Class 2 – Components of the Traffic System – Part A

Traffic Engineering

1. Definition

- Transportation engineering is the application of technology and scientific principles to the planning, functional design, operation, and management of facilities for any mode of transportation in order to provide for the safe, rapid, comfortable, convenient, economical, and environmentally compatible movement of people and goods

- Traffic engineering is that phase of transportation engineering which deals with the planning, geometric design and traffic operations of roads, streets, and highways, their networks, terminals, abutting lands, and relationships with other modes of transportation

Traffic Engineering (contd.)

Primary objective:

Other objectives:

Recent topics: ITS, access management, congestion management.

Continuous topic: environmental impacts

Basic and essential tasks: effective communication through signs; maintaining inventories and evaluating safety performance

Traffic Engineering (contd.)

2. Elements

   A. Traffic studies and characteristics

      Focus on data collection and analysis that is used to characterize traffic

      - Traffic volume
      - Speed

   B. Performance evaluation

      - Intersections and individual sections of facilities

   C. Facility design

      - Functional and geometric design of highways and other traffic facilities

   D. Traffic control

      - Establishment of traffic regulations
      - Use of traffic control devices

Traffic Engineering (contd.)

E. Traffic Operations

- Measures that influence overall operation of a facility

F. Transportation systems management

- Optimizing system capacity and operations

G. Integration of Intelligent Transportation Systems

Key references for Traffic Engineering

Standard references

- Manual on Uniform Traffic Control Devices (MUTCD)
- Highway Capacity Manual (HCM)
- AASHTO (Green Book) A Policy on a Geometric Design of Streets and Highways.
- Traffic Engineering Handbook

Traffic Engineering (contd.)

Technical Papers (TRIS online)

- Institute of Transportation Engineers (ITE)
- Transportation Research Board (TRB)
- American Society of Civil Engineers (ASCE)

These and other organizations publish periodicals such as:

- ITE journal (ITE)
- Transportation Research Record (TRR)
- Transportation Engineering

Other reports of great interest:

- National Cooperative Highway Research Program (NCHRP)

Internet resources:

- ITE: http://www.ite.org
- TRB: http://www.trb.org

Components of Traffic System

Primary components of the traffic system:

- Road users: drivers, pedestrians, bicyclists, and passengers
- Vehicles: private and commercial
- Streets and Highways
- Traffic control devices
- The general environment

The general environment has an impact on traffic operations but it is difficult to assess.

Traffic engineering would be great if these component had uniform characteristics

Traffic engineers have little control over driver and vehicle characteristics, design of roadway systems and traffic controls is in the core of their professional practice

Road Users

- Very important as all transportation facilities have to be eventually used efficiently and safely by “Humans”
- Driver (user) response is a major component of planning and design of transportation systems
- Human beings have a wide range of characteristics that influence the driving task
- A major task is to find ways to provide drivers with information in a clear, effective, manner that induces safe and proper responses
- Engineering designs generally accommodate the abilities of 85% of users
- Two important driver characteristics are visual acuity factors and the reaction process.

Road Users (contd.)

Critical Characteristics:

a. Visual characteristics of drivers

require eye test to measure static visual acuity or the ability to see small stationary details clearly

- visual factors in driving:

the dynamic nature of the driving task implicates that most objects are viewed by drivers in relative motion with respect to the driver's eye. See Table 2.1

- fields of vision:

