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Highway & Traffic Engineering

Driver, Vehicle and Road Characteristics

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Chapter Description

Aims

This chapter provides students an overview on the various elements of traffic system and their interaction.

Expected Outcomes

- Explain characteristics of driver, vehicles, road and their interrelationships
- Carry out sight distance concept of stopping sight distance and overtaking sight distance.

Contents

- Driver Characteristics
- Perception Reaction Time (PRT)
- Vehicle Characteristics
  - Static
  - Kinematic
  - Dynamic
- Road Characteristics
  - Stopping Sight Distance
  - Overtaking Sight Distance

What is Traffic Streams

An interaction between INDIVIDUAL DRIVERS, VEHICLE and ROADWAY ENVIRONMENT.

Road Environment:

- Geometric Design
- Traffic Control System
- Weather
- Light condition

Road Users:

- Drivers
- Pedestrian,
- Bicyclist,
- Passengers
- Animals

Vehicles:

- Motorized
- Non Motorized

Traffic Diversity

- Each traffic components have a different characteristics.

- Traffic is hard to control because :
  - Drivers are not reacted in a same way
  - Vehicles have a different sizes, weight, operating characteristics.
  - General environment always change within time.
  - Problems in traffic control devices.

Driver Characteristics

- Human beings are complex, wide range of characteristic that influence driving
- Traffic engineers have to find ways to deliver clear message in an effective manner to driver.
- Especially in designing traffic control devices and system.

Driver Characteristics

- Drivers have varying skills and perceptual abilities that are influenced by three factors:

a) Physical

i. Visual & Hearing Perception

ii. Perception Reaction Time (PRT)

a) Environment (e.g: weather and lighting, traffic volumes, road geometry etc)

b) Psychology (driver emotion, motive of the journey, etc)

Perception Reaction Time (PRT)

- process through which a driver / pedestrian evaluates and reacts to a stimulus:

i. **Detection** : drivers aware of any object or condition.
ii. **Identification** : drivers acquire info. About object and consider appropriate response.
iii. **Decision** : analyzing the info & decide how to response.
iv. **Response** : response physically implemented.

Vehicle Characteristics

- Vehicle characteristics that important in designing a highway are :-
  - Static
  - Dynamic
  - Kinematics

Static Characteristics

- The weight and size of vehicle is important in determine the physical component of highway such as:-
  - Lane width
  - Shoulder width
  - Length and width of parking bays
  - Length of vertical curve
  - Pavement depth

- 4 general classes of vehicles by AASHTO:

i. Passenger-cars (PC)
ii. Trucks (T)
iii. Buses
iv. Recreational vehicles (RV)

Static Characteristics

TABLE 3-1-DIMENSION OF DESIGN VEHICLES

Design Vehicles		Dimension in Metres						Turning Radius (Metres)	
Type	Equivalent Type in AASHTO	Wheel base	Overhang		Overall Length	Overall Width	Height	Inner	Outer
			Front	Rear					
Passenger Car	P	3.4	0.90	1.5	5.8	2.1	1.3	4.2	7.3
Rigid Truck	SU	6.10	1.2	1.8	9.1	2.60	4.10	8.5	12.8
Semi-Trailer	WB-15	9.10	0.9	0.60	16.7	2.60	4.10	5.8	13.7

Note :

A. Maximum allowable overall lengths under current Malaysian Legislation are as follows:
   (i) Rigid vehicle - 12.2 m (40 ft)
   (ii) Articulated vehicle - 16.0 m (52.5 ft)
   (iii) Semi-Trailer - 12.5 m (41ft)
   (iv) Trailer - 9.0 m (29.5 ft)
   (v) Truck Trailer - 18.0 m (59 ft)

B. Maximum allowable overall width under current Malaysian Legislation is 2.5 m.

Source: REAM

Kinematics Characteristics

- Primary element is the acceleration capability of vehicle:

  - Acceleration is important in operation of passing maneuvers and gap acceptance.

