VISVESVARAYA TECHNOLOGICAL UNIVERSITY
BELGAUM

TRANSPORTATION ENGINEERING

(Subject Code: BCV403)

LECTURE NOTES

IV-SEMESTER

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MODULE 3

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Module-3

Definition of Transportation Modes

- A transportation system is an infrastructure that serves to move people and goods efficiently.
- Efficient = safe, rapid, comfortable, convenient, economical, environmentally compatible

Study of Traffic Engineering

Traffic engineering is a comparatively new branch of engineering and has grown with the increase in traffic in recent years. As vehicular traffic began to increase, the congestion on the streets began to hamper the safe and efficient movement of traffic. More and more accidents were caused, and serious problems of parking and environmental pollution began to felt. It was therefore necessary to give increasing attention to the operational characteristics of highway transportation and study the need for better geometric design , capacity intersections traffic regulations, signals traffic signs, roadway markings, parking facilities and street lightning.

Definition:

- Traffic engineering is that branch of engineering which deals with **planning and geometric design of streets, highways, and operating traffic systems** to **achieve safe, economical, convenient and efficient movement of persons and goods**.

Professor Ress Blunden of California University has proposed a modified definition

"Traffic engineering is the science of measuring traffic and travel, the study of the basic laws relating to traffic flow and generation and application of this knowledge to the professional practice of planning, designing and operating traffic systems to achieve safe and efficient movement of persons and goods".

Scope of Traffic Engineering:

I. The basic object of traffic engineering is to achieve efficient, free and rapid flow of traffic with least number of traffic accidents.

II. The surface details Sight distances requirements. Horizontal and vertical alignment. Intersections and parking facilities are to be suitably designed for better traffic performance

III. The study of traffic engineering may be divided into six major sections viz:

- Traffic characteristics
- Traffic studies and analysis
- Traffic operation -control and regulation
- Planning and analysis
- Geometric design
- Administration and management

IV. The various phases of traffic engineering are implemented with help of 3E

- Engineering
- Enforcement
- Education

Enforcement: is usually made through traffic laws, regulations, and control.
Education: may be possible by sufficient publicity and through schools and television.
Engineering: deals with the improvement of road geometric, providing additional road facilities and installation of suitable design traffic control devices.

Functions of Traffic Engineering:

1. **Planning and travel forecasting:** To manage the future requirements of safe, comfort and economic travel.

2. **Collection of the factual information**: collection analysis and interpretation of factual data's the main function of traffic engg. The data collected from different types of field's survey and studies helps in planning and designing new facility.

3. **Research:** To develop more efficient methods and techniques research is essential. The various areas if importance under this are read design factors, safety, economic impact etc.

4. **Traffic accident recording**: If proper data recording and analysis is done on a scientific basis then accidents can be avoided.

5. **Design and placement of control and regulatory measures**. The main object of control device and regulation is to control the mad user, direct him in a better way.

Fundamentals of Traffic Flow

Traffic flow is the study of the movement of individual drivers and vehicles between two points and the intersections they make with one another.
These relationships help in planning, design and operations of roadway facilities. It is classified as,

- Interrupted flow: Flow occurring at long sections of road where vehicles are required to stop by any external cause to the traffic movement

- Uninterrupted flow: Flow occurring at long sections of road where vehicles are not required to stop by any external cause to the traffic movement

To represent traffic flow, relationships have been established between the speed, flow rate or volume, density.

I. Speed (v) is considered as a quality measurement of travel as the drivers and passengers will be concerned more about the speed of the journey than the design aspects of the traffic. It is defined as the rate of motion in distance per unit of time. Mathematically speed or velocity v is given by,

$$v = \frac{d}{t} \tag{1}$$

Where, v is the speed of the vehicle in m/s, d is distance travelled in m in time seconds. Speed of different vehicles will vary with respect to time and space. To represent these variation, several types of speed can be defined. Important among them are spot speed, runningspeed, journey speed, time mean speed and space mean speed. These are discussed below.

Types of speeds

a) Spot Speed
b) Running Speed
c) Journey speed

a) Spot Speed

Definition

Spot speed is the instantaneous speed of a vehicle at a specified location or section.

Spot speed can be used to design the geometry of road like horizontal and vertical curves, super elevation etc. Location and size of signs, design of signals, safe speed, and speed zone determination, require the spot speed data. Accident analysis, road maintenance, and congestion are the modern fields of traffic engineer, which uses spot speed data as the basic input. Spot speed can be measured using an enoscope. pressure contact tubes or direct timing procedure or radar speedometer or by time-lapse photographic methods. It can be determined by speeds extracted from video images by recording the distance traveling by all vehicles between a particular pair of frames.

b) Running speed

Definition

Running speed is the average speed maintained over a particular course while the vehicle is moving and is found by dividing the length of the course by the time duration the vehicle was in motion.

I.e. this speed doesn't consider the time during which the vehicle is brought to a stop, or has to wait till it has a clear road ahead. The running speed will always be more than or equal to the journey speed, as delays are not considered in calculating the running speed

c) Journey speed or Travel speed

Definition

Journey speed is the effective speed of the vehicle on a journey between two points and is the distance between the two points divided by the total time taken for the vehicle to complete the journey including any stopped time.

If the journey speed is less than running speed, it indicates that the journey follows a stop-go condition with enforced acceleration and deceleration. The spot speed here may vary from zero to some maximum in excess of the running speed. A uniformity between journey and running speeds denotes comfortable travel conditions.

Speed is the important factor of traffic flow and time mean speed and space mean speed are two representations of speed.

Time mean speed (V_t)

time mean speed is the average speed of all vehicles passing a point on a highway over a duration of time. It is the simple average of spot speed. Time mean speed v_t is given by,

Where V_i is the spot speed of the i^{th} vehicle, and n is the number of observations. Given by eq

$$v_t = \frac{1}{n}\sum_{i=1}^{n} v_i,$$

In many speed studies, speeds are represented in the form of frequency table. Then the time mean speed is

$$v_t = \frac{\sum_{i=1}^{n} q_i v_i}{\sum_{i=1}^{n} q_i},$$

Where q_i is the number of vehicles having speed v_i,

and n is the number of such speed categories.

Space mean speed (v_s)

Space mean speed is defined as the average speed of all the vehicles occupying a given section of a highway over some specified time period.

Consider unit length of a road, and let v is the spot speed of i^{th} vehicle.

Let ti is the time the vehicle takes to complete unit distance and is given by $1/v_i$.
If there are n such vehicles, then the average travel time t_s is given by,

$$t_s = \frac{\Sigma t_i}{n} = \frac{1}{n}\Sigma\frac{1}{v_i}$$

If t_{av} is the average travel time, then average speed $v_s = 1/t_s$ Therefore from the above equation

$$v_s = \frac{n}{\sum_{i=1}^{n}\frac{1}{v_i}}$$

II. Flow is known as volume (q), is the number of vehicles passing a specified point during a stated period of time expressed as vehicles per hour.
The measurement is carried out by counting the number of vehicles, n_t, passing a particular point in one lane in a defined period t Then the flow q expressed in vehicles/hour is given by

$$q = \frac{n_t}{t}$$

III. Density (k), **also known as concentration,** is the number of vehicles present in a stated length of road at an instant, expressed as vehicles per km.
One can photograph a length of road X, count the number of vehicles n_x in one lane of the road at that point of time and derive the density k as,

$$k = \frac{n_x}{x}$$

IV. Space headway (s) is the distance between the of successive vehicles expressed in meters

V. Time headway (h) is the time interval between the passages of the fronts of successive vehicles at a specified point expressed in seconds

Speed is one of the basic parameters of traffic flow and time mean speed and space mean speed are the two representations of speed