a. acute or clear vision cone

b. fairly clear vision cone

c. peripheral vision

See Figure 2.1

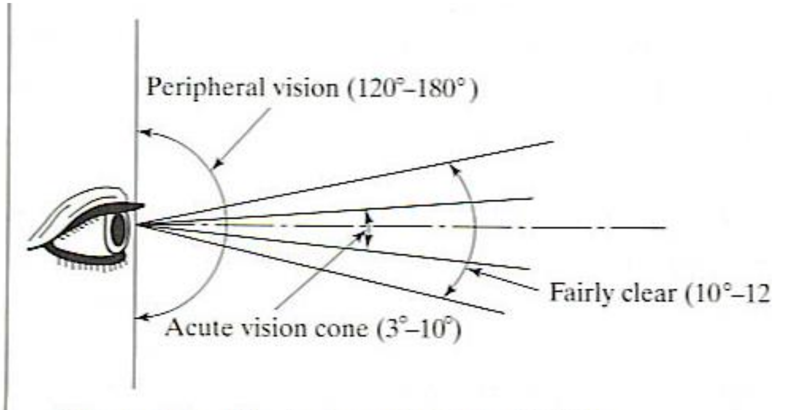


Figure 2.1: *Illustration of Fields of Vision*

Table 2.1: Visual Factors in the Driving Task

Visual Factor	Definition	Sample Related Driving Task(s)
Accommodation	Change in the shape of the lens to bring images into focus.	Changing focus from dashboard displays to roadway.
Static Visual Acuity	Ability to see small details clearly.	Reading distant traffic signs.
Adaptation	Change in sensitivity to different levels of light.	Adjust to changes in light upon entering a tunnel.
Angular Movement	Seeing objects moving across the field of view.	Judging the speed of cars crossing drivers' paths.
Movement in Depth	Detecting changes in visual image size.	Judging speed of an approaching vehicle.
Color	Discrimination between different colors.	Identifying the color of signals.
Contrast Sensitivity	Seeing objects that are similar in brightness to their background.	Detecting dark-clothed pedestrians at night.
Depth Perception	Judgment of the distance of objects.	Passing on two-lane roads with oncoming traffic.
Dynamic Visual Acuity	Ability to see objects that are in motion relative to the eye.	Reading traffic signs while moving.
Eye Movement	Changing the direction of gaze.	Scanning the road environment for hazards.
Glare Sensitivity	Ability to resist and recover from the effects of glare.	Reduction in visual performance due to headlight glare.
Peripheral Vision	Detection of objects at the side of the visual field.	Seeing a bicycle approaching from the left.
Vergence	Angle between the eyes' line of sight.	Change from looking at the dashboard to the road.

(Used with permission of Institute of Transportation Engineers, Dewar, R., "Road Users," *Traffic Engineering Handbook*, 5th Edition, Chapter 2, Table 2.2, pg. 8, 1999.)

Road Users (contd.)

b. Perception-reaction time:

Four distinct processes:

- Detection: recognition that something requiring response is present

- Identification: driver acquires sufficient information concerning the object or condition to allow the consideration of a proper response

- Decision: analyze the information and make a decision about how to respond

- Response: physical response that result from the decision

Perception-reaction time depends on many factors: age, gender, medical condition, alcohol and drug use, fatigue, sleep deprivation, emotional condition, type of vehicle, experience and knowledge, etc.

Road Users (contd.)

b. Perception-reaction time (contd.):

- The American Association of State Highway and Transportation Officials (AASHTO) recommends 2.5 sec for design value. Based on research, this is the 90^{th} percentile criterion

- For signal timing, the Institute of Transportation Engineers (ITE) recommends 1.0 sec.

- For specific situations, a longer time may be recommended

- Expectancy :drivers will react more quickly to situations they expect to encounter as opposed to those that they do not expect to encounter

Road Users (contd.)

b. Perception-reaction time (contd.):

- Reaction distance: distance the vehicle travels while the driver goes through the process of perception reaction time

$$dr = 0.278\ v\ t$$

where:

dr = reaction distance (m), v = speed (kph)

t = perception reaction time (sec)

0.278 = conversion factor from kph to mps

or,

$$dr = 1{,}47\ S\ t$$

where:

dr = reaction distance (ft), S = speed (mph)

t = perception reaction time (sec)

1.47 = conversion factor from mph to fps

Road Users (contd.)

c. Pedestrians:

A critical safety problem in the street and highway system involves the interactions of vehicles and pedestrians

For pedestrians, it has to be considered:

- Walking speed for signalized intersections

  Standard walking speed used for signal timing is:4.0 fps or 3.5 fps where older population is predominant

  This speed will accommodate 85^{th} percentile of the population

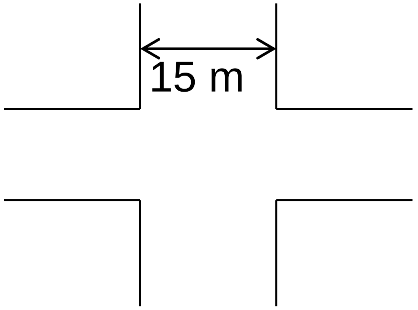
- Gap acceptance for unsignalized intersections

  it refers to the clear time intervals between vehicles encroaching on the crossing path and the behavior of pedestrians in accepting them to cross through

  Recommended gap of approximately 125 ft (85^{th} perc.)

