TRAFFIC ENGINEERING

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Vehicle Characteristics

Vehicle characteristics, which include such details as size and weight of vehicle.

Design vehicle : is the vehicle selected to represent all vehicles on the highway. It's weight, dimensions and operating characteristics.

1. Static characteristics

- The gross weight, size, length of the vehicles is an important factor in the determination of design standards for several physical components of highway. These include lane width, shoulder width, length and width of parking bays, and lengths of vertical curves.

- The axle weights of the vehicles are important when pavement depths and maximum grades are being determined.

- The single-unit truck (SU): represents all single unit truck and small buses.
- The single-unit Bus (BSU): represents transit buses with length (40 ft).

2) Kinematic Characteristics

The primary element among Kinematic characteristics is the acceleration capability of the vehicle. It is important in passing maneuvers and gap acceptance also the dimensioning of highway features such as freeway ramps and passing lanes is often governed by acceleration.

The fundamental relationship connecting force and acceleration is given by the equation :

$$F = m \times a$$

where:

F : force

m : mass

a : acceleration

Two Cases of Interest :

1. acceleration is assumed constant.

$$V = V_o + at \quad \text{----} \quad (1)$$

$$X = V_o t + \frac{1}{2} a t^2 \quad \text{----} \quad (2)$$

$$X = \frac{V^2 - V_o^2}{2a} \quad \text{----} \quad (3)$$

a: acceleration (ft/sec^2).

v: speed $(ft/sec.)$.

V_o: initial speed $(ft/sec.)$.

X: distance (ft).

t: time $(sec.)$.

2. Non-uniform acceleration :

$$\frac{dv}{dt} = \alpha - \beta v \quad \text{-----} \; (1)$$

$$\frac{dv}{dt} = (\alpha - \beta V_o)\, e^{-\beta t} \quad ; \text{ where } \alpha \text{ and } \beta \text{ are constant} \; \text{---} \; (2)$$

$$v = \frac{\alpha}{\beta}\left(1 - e^{-\beta t}\right) + \frac{V_o}{\beta}\left(1 - e^{-\beta t}\right) \quad \text{----} \; (3)$$

$$X = \frac{\alpha t}{\beta} - \frac{\alpha}{\beta^2}\left(1 - e^{-\beta t}\right) + \frac{V_o}{\beta}\left(1 - e^{-\beta t}\right) \quad \text{----} \; (4)$$

Example: a truck traveling at 25 mph is approaching a stop sign. At time t_o and a distance of 60 ft the truck begins to slow down by decelerating at 14 ft/sec^2. Will the truck be able to stop in time.

Solution:

$V = V_o + at$

V: final velocity $= 0$ ft/sec.

$V_o = 25\,mph = 36.67$ ft/sec.

$a = 14$ ft/sec^2.

$0 = 36.67 - 14t$

$\therefore t = 2.62$ sec.

The distance covered by the truck in these 2.62 sec. is :

$X = V_o t + \frac{1}{2} a t^2$

$= (36.67)(2.62) + \frac{1}{2}(-14)(2.62)^2$

$= 48.02\text{ ft} < 60\text{ ft}$

This indicate that the truck will stop just in time.

Example: an impatient car driver stuck behined a slow-moving truck traveling at 20 mph decides to overtake the truck. The acceleration characteristics of the car is given by:

$$\frac{dv}{dt} = 3 - 0.04V$$

where:

v: speed (ft/sec) , t: time (sec).

Determine the acceleration after 2, 3, 10 and 120 sec. and also determine the maximum speed attainable by the car.

solution:

$$\frac{dv}{dt} = 3 - 0.04V = (\alpha - \beta V_0)\, e^{-\beta t}$$

$\alpha = 3\ ft/sec^2$, $\beta = 0.04\ sec.$, $20\,mph = 29.33\ ft/sec.$

acceleration after 2 sec.

$$\frac{dv}{dt} = [3 - (0.04)(29.33)]\, e^{-0.04 \times 2} = 1.686\ ft/sec^2$$

after 3 sec.

$\frac{dv}{dt} = 1.618 \text{ ft/sec}^2$.

and after 10 sec. , $\frac{dv}{dt} = 1.233 \text{ ft/sec}^2$.

and after 120 sec. , $\frac{dv}{dt} = 0.015 \text{ ft/ sec}^2$.

acceleration $= 3 - 0.04V$, when acceleration $= 0$

$3 - 0.04V = 0$

$\Rightarrow V = 75 \text{ ft/sec.} = 51.14 \text{ mph}$