CE 34500: Transportation Engineering
Spring 2020
Homework 1

1. The design speed of a multilane highway is 60mph. Determine a) the minimum stopping sight distance that should be provided for a level roadway, and b) the minimum stopping sight distance that should be provided for a roadway with a maximum grade of 5%. Note: the term $\frac{a}{g}$ in the appropriate equation is typically rounded to 0.35 in calculations. Assume perception reaction time = 3.0 sec.

Solution:

a. Road is level, $\therefore G = 0$

$$SSD = 1.47ut + \frac{u^2}{30\left(\frac{a}{g} \pm G\right)}$$

$$\Rightarrow SSD = 1.47 * 60 * 3 + \frac{60^2}{30\left(\frac{11.2}{32.2} \pm 0\right)}$$

$$\Rightarrow SSD = 265 + 345 = 565\ ft$$

b. G=5%=0.05, $SSD = 1.47 * 60 * 3 + \frac{60^2}{30\left(\frac{11.2}{32.2} - 0.05\right)}$

$$\Rightarrow SSD = 265 + 403 = 668\ ft$$

2. The acceleration of a vehicle can be expressed as:

$$\frac{du}{dt} = 3.6 - 0.06u$$

If the vehicle speed, u, is 30 ft/sec at time T_0, determine:

a. Distance traveled when the vehicle has accelerated to 45 ft/sec.
b. Time for vehicle to attain the speed of 45 ft/sec.

Solution:

$t = \frac{1}{\beta} \ln\left(\frac{\alpha - \beta * u_o}{\alpha - \beta * u_t}\right) = \mathbf{11.55}\ s;\ \alpha = 3.6, \beta = 0.06, u_o = 30\ ft./sec,$

$x = \frac{\alpha}{\beta} * t - \frac{\alpha}{\beta^2}\left(1 - e^{-\beta * t}\right) + \frac{u_o}{\beta}\left(1 - e^{-\beta * t}\right);\ \alpha = 3.6, \beta = 0.06, u_o = 30\ ft./sec$

=> x =693-500+250= 443 ft.

3. Determine the horsepower developed by a passenger car travelling at a speed of 50 mph on an upgrade of 4% with a smooth pavement. The weight of the car is 4000Ib and the cross-section area of the car is 40 ft^2.

Solution:

$$R_u = R_a + R_r + R_G$$

$= 0.5 * [2.15 * p * C_D * A * \frac{U^2}{g}] + (C_{rs} + 2.15 * C_{rv} * u^2) * W + W * G$

$$= 0.5 * 2.15 * .0766 * .04 * 40 * \frac{50^2}{32.2} + (0.012 + 2.15 * .65x10^{-6} * 50^2) * 4000 + 4000 * .04$$

=10.23+61.97+160

=233 Ib

$$P = 1.47 * \frac{233 * 50}{550} = 31.1\ hp$$

4. Determine the minimum radius of a horizontal curve required for a highway if the design speed is 70 mph and the super-elevation rate is 0.08.

Solution:

$$u = 70\ mph;\ e = 0.08;\ f_s = 0.1\ at\ 70mph\ (from\ table\ 3.3)$$

$$R = \frac{u^2}{15(e + f_s)} = \frac{70^2}{15(0.08 + 0.1)} = 1{,}815\ ft$$

5. A curve of radius 250 ft. and $e = 0.08$ is located at a section of an existing rural highway, which restricts the safe speed at this section of the highway to 50% of the design speed. This drastic reduction of safe speed resulted in a high crash rate at this section. To reduce the crash rate, a new alignment is to be designed with a horizontal curve. Determine the minimum radius of this curve if the safe speed should be increased to the design speed of the highway. Assume $f_s = 0.17$ for the existing curve and the new curve is to be designed with $e = 0.08$.

Solution:

$$250 = \frac{u^2}{15(0.08+0.17)}$$

$$\Rightarrow u = 30.6\ mph\ on\ the\ curve$$

$$\therefore Design\ speed\ in\ section = \frac{30.6}{0.5} = 61.24\ mph$$

$$f_s = 0.12\ at\ 60mph,\ \therefore Radius, R = \frac{61.24^2}{15(0.08+0.12)} = 1{,}250\ ft$$