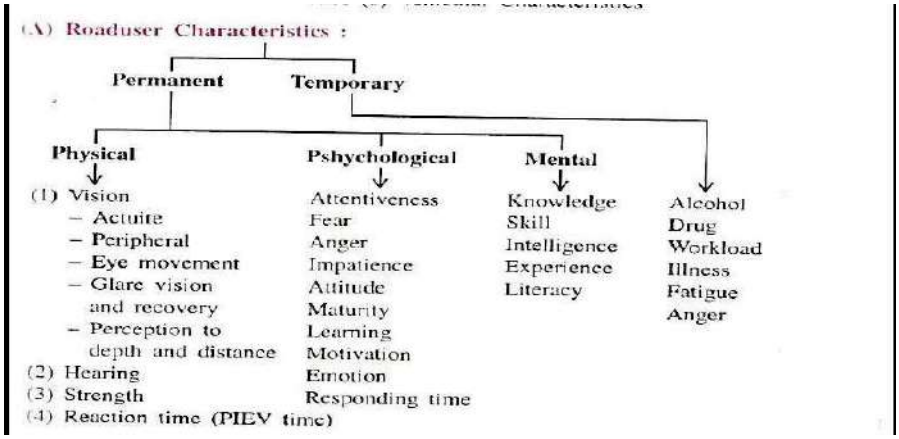
Components of Traffic engineering

1. Traffic characteristics
2. Traffic studies ad Traffic analysis
3. Traffic Operations

4. Traffic Planning and Analysis
5. Geometric Design
6. Administration and Management

Factors affecting Traffic Characteristics:

1. The Road user (Driver and Pedestrian)
2. The Vehicle
3. The Roadway (Transport Facility)
4. The environment



1. The Road user (Driver and Pedestrian)

The various factors which affect under road user characteristics may broadly be Classified under four heads:

a) Physical characteristics
b) Mental characteristics
c) Psychological factors
d) Environmental factors

a. Physical characteristics: The permanent physical characteristics of the driver are vision, hearing, strength and the general reaction to the traffic situations.

Vision include the acuity of vision, peripheral vision and eye movement; glare vision, glare recovery and depth judgment. Field of accurate, clear vision is about a 3 degrees cone however the vision is fairly satisfactory up to 10 degrees in general and 20 degrees in horizontal plane. In vertical plane the vision may be limited to 2/3 of that in horizontal plane.

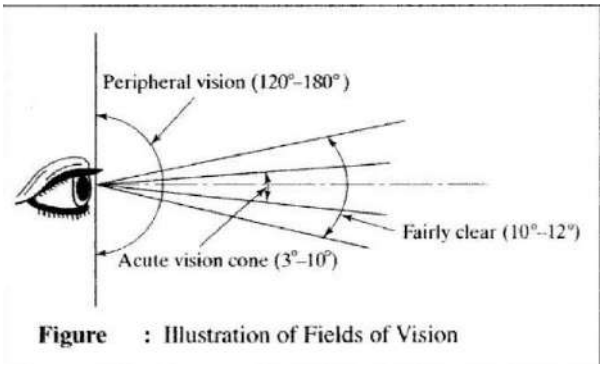


Figure : Illustration of Fields of Vision

Hearing is helpful for drivers but of more important for the pedestrians and cyclists

b. Mental Characteristics: Knowledge, skill, intelligence, experience and literacy can affect the road user characteristics. Knowledge of vehicle characteristics, traffic behaviour, driving practice, rules of roads and psychology of road users will be quite useful for safe traffic operations.

c. Psychological factors: These effect reaction to traffic situations of road users to a great extent. Attentiveness, anger, fear, anxiety, phobias, superstition, and impatience may affect the traffic performance to great extent.

d. Environment factors: The various environmental conditions affecting the behaviour of road user are traffic stream characteristics, facilities to the traffic, atmospheric conditions and locality. The traffic stream may consist of mixed traffic or heavy traffic whereas facilities to overtake to the faster vehicles may be limited. The behaviour of the driver varies from one traffic stream to another.

Similarly the facilities of the traffic separators, multi-lanes etc will affect the performance. Surrounding environment effect the performance of the traffic because one will get slower at the market places and will be faster at the open places.

Reaction Time:

Reaction time of the driver is the time taken from the instant the object is visible to the driver to the instant the brakes are effectively applied.

The amount of time gap depends on several factors. During this time the vehicle travels a certain distance at the original speed or the design speed.

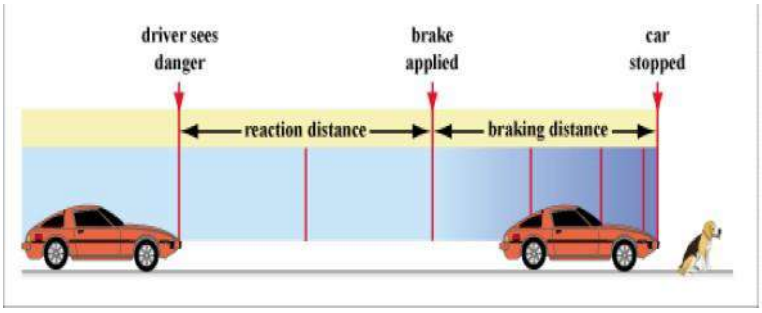
The distance travelled by the vehicle during the total reaction time is known as **lag distance**

Total reaction time of an average driver may be vary from **0.5 sec to 4 sec**

Lag distance = v * t

Where, v = speed of vehicle in m/s

t = total reaction time (s) [as per **IRC t = 2.5 s]**

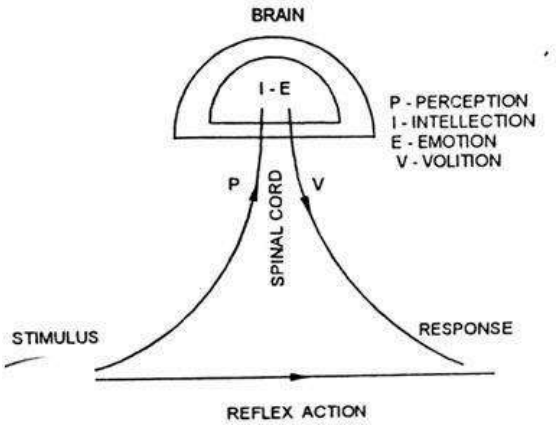


PIEV theory

According to this theory the total reaction time of the driver is split into four parts viz, time taken by the driver.

The total time required to perceive and complete a reaction to a stimulus is the sum of the time necessary for perception, intellection, emotion and volition is called PIEV TIME or RESPONDING TIME

1) Perception
2) Intellection
3) Emotion
4) Violation

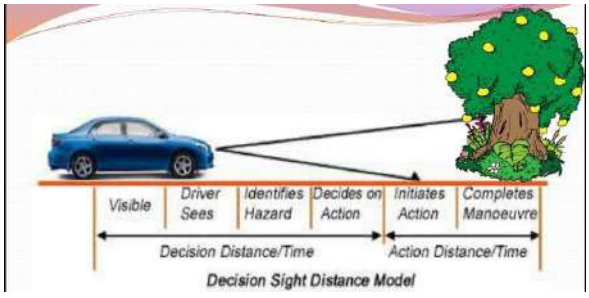


1) Perception time: is time required for the sensations received by the eyes or ears of the driver to be transmitted to the brain through the nervous system & spinal cord or it is the time required to perceive an object or situation.

