 kmph design speed. It has been estimated that friction coefficient between a used (40,000 km- 4 year) tyre and wet road surface to be 0.15. Minimum super elevation and cross fall is 1.5%. Maximum super-elevation rate is 5%. A spiral curve with (n, Rate of pavement rotation=2.5 %/s and C, rate of increase of lateral acceleration=0.3 m/s^3) is used at two ends. Based on the information given above calculate the following:

i. Minimum radius required;
ii. Radius of the circular curve selected;
iii. Super elevation that should be used;
iv. Minimum length of the spiral curve that would satisfy both n, and C; and
v. Angle coved by the one spiral.

[4.0 Marks]

Q3. a) From first principals derive equations for following elements in a circular curve of Highway in terms of **degree of curvature**, and **deflection angle of curve**:

i. Tangent distance;

ii. External distance; and

iii. Arch length.

[1.5 Marks]

b) A 8 degree curve is to be designed on a highway with two 3.5 m as lanes and a design speed of 120km/h. A maximum super-elevation rate of 6% has been established (Friction 0.15). The normal drainage cross-slope on the tangent is 1.5%. 125 m long spiral transition curves are to be used at the both ends of the circular curve. Total deflection of the original tangents is 25°, and the PI is at station 67 + 300. Based on the information given above calculate the following:

i. Angle covered by the circular portion;

ii. Length of circular curve;

iii. Tangent distance;

iv. Appropriate stations for the T.S., S.C., C.S., and S.T.

[3.5 Marks]

Q4. a) Starting from the sketch develop a equation for the stopping distance of a vehicle travelling a velocity of V kmph, on a ±G% slope road with friction coefficient of f and driven by a driver with a reaction time of t s.

[3.0 Marks]

b) Describe 4 main factors that would dictate the selection of a route for a new highway.

[2.0 Marks]

Equations

$$L_s = \frac{v^3}{CR_c} = \frac{V^3}{3.6^3 \times CR_c}$$

$$L_s = \frac{e_n \times V}{3.6 \times n}$$

$$\delta = \frac{L_s D}{200}$$

$$T_s = R \tan\left(\frac{\Delta}{2}\right) + \left[R\cos(\delta) - R + \frac{L_s^2}{6R}\right] \times \tan\left(\frac{\Delta}{2}\right) + \left[L_s - R\sin(\delta)\right]$$

$$e = 100 \times \left[\frac{V^2}{127 \times R} - f_s\right]$$

$$R_{min} = \frac{V^2}{127 \times (0.01 \times e + f_s)}$$

$$D = \frac{5729.58}{R}$$