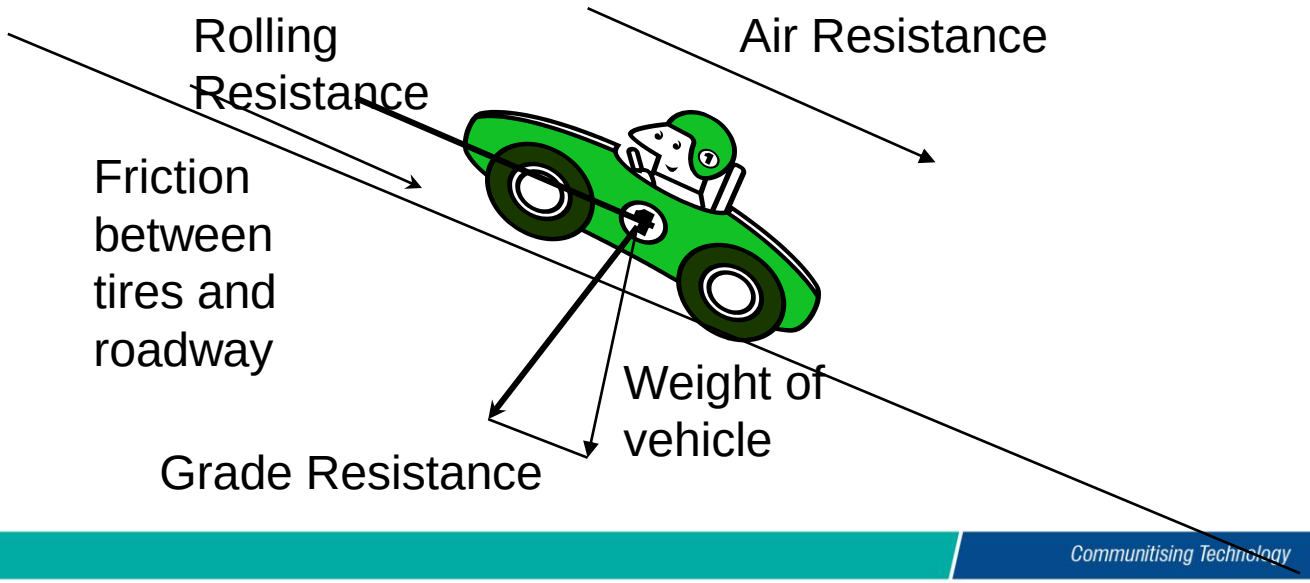
  - Dimension of highway also determine through acceleration capability

  - in determining forces that causes motion.

- involve the study how acceleration rates influence the elements of motion such as velocity, distance and time

Dynamic Characteristics

- Forces that act on a vehicle while it is in motion are:-
  i. Air resistance – resistance of air in front of vehicles.
  ii. Grade Resistance – an opposite forces acting on grade to move the vehicles (accelerate / decelerate)
  iii. Rolling Resistance – frictional slip between pavement surface and tires.
  iv. Curve Resistance – an external forces on the front wheel when taking a curve.



Road Characteristics

- Design of highway elements includes alignment, lane capacity, sight distance etc
- Sight distance:
  - length of the road surface at which object stationary or moving are visible by the driver while driving
- Two types of sight distance:
  - Stopping Sight Distance (SSD)
  - Overtaking/Passing Sight Distance (OSD)

Stopping Sight Distance (SSD)

- Minimum distance required for a driver to stop a vehicle after seeing an object in the vehicle's path without hitting the object

✓ To ensure that safety elements are included in the geometry design

✓ To determine the locations of warning/reminder system to the users

Stopping Sight Distance (SSD)

Consists of two components:

i. distance traveled from the time the object is sighted to the instant the brakes are applied / the distance traveled in *total reaction time, dr:*

$$dr = 0.28Vt$$

ii. distance required for stopping vehicle after the brakes are applied / braking distance, *db:*

$$db = \frac{V^2 - u^2}{254(f \pm G)}$$

where
- *V* : *initial speed (km/h)*
- *t* : *perception reaction time (s)*
- *u* : *final speed(km/hr)*
- *f* : *coefficient of friction between tires and pavement*
- *G* : *gradient of the road*