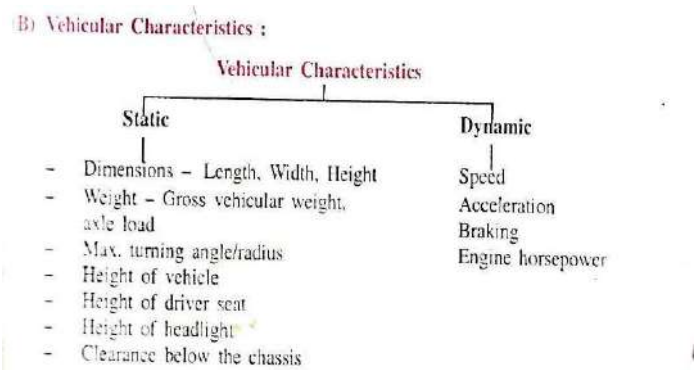
2) Intellection time : is the time require for the driver to understand the situation it is also the time required for comparing the different thoughts.

3) Emotion time: is the time elapsed during emotional sensational and other mental disturbance such as fear, anger or any other emotional feeling superstition etc.

4) Volition time: is the time taken by the driver for the final action such as brake application.



2. Vehicle characteristics:



A knowledge of vehicular characteristic is necessary for proper geometric design and traffic control systems allowing for safe and smooth operations.

Maximum dimensions of Road Vehicles

Dimension of Vehicles	Details	Maximum dimension in m (excluding front and rear bumpers)
Width	Vehicles	2.50
Height	a) Single-decked vehicle for normal application	3.80
	b) Double-decked vehicle	4.75
Length	a) Single-unit truck with two or more axles	11.00
	b) Single-unit bus with two or more axles	12.00
	c) Semi-trailer tractor combinations	16.00
	d) Tractor and trailer combinations	18.00

a) Static characteristics: include the dimensions, weight and maximum turning angle.
b) Dynamic characteristics: involve the forces that cause the motion of vehicle such as speed, acceleration and braking characteristics and some aspects of vehicle shape body design.

a) Static Characteristics

Vehicle Characteristics	**Affecting vehicle**
1.Width of vehicle	Lane width, Width of shoulders, width of parking slots
2.Length of vehicle	Horizontal alignments, minimum Turing radius, extra widening on passage side distance, road capacity, parking facilitates.

3.Height of vehicle	Clearance to be provided while moving under flyovers, subways, electric service lanes etc.
4.Weight of vehicle	To determine the pavement depths and maximum gradient to be provided for smooth movement of vehicles
5.Turning radius of vehicle	Parking manoeuvres, curves, intersection design channelization driveways etc.

b) Dynamic characteristics:

Vehicle Characteristics	**Affecting vehicle**
1.Speed of vehicle	Horizontal and vertical alignment, super elevation, limiting radius, sight distance, lane capacity, intersection design, skid resistance
2.Power of vehicle	Ruling and limiting gradient speed of the vehicle in conjunction roads.
3.Acceleration characteristics	Time required to cross intersection passing a vehicle, gap acceptance.
4.Breaking characteristics	Stopping distance, over sighting distances, traffic capacity.
5.Head light of vehicle	Night operation of vehicle

Fundamental sketchs of traffic flow:

1. Flow Density curve
2. Speed-density diagram
3. Speed flow relation

1. Flow Density curve

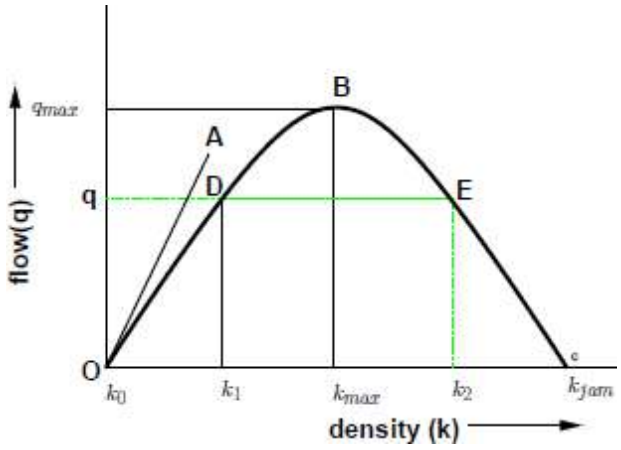


Fig: Flow-Density curve

The flow and density varies with time and location. The relation between the density and the corresponding flow on a given stretch of road is referred to as one of the fundamental diagram of traffic flow.
Some characteristics of an ideal flow-density relationship is listed below:

a. When the density is zero, flow will also be zero, since there is no vehicles on the road.
b. When the number of vehicles gradually increases the density as well as flow increases.
c. When more and more vehicles are added, it reaches a situation where vehicles can't move. This is referred to as the jam density or the maximum density. At jam density, flow will be zero because the vehicles are not moving.
d. There will be some density between zero density and jam density, when the flow is maximum. The relationship is normally represented by a parabolic curve as shown in figure
e. The point O refers to the case with zero density and zero flow. The point **B** refers to the maximum flow and the corresponding density is k_{max}. The point **C** refers to the maximum density k_{jam} and the corresponding flow is zero.
f. OA is the tangent drawn to the parabola at O, and the slope of the line OA gives the mean free flow speed, i.e. the speed with which a vehicle can travel when there is no flow. It can also be noted that points D and E correspond to same flow but has two different densities. Further, the slope of the line OD gives the mean speed at density k_1 and slope of the line OE will give mean speed at density k_2. Clearly the speed at density k_1 will be higher since there are less number of vehicles on the road.

2. Speed Density diagram

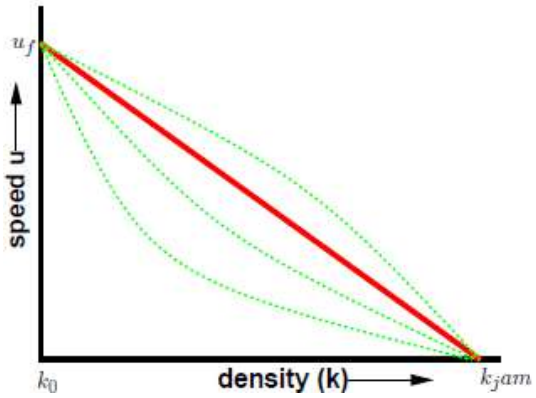


Fig: Speed-Density curve

Similar to the flow-density relationship, speed will be maximum, referred to as the free flow speed, and when the density is maximum, the speed will be zero. The simplest assumption is that this variation of speed with density is linear as shown by the solid line in figure corresponding to the zero density, vehicles will be owing with their desire speed, or free flow speed. When the density is jam density, the speed of the vehicles becomes zero. It is also possible to have non-linear relationships as shown by the dotted lines.

3. Speed flow relation

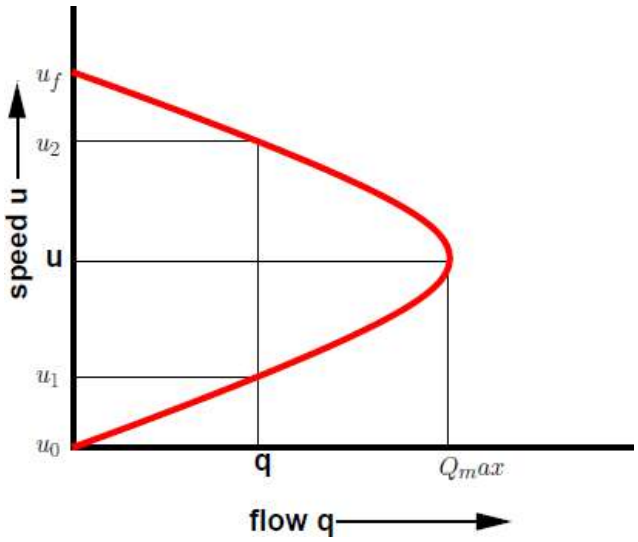


Fig: Speed-flow curve

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Urban Traffic problems

Cities are locations having a high level of **accumulation** and **concentration** of economic activities and are complex spatial structures that are supported by transport systems. The larger the city, the greater its complexity and the potential for disruptions, particularly when this complexity is not effectively managed

The following are some of the notable urban transport problems are:

- Traffic congestion and parking difficulties
- Longer commuting.
- Public transport inadequacy
- Difficulties for non-motorized transport.
- Loss of Public Space.
- High maintenance costs
- Land Consumption
- Freight distribution
- Automobile Dependency
- Accident and safety
- Environmental Impacts and energy consumption

Explanation of above points is given below.