Road Users (contd.)

Example:



Walking speed = 1.5 m/sec
Other consideration:?
Total time to cross the street =

Note: a traffic light is designed not only to aloud vehicles to pass through the intersection but also to aloud pedestrian to cross

If no gap is available then alternatives arrangements such as pedestrian signals may be considered

Vehicles

For purpose of geometric design, AASHTO has classified motor vehicles into four main categories:

- Passenger cars
- Buses
- Trucks
- Recreational vehicles including cars with trailers

Critical vehicles properties that need to be considered::

- braking and deceleration
- acceleration
- low speed turning characteristics
- high speed turning characteristics

a. Design Vehicle:

AASHTO has established a set of 20 design vehicles with standard physical dimensions.

Vehicles (contd.)

b. Turning Characteristics of vehicles

- Low speed turns (≤ 10 mph)

Limited by the characteristics of the vehicle (minimum radius allowed). AASHTO specifies minimum design radii for each of the design vehicles

- High speed turns (≥ 10 mph)

Limited by the dynamics of side friction between the roadway and the tires, and by the superelevation of the roadway.

c. Acceleration performance of vehicles

Vehicles – high acceleration rates

Heavy vehicles – lower rates of acceleration

Vehicles (contd.)

d. Breaking performance

- Most critical performance characteristics: breaking performance. The time and distance required to stop:
- Primary consideration in virtually every aspect of traffic -system design and operation.
- Factors: vehicles braking system, type & condition of tires

Breaking distance:

$$d_b = \frac{v_i^2 - v_f^2}{254(f+G)}$$ Uphill

Where,

db = breaking distance (m)

vi = initial vehicle speed (kph)

vf = final vehicle speed (kph)

f = coefficient of forward friction between tires and roadway

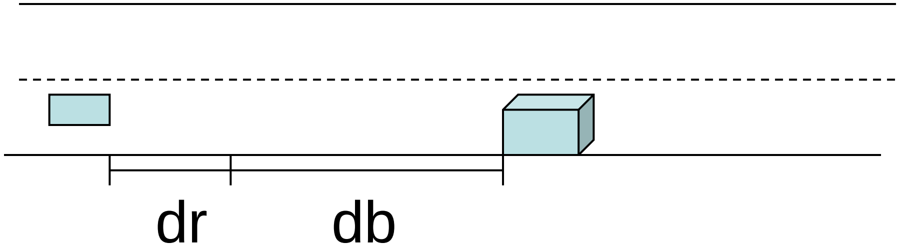
g = grade expressed as a decimal

254 = units conversion factor (used 30 if speed in mph)

Vehicles (contd.)

e. Applications of Braking and Reaction distance

Total stopping distance: ds = dr + db



Where:

ds = total stopping distance (m)

dr = reaction distance (m)

db = breaking distance (m)

By combining the reaction distance and breaking distance equations:

ds = 0.278 v t + $d_b = \frac{v_i^2 - v_f^2}{254(f + G)}$

Vehicles (contd.)

Safe Stopping distance:

It is assumed that, in the worst case, a driver encounters an object stopped in his or her lane and evasive action is not possible. Thus, the driver must see the object in time to react and stop the vehicle.

Use: t = 2.5 sec (AASHTO)

Decision Stopping distance:

for sections where driver should react to potentially more complex situations than a simple stop. Use t for the appropriate collision avoidance reaction time for the situation

Example:

f=0.29 t=2.5 sec design speed=110 kph

$$ds = 0.278(110)(2.5) + \frac{110^2}{254(0.29)} = 240.72 \text{ m}$$