Therefore, $SSD = d_r + d_b$

Passing / Overtaking Sight Distance(PSD/OSD)

- applies when the sight distance is long enough to enable a vehicle to overtake and pass another vehicle safely on a two-way lane highway, without colliding with an oncoming vehicle
- The passing/overtaking sight distance, PSD/OSD is the total of four distances components d1+d2+d3+d4 as shown in the following figure:

Passing / Overtaking Sight Distance(PSD/OSD)

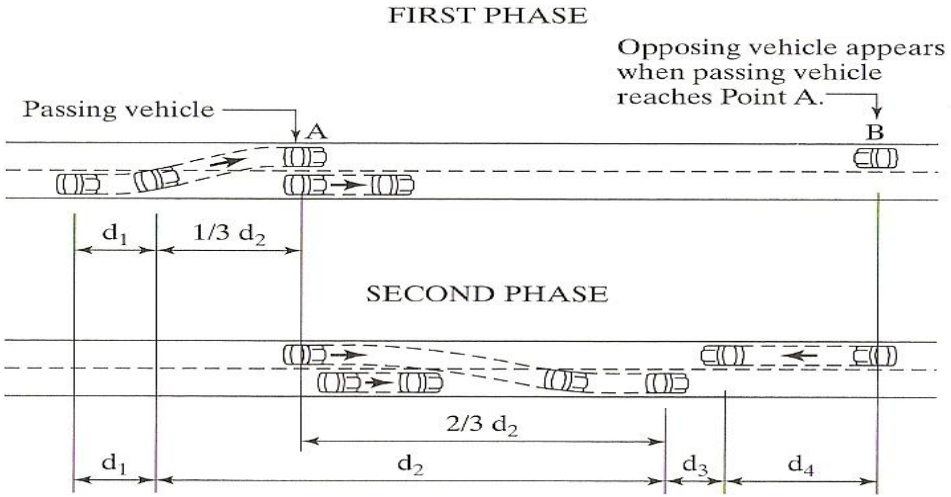


Figure : Elements of passing sight distance on two-lane highways
Note: This figure was based on roads in United States
Source: AASHTO in Traffic and Highway Engineering,2001

d1 : distance traversed during the perception and reaction time and during the initial acceleration to the point of encroachment on the passing

d2 : distance traveled while the passing vehicle occupies the passing lane (overtaking distance)

d3 : distance between the passing vehicle at the end of its maneuver and the opposing vehicles

d4 : distance traversed by an opposing vehicle for two-thirds of the time the passing vehicle occupies the passing lane

Conclusion of The Chapter

- Conclusion #1
  - Driver, vehicles, road and their interrelationships have influences in highway design and traffic control.
  - These in combination must be understood by highway engineers to provide safe facilities and services to the the road users.

- Conclusion #2

  - Stopping and passing sight distance are two main elements of road characteristics that are directly related to the fundamental principles of highway design to ensure driver able to see far enough to avoid potential collision.

Example SSD:

The local traffic engineer conducted a speed study of a rural road and found that the design speed imposed is 90 km/hr. The coefficient of friction between tires and roadway on wet pavement is 0.29. Determine the stopping sight distance if the perception - reaction time is 2.5 s.

Solutions:

$$SSD = d_r + d_b$$

$$dr = 0.28 * 90 * 2.5 = 62.55m$$

$$db = \frac{90^2 - 0^2}{254(0.29 \pm 0)}$$

$$= 109.96m$$

Therefore,

$$SSD = 62.55 + 109.96 = 172.51m$$

References

- Road Engineering Association of Malaysia, A GUIDE ON GEOMETRIC DESIGN OF ROADS, REAM-GL 2/2002, 2002.
- Garber, N.J., Hoel, L.A., TRAFFIC AND HIGHWAY ENGINEERING,3rd Edition, Brooks/Cole, 2001.