Traffic congestion and parking difficulties

One of the most prevalent transport problems in large urban agglomerations, usually above a threshold of about 1 million inhabitants. It is particularly linked with motorization and the diffusion of the automobile, which has increased the demand for transport infrastructures.

Public Transport Inadequacy

Many public transit systems, or parts of them, are either over or under used. During peak hours, crowdedness creates discomfort for users as the system copes with a temporary surge in demand.

Difficulties for non-motorized transport

These difficulties are either the outcome of intense traffic, where the mobility of pedestrians, bicycles and vehicles is impaired, but also because of lack of consideration for pedestrians and bicycles in the physical design of infrastructures and facilities

Environmental impacts and energy consumption

Pollution, including noise, generated by circulation has become a serious barrier to the quality of life and even the health of urban populations.

Energy consumption by urban transportation has dramatically increased and so the dependency on petroleum. Yet, peak oil considerations are increasingly linked with peak mobility expectations were high energy prices incite a shift towards more efficient and sustainable forms of urban transportation, namely public transit.

Accidents and safety

Growing traffic in urban areas is linked with a growing number of accidents and fatalities, especially in developing countries. Accidents account for a significant share of recurring delays. As traffic increases, people feel less safe to use the streets.

Freight distribution.

Globalization and the materialization of the economy have resulted in growing quantities of freight (Cargo or goods) moving within cities. As freight traffic commonly shares infrastructures along with the circulation of common passengers, the mobility of freight in urban areas has become increasingly problematic

Automobile Dependency

The acute growth in the total number of vehicles also gives rise to congestion at peak traffic hours on major thoroughfares, in business districts and often throughout the metropolitan area

- **Traffic Surveys:** Traffic Surveys- Speed, journey time and delay surveys, Vehicles Volume Survey including non-motorized transports,
- Methods and interpretation, Origin Destination Survey, Methods and presentation, Parking
- Survey, Accident analyses-Methods, interpretation and presentation, Statistical applications in traffic studies and traffic forecasting, Level of service- Concept, applications and significance.

Traffic Surveys – need and overview

Traffic Studies
- Traffic volume study
- Speed study
- Spot speed study
- Speed and delay study
- Origin and destination study
- Traffic flow characteristics
- Traffic capacity study
- parking study
- Accident studies

Traffic engineering studies are carried out for collecting traffic data & are also termed as traffic surveys. These studies are carried out to analyse the traffic characteristics & their movements along the identified roads. If the traffic is heavy, the road suffers from congestion with consequent loss in journey speeds. The results are carried out for design of geometric features & traffic control measures for safe & efficient traffic movement.

The different traffic engineering surveys are-

a) Traffic volume studies
b) Spot speed studies
c) Speed & delay studies
d) Origin & destination studies
e) Parking studies
f) Accident studies

1) Traffic volume studies-

It is the measure to quantify the traffic flow & is expressed as number of vehicles that pass across a given transverse line of road. It is expressed as number of vehicles **per hour or per day.** In India vehicle classes are Classified as passenger cars, buses, trucks, heavy commercial vehicles, light commercial vehicles, two wheelers and slow moving vehicles such as bullock carts, cycle rickshaws, pedal cycles etc. **Determination of volume of each vehicle class separately & finding the total volume is called traffic volume studies**.

The objectives and uses of traffic volume studies are given below.

1. To know the number and type of vehicle using a particular road
2. To plan design and regulate the traffic factors in traffic engineering.
3. To establish relative importance of an road facility
4. To help in design of roadways.
5. To carry out the economic studies in highway financing
6. To plan and design the new streets and new facilities.

Duration and Interval of Traffic Counts

In order to predict traffic flow volumes that can be expected on the road network during specific periods, knowledge of the fact is required that traffic volumes changes considerably at each point in time. There are three important cyclical variations:

- **Hourly pattern:** the way traffic flow characteristic varies throughout the day and night;
- **Daily Pattern:** The day-to-day variation throughout the week
- **Monthly and yearly Pattern:** The season-to-season variation throughout the year.

When analysing the traffic one must also be aware of the directional distribution of traffic and the manner in which its composition varies as it is important to deal with tidal flow.

- ***Hourly patterns* –** Typical hourly patterns of traffic flow, particularly in urban areas, generally show a number of distinguishable peaks. Peak in the morning followed by a lean flow until another peak in the middle of the afternoon, after which there may be a new peak in the late evening. The peak in the morning is often more sharp by reaching the peak over a short duration and immediately dropping to its lowest point. The afternoon peak on the other hand is characterised by a generally wider peak. The peak is reached and dispersed over a longer period than the morning peak.
- ***Daily patterns* –** The traffic volume generally varies throughout the week. The traffic during the working days (Monday to Friday) may not vary substantially, but the traffic volume during the weekend is likely to differ from the working days on different type of roads and in different directions

Counting of Traffic volume

Traffic volume counts may be done by mechanical counters or manually.

1a. Manual counts method

The most common method of collecting traffic volume data is the manual method of traffic volume count, which involves a group of people recording number of vehicles passing, on a pre-determined location, using tally marks in inventories. Raw data from those inventories is then organized for compilation and analysis. This method of data collection can be expensive in terms of manpower, but it is necessary in most cases where vehicles are to be classified with a number of movements recorded separately, such as at intersections also in case where automatic methods cannot be used due to lack of infrastructure, necessary authorization etc.

Note: It is not practicable to have manual count for all the 24 hours of the day and on all days round the year. Hence it is necessary to resort to statistical sampling techniques in order to

cut down the manual hours involved in taking complete counted. First the fluctuations of traffic volume during the hours of the day and the daily variations are observed. Then by selecting typical short count periods the traffic volume study is made by manual counting. Further by statistical analysis the peak hourly traffic volumes as well as the average daily traffic volumes are calculated. This method is very commonly adopted due to the specific advantages over other methods.

A manual classified count (MCC) involves counting all the vehicles passing a selected location on a road for a pre-determined period of time.

- The count is conducted by persons standing at the roadside and recording passing vehicles on a form, hence the term "*manual traffic count". This distinguishes it from* counts by machines that can record passing vehicles automatically, which are known as "automatic traffic counts".

Procedure

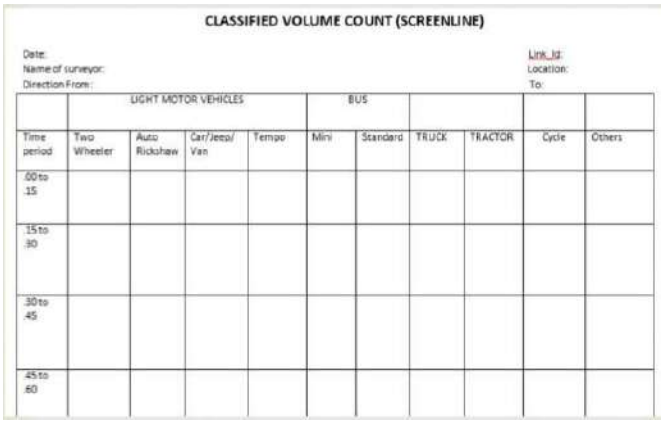
 No. of observers required depends upon no. of Lanes and type of information required.
 More desirable to record traffic in each direction of travel by posting separate observers for each direction.
 For all-day counts, work in three shifts can be arranged.
 Data is recorded by Five- dash system. (**IIII)**

Equipment's for manual counts

• Watch
• clip board
• Pencil, rubber, sharpner
• Data sheet (Tally Sheets)

Tally Sheets

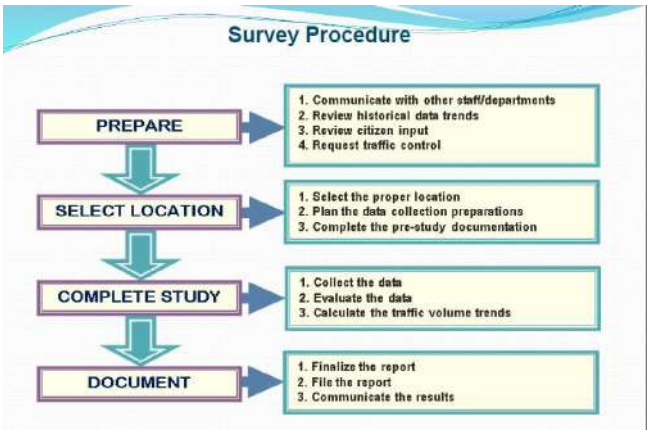
Recording data onto tally sheets is the simplest means of conducting manual counts. The data can be recorded with a tick mark on a pre-prepared field form. A watch or stopwatch is necessary to measure the desired count interval.



CLASSIFIED VOLUME COUNT (SCREENLINE)

Date: Link_Id:
Name of surveyor: Location:
Direction From: To:

	LIGHT MOTOR VEHICLES				BUS					
Time period	Two Wheeler	Auto Rickshaw	Car/Jeep/ Van	Tempo	Mini	Standard	TRUCK	TRACTOR	Cycle	Others
00 to 15										
15 to 30										
30 to 45										
45 to 60										



Manual Method-Advantages

- It gives the classified volume of each category of the traffic
- The directions of each class of traffic and intersection is also recorded.
- The loading conditions(or number of occupants) are also recorded in this method

Manual Method-Dis-advantages

- Not practicable to have manual count for 24 hrs of the day and throughout the year.
- Counts of remote areas is possible by automatic devices.
- It needs supervision and this method is tedious and costly.
- It requires experienced person for additional surveys.

1b.Automatic Counting Methods

 An automatic survey involves placing a tube or loop across a road which is connected to a box containing the means for storing the information of movement of vehicles across the road.
 In this method, vehicles are counted automatically without any human involvement.
 There are two techniques of automatic counting:

a) Contact system based on pneumatic, mechanical, magnetic or
b) Contactless system based on electrical/optical, ultrasound/infrared radar, micro wave, CCTV/video image processing method etc.

 The automatic count method provides a means for gathering large amounts of traffic data. Automatic counts are usually taken in 1- hour intervals for each 24-hour period.
 The counts may extend for a week, month, or year. When the counts are recorded for each 24-hour time period, the peak flow period can be identified.
 Automatic counts are recorded using one of three methods:

i. **portable counters,**
ii. **permanent counters, and**
iii. **videotapes**

i.Portable Counters

Portable counting is a form of manual observation. Portable counters serve the same purpose as manual counts but with automatic counting equipment. The period of data collection using this method is usually longer than when using manual counts. The portable counter method is mainly used for 24-hour counts.

Pneumatic road tubes are used to conduct this method of automatic counts. Specific information pertaining to pneumatic road tubes can be found in the users 'manual

ii. Permanent Counters

Permanent counters are used when long-term counts are to be conducted. The counts could be performed every day for a year or more. The data collected may be used to monitor and evaluate traffic volumes and trends over a long period of time.

iii. Videotape or Videography

Observers can record count data by videotaping traffic. Traffic volumes can be counted by viewing videotapes recorded with a camera at a collection site. A digital clock in the video image can prove useful in noting time intervals.

Advantages of Automatic recording method

- This method is suitable for long counts and permanent installations.
- It does not requires the supervision
- It can record the total hourly traffic volume

Disadvantages of Automatic recording method

- This method is not an accurate method. (If two or more vehicles pass at the same time the machine records only one vehicle).
- It is not possible to record the types of traffic and their turning movements.
- It is not suitable for pedestrian traffic volume.

Types of volume measurements

Depending on the requirements the data collected during the traffic volume studies are presented in any one of the following methods.

1. **Average Daily Traffic (ADT)**: An average 24-hour traffic volume at a given location for some period of time less than a year. It may be measured for six months, a season, a month, a week, or as little as two days. An ADT is a valid number only for the period over which it was measured.
2. **Average Annual Daily Traffic (AADT)**: The average 24-hour traffic volume at a given location over a full 365-day year, i.e. the total number of vehicles passing the site in a year divided by 365.
3. **Average Weekday Traffic (AWT)**: An average 24-hour traffic volume occurring on weekdays for some period of time less than one year, such as for a month or a season.
4. **Average Annual Weekday Traffic (AAWT)**: The average 24-hour traffic volume occurring on weekdays over a full year. It is computed by dividing the total weekday traffic volume for the year by 260(52 weeks x5 days=260weekdays).

The relationship between AAWT and AWT is similar to that between AADT and ADT. Volume in general is measured using different ways like manual counting, detector/sensor counting, moving-car observer method, etc. Mainly the volume study establishes the importance of a particular route with respect to the other routes, the distribution of traffic on road, and the fluctuations in flow. All which eventually determines the design of a highway and the related facilities. Thus, volume is treated as the most important of all the parameters of traffic stream.

2. Spot Speed Studies.

Spot speed is the instantaneous speed of a vehicle at a specified location or section. However there are two distinctly different methods of determination of spot speeds.

In the first method the time t (sec) taken by the vehicle to travel a short distance d (m) is determined. Therefore the speed v= (d/t)m/sec.

In the second methid the instantaneous speed is measured by a pre-calibrated 'radar' equipment which displays or records the speed in desired units such as Kmph

In view of these two methods there are two definitions for the average of a series of spot speed measurements viz: 'space mean speed' and 'time mean speed'.

Time mean speed (V_t)

time mean speed is the average speed of all vehicles passing a point on a highway over a duration of time. It is the simple average of spot speed. Time mean speed v_t is given by,

Where V_i is the spot speed of the i^{th} vehicle, and n is the number of observations. Given by eq

$$v_t = \frac{1}{n}\sum_{i=1}^{n} v_i,$$

In many speed studies, speeds are represented in the form of frequency table. Then the time mean speed is

$$v_t = \frac{\sum_{i=1}^{n} q_i v_i}{\sum_{i=1}^{n} q_i},$$

Where q_i is the number of vehicles having speed v_i,

and n is the number of such speed categories.

Space mean speed (v_s)

Space mean speed is defined as the average speed of all the vehicles occupying a given section of a highway over some specified time period.

Consider unit length of a road, and let v is the spot speed of i^{th} vehicle.

Let ti is the time the vehicle takes to complete unit distance and is given by $1/v_i$.
If there are n such vehicles, then the average travel time t_s is given by,

$$t_s = \frac{\Sigma t_i}{n} = \frac{1}{n}\Sigma\frac{1}{v_i}$$

If t_{av} is the average travel time, then average speed $v_s = 1/t_s$ Therefore from the above equation

$$v_s = \frac{n}{\sum_{i=1}^{n} \frac{1}{v_i}}$$

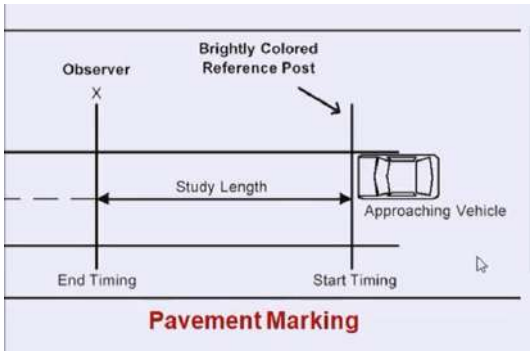
Uses of spot speed studies:

a) Planning traffic regulation and control measures such as speed limit etc
b) Design or redesign of various geometric elements of the road
c) To decide the design speed of existing or new facilities
d) In accident studies and preventive measures
e) Study of traffic capacity
f) To find the speed trends with respect to last several years
g) To compare the behaviour of diverse type of drivers and vehicles under specified set of conditions.

Time mean speed	Speed mean speed
1. We decide a point/location with sufficient interval of time say 15 minutes, 1hour. 2. More weightage is given to Time in hrs/min/secs.	1. We decide the time i.e. Morning 9am for a specified length/stretch of road. 2. More weightage is given to Location/point/place.

Measurements of spot speeds

One of the earliest methods of determining the spot speed of a vehicle is by finding the time taken to cover a short distance of say 15 or 30m.The selected distance (d) m may be marked on the pavement surface and the time taken (t sec) for a vehicle to traverse this distance may be observed either manually using a timer from a elevated location or recorded automatically using set of appropriate sensors.The speed v is gicen by v=(d/t) m/sec.



Other equipments used for spot speed measurements

i. Graphic recorder
ii. Electronic meter
iii. Photographic methods
iv. Radar speed meter

i.Radar speed meter

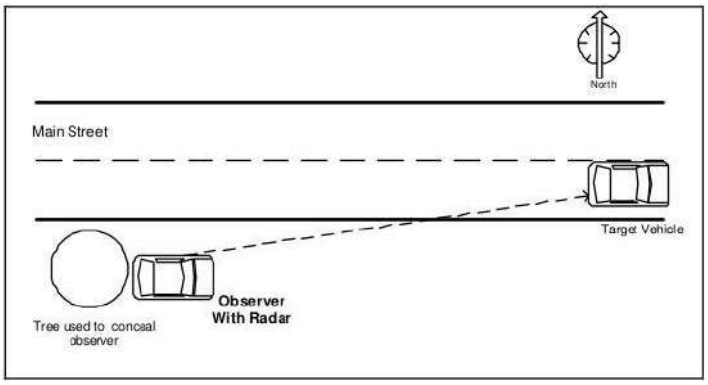
Radar speed meter directs a radar or audio beam of a certain frequency at the moving vehicles.The reflected signal is shifted in frequency and the difference in frequency is proportional to the speed of the vehicle:the radar speed meter is pre-caliberated to display/record the vehicle speed in Kmph

The radar speed meter should be located as close as possible to the line of vehicle travel.The equipment may be set up at an angle between the direction of travel of the vehicle and a straight line from the transmitter-reciever

In order to minimize the possible errors it is desirable that the vertical and horizontal angles ro the vehicle is as less as possible less than 20degrees.

Uses

To check measuring speed of vehicles from about 5 kmph to over 300kmph as may be required for measurements of speed of cars during the car-race.



(ii) Enoscope:

The parallax error of the observer can be eliminated by using a simple device called 'Enoscope', especially in the case of a single observer. Also known as 'Mirror box', it is an L-shaped box, open at both ends; a mirror is set inside it at 45° to both the arms as shown
In fig 4.8

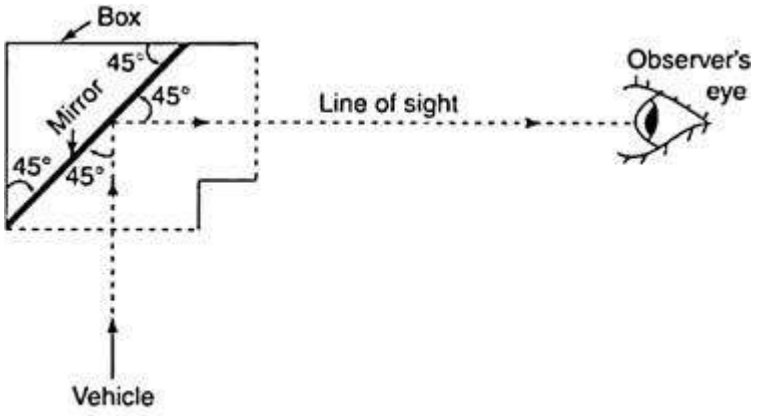


FIG. 4.8 *Principle of Enoscope*

Principle of Enoscope

Light rays from the vehicle impact on the mirror, get reflected and pass in a direction perpendicular to the incident ray. They reflected rays fall on the eye of the observer as shown. The observer can start and stop the stop-watch more accurately, with no parallax, because the line of sight is perpendicular to the direction of motion of the vehicle.

Either one enoscope can be used or two. If only one is used the device is placed directly opposite the first reference point and the observer is stationed at the other, as shown in Fig. 4.9.

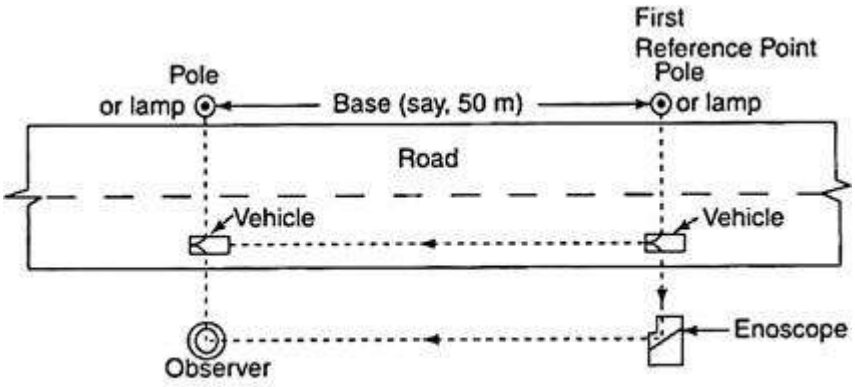


FIG. 4.9 *Spot speed using one Enoscope*

(iii) Pressure Contact Tubes:

In this method, pneumatic tubes laid across the carriageway at the two reference act a detectors; when a vehicle passes over them, air impulses are sent to an electromagnetically controlled stop-watch in the hands of the observer, starting the time at the first reference point and stopping it at the second. The readings can be recorded by automatic date records also, reducing the manual work.

Presentation of spot speed data

i. Speed Distribution table
ii. Frequency distribution diagram of spot speeds
iii. Cumulative speed distribution diagram

i) Frequency distribution diagram of spot speeds

A graph is plotted with the average values of each speed group on the X-axis and the percentage of vehicles in that group on the Y-axis. This graph is called the frequency distribution of spot speeds. This diagram will have a definite peak value of travel speed across the section and this speed is denoted as **'modal speed'.** It may be inferred that maximum proportion of vehicles in stream prefers to travel at about this modal speed on this particular location of the road.

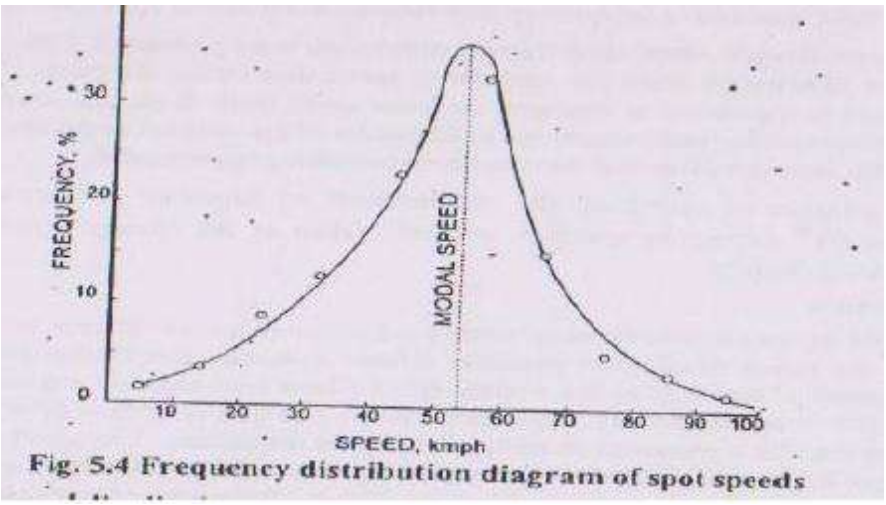
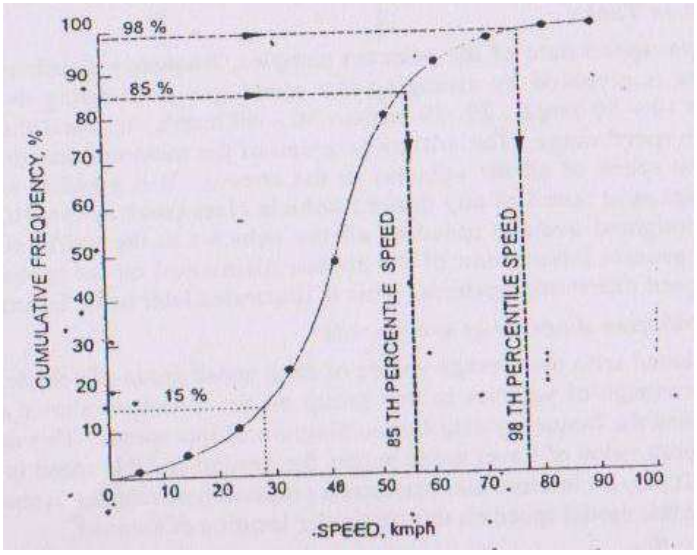


Fig. 5.4 Frequency distribution diagram of spot speeds

ii) Cumulative speed distribution diagram

- A graph is plotted with the average values of each speed group on the X-axis and the cumulative percent of vehicles at or below the different speeds on the Y-axis, as shown in figure.
- This graph is called 'cumulative speed distribution diagram' From this diagram, the '85th percentile speed' is determined i.e., the speed at or below which 85 percent of the vehicles are passing the point on the highway can be assessed;
- In other words, only 15 per cent of the vehicles exceed this speed at that spot.
- The drivers exceeding 85th percentile speed are usually considered to drive faster than the safe speed under existing conditions. Hence this speed is adopted for the 'safe speed limit' at this zone. Therefore if a 'speed limit' regulation sign is to be installed at an accident prone location, spot speed studies are carried out during different periods of the day, cumulative speed distribution diagram is plotted and 85" percentile speed is adopted as the upper speed limit.
- On some arterial roads where slow moving vehicles are to be prohibited,15^{th} percentile speed may be determined from the cumulative speed distribution diagram.
- The 15th percentile speed is considered to represent the lower speed limit, to prohibit slow moving' vehicles to decrease delay and congestion.
- For the purpose of checking the requirements of highway geometric design elements, the 98th percentile speed is generally taken as the 'design speed' of the existing ‘roadway facility
- 

3. Speed and delay studies

Speed and delay studies give running speeds, overall speeds, and fluctuations in speed and delay between two stations of a road spaced far apart. They also give the information such as amount, location, duration, frequency and causes of the delay in the traffic stream. Various methods to carry out speed and delay survey are:

• Floating Car method

• Licence Plate record method

• By Interview
• By Photography and videography

i) <u>Floating car method or moving observer method or car Moving method for running speed and journey speed</u>

- In the 'floating car method', a test vehicle is driven over a given route of travel at approximately the average speed of the stream, thus trying to 'float' with the traffic stream.
- A number of test runs are made by the test vehicle along the study stretch.
- A group of observers are seated in the test vehicle to record various observations during each run of the test vehicle.
- **One observer** is seated in the test car with two stop watches or timers; One timer is used to record the time of arrival of the-test car at various control points like intersections, bridges or any other fixed points during each trip and the other stop watch is used to find the duration of individual delays.
- The time, location and cause of these delays during each test run are recorded by **the second observer** either on suitable tabular forms or by voice recording equipment.
- The number of vehicles overtaking the test vehicle and the number overtaken by the test vehicles are noted in each test run by **a third observer**.
- The number of vehicles travelling in the opposite direction in each test run is noted by a **fourth observer.**
- In this method all the required details of speed and delay including location, duration and causes of delay are obtained during each test run**.**

$$\bar{t} = t_w - \frac{n_y}{q} \qquad q = \frac{n_a + n_y}{t_a + t_w}$$

t(bar)= Avg journey time in minutes
q = Flow of vehicles (volume per min), in one direction of the 'stream'.
n_a = Average number of vehicles counted in the direction of the stream q when the test vehicle travels in the opposite direction or against the stream.
n_y = The average number of vehicles overtaking the test vehicle minus the number of vehicles overtaken when the test is in the direction of the stream, q.
t_w = Average journey time, (min) when the test vehicle is travelling with the stream, q.
t_a = Average journey time, (min) when test vehicle is running against the stream, q.

<u>ADVANTAGES</u>
1. The method gives an unbiased estimate of flow.
2. It is economical in man power as compared to the stationery observer method.
3. It enables the data on speed and flow to be collected at the same time.
4. It gives mean values of flow and speed over a section, rather than at a point. Thus it gives directly the space mean speed .Whereas spot speed studies gives time mean speed
5. It gives additional information on stops at intersections, delays, parked vehicles

ii) LICENSE PLATE OR VEHICLE NUMBER METHOD
• In this method, stop watches/timers or voice recording equipment are used.
• Observers are stationed at the entrance and exit of the test stretch where information of travel time is required.

• The timings and the vehicle numbers are noted by the observers of the selected sample of vehicles in the stream.
• From the office computations, travel time of each vehicle could be found.
• But the method does not give important details such as causes of delays and the duration and number of delays within the test 'stretch.

iii) INTERVIEW TECHNIQUE

• In the interview technique, the work can be completed in a short time 'by interviewing and collecting the required details from the road users on the spot.
• However the data on delays collected depend on the assessment of each individual driver and are likely to be subjective. Also this method and may not provide with-all the required details correctly.

iv) ELEVATED OBSERVATION AND PHOTOGRAPHIC TECHNIQUE

• Observers with timers are located at an elevated observation point from where the movement of most of the vehicles within the desired stretch or intersection area could be observed.
• Alternatively cameras or video equipment are located and the desired observations recorded.
• Elevated observation and photographic techniques are thus useful for studying the speed and delay characteristics on short test stretches or at intersection areas
• Intersection delays studies need special attention as this poses a major problem to the traffic engineer.
• Such studies at each intersection will help in evaluating the efficiency and effectiveness of the control device like signal system, the remedial measures for accidents etc.

4. Origin and destination studies

- Origin and destination studies (0 & D studies) give information on the actual location or zone of origin of travel of vehicles or individual passenger trips and their destination; these studies provide details such as direction of travel, selection of routes, trip length and the frequency and number of such trips.
- The study area may cover the entire country or a selected region within the country or state or within a 'city or any identified area.
- The 0 & D studies provide the basic data for determining the desired directions of vehicular flow or passenger trips in terms of the 'desire lines'. Desire lines are straight lines joining the points of origin and destination of each trip.
- Destination studies on vehicular traffic are essential for either comprehensive planning of new road network or for improvements in the existing road network.
- The 0-D data on vehicular traffic are also useful for planning and design of expressways, by passes around congested towns and cities, location for truck terminals, truck lay-byes/rest areas. etc.
- The routes and their schedules could also be scientifically planned using the data of the study. The future traffic needs may be also be estimated by extrapolating the data from 0 & D studies and the socio-economic studies.

APPLICATIONS

- To judge the adequacy of existing routes and to plan new network of roads.
- To establish design standards for the road, bridges and culverts along the route.
- To locate expressways or major routes along the desire lines.
- To establish preferential routes for various categories of vehicle including bye pass.

- To plan transportation system and mass transit facilities in cities including routes and schedules of operation.
- To locate terminals and to plan terminal facilities
- To locate intermediate stops of public transport.

METHODS OF CONDUCTING 0 & D STUDIES

There are a number of methods for collecting the 0 & D data. Some of the methods commonly adopted are:

(a) Road-side interview method
(b) License plate method
(c) Return post card method
(d) Tag-on-car method; and
(e) Home interview method

- Each method has its own advantages and limitations.
- The choice of the method is made judiciously depending on the objective and location

a) ROAD SIDE INTERVIEW METHOD

- The vehicles are stopped at selected interview stations by a group of persons and the answers to prescribed questionnaire are collected on the spot and entered in the prescribed forms.
- The information collected include the place and time of origin, and, destination, route, locations of intermediate stoppages if any, purpose of the tripe type of vehicle, number of passengers in each vehicle, etc.
- Both the road side interview study on selected sample of each vehicle class and classified traffic volume study of the total traffic flow are to be conducted simultaneously during the same time periods;
- Part of the traffic may be filtered and diverted through a prescribed lane with the help of the police and warning signs so that the drivers of the selected sample of vehicles are interviewed.
  - The answers, to the set of questionnaire are noted by the observers The vehicles are allowed to proceed with minimum possible delay.

Information collected

- Place and time of origin point
- Place and time of destination
- Route
- Purpose of the trip
- Type of vehicle
- Number of passengers in each vehicle

Advantages:

 Data is collected quickly in short Duration

Disadvantages:

 the vehicles are stopped for interview And there is delay to the vehicular Movement.

b) HOME-INTERVIEW SURVEY

 In this method random sample of 0.5 to 10% Of the population is selected and the Residence are visited by the trained person who collect the travel data from each Member of the household.
 Detailed information regarding the trips Made by the members is obtained on the spot.

 The data collected may be useful either for Planning the road network and other Roadway facilities.

Data collected

- Number of trips made
- Purpose of trip
- Travel mode
- Number of residents
- Age
- Vehicle ownership
- Number of drivers
- Family income

ADVANTAGES & DISADVANTAGES

ADVANTAGES:

- The problem of stopping of vehicles and consequent difficulties are avoided
- The present travel needs are clearly known and the analysis is also simple.
- Additional data including socioeconomic and other details may be collected so as to be useful for forecasting traffic and transportation growth.

C) TAXI SURVEYS

- Large urban areas usually have a sizeable amount of travel by taxis.
- In such cases, a separate taxi survey is necessary.
- The survey consists of issuing questionnaires or log sheets to the Taxi drivers and requesting them to complete the same.

D) REGISTRATION NUMBER PLATE SURVEY

- Registration number plate survey consists of noting the registration Number of vehicles entering or leaving an area at survey points located on the Cordon line.
- By matching the registration number of the vehicles at the point of entry and exit from the area , one is enabled to identify two points on the paths of the vehicles.

ADVANTAGES:
Work does not interfere with the Traffic in any way.

DISADVANTAGES:
 Large number of observers are needed analysis of the results can be complicated.

E) TAG SURVEY

- In this method at each point where the Roads cross the cordon line, vehicles are stopped and a tag is affixed usually under a Wind screen wiper.
- The tags for different surveys stations have different shapes/colour to identify the
- Survey station.
- The vehicles are stopped again at the exit points where the tags are removed.
- The time of entering and leaving the area may be marked on the tags in order to enable. The journey time to be determined.

Advantages:

- This method is simple and error are not very large.

Disadvantages:

- It is not possible to handle all the vehicles, sampling may be restored to done.

PRESENTATION OF 0-D DATA

Origin and destination tables are prepared showing number of trips between different zones.
 'Desire lines' are plotted which a graphical representation is prepared in almost all 0 and D surveys.
 Desire lines are straight lines connecting the origin points with-destinations, summarized into different area groups
 The width of such desire lines is drawn proportional to the number of trips in both directions.
 The desire line density map helps to decide the actual desire of the road users and thus helps to find the necessity of a new road link, a diversion, a by-pass or a new bridge.
 These desire lines be compared with the existing flow pattern along the existing routes by superimposing one over the other with the help of tracing sheets.
 Similarly the desire line diagram showing the passenger trips is useful to scientifically plan the mass transport facilities or the need to provide direct routes between certain zones
 The relative magnitude of the generated traffic and geometrical relationships of the zones involved may be represented by 'pie charts', in which circles are drawn; the diameter being proportional to the number of trips
 Contour lines may be plotted similar to topographic contours.
 The shape of the contours would indicate the general traffic need of the area.

Parking studies

NEED FOR PARKING

• Though the roadway width including the number of lanes are decided based on the design traffic flow or volume, all the vehicle's do not keep moving during the entire day.
• Some portion of the traffic will need to stop or park at the desired locations for different durations.
• For example, those who use their vehicles for travel to a market area may need parking facility for short durations until they complete the purchases; but those who work in the shopping establishments will need parking facility for long duration.
• The commercial vehicles need space near the destination for loading/unloading operations.
• The demand by automobile users for parking space is one of the major problems of highway transportation, especially in metropolitan cities.
• In industrial, commercial and residential places with multi-storied buildings, parking demand is particularly high

Effect of parking

 Congestion
 Accidents
 Obstruction to fire fighting operations

 Effect on environment

1. **Congestion:** Parking takes considerable street space leading to the lowering of the road capacity. Hence, speed will be reduced, journey time and delay will also subsequently increase. The operational cost of the vehicle increases leading to great economical loss to the community.
2. **Accidents:** Careless maneuvering (movement) of parking and unparking leads to accidents which are referred to as parking accidents. Common type of parking accidents occur while driving out a car from the parking area, careless opening of the doors of parked cars, and while bringing in the vehicle to the parking lot for parking.
3. **Environmental pollution:** They also cause pollution to the environment because stop- ping and starting of vehicles while parking and unparking results in noise and fumes. They also affect the aesthetic beauty of the buildings because cars parked at every available space creates a feeling that building rises from a plinth of cars.
4. **Obstruction to fire fighting operations:** Parked vehicles may obstruct the movement of fire-

fighting vehicles. Sometimes they block access to hydrants and access to buildings.

General Terms of Parking Facilities

 Parking Accumulation :-The total number of vehicles parked in an area at a specified moment.
 Parking volume:-The number of vehicles parked in a particular area over a given period of time. It is usually measured in vehicles per day. This does not account for repetition of vehicles. The actual volume of vehicles entered in the area is recorded.
 Parking load:-Parking load gives the area under the accumulation curve. It can also be obtained by simply multiplying the number of vehicles occupying the parking area at each time interval with the time interval. It is expressed as vehicle hours.
 Parking duration:-The length of time spent in a parking space.
 Parking turn over:-It is the ratio of number of vehicles parked in a duration to the number of parking bays available. This can be expressed as number of vehicles per bay per time duration

Parking system

On street parking:
On street parking means the vehicles are parked on the sides of the street itself. This will be usually controlled by government agencies itself. Common types of on-street parking are as listed below. This classification is based on the angle in which the vehicles are parked with respect to the road alignment. As per IRC the standard dimensions of a car is taken as 5× 2.5 meters and that for a truck is 3.75× 7.5 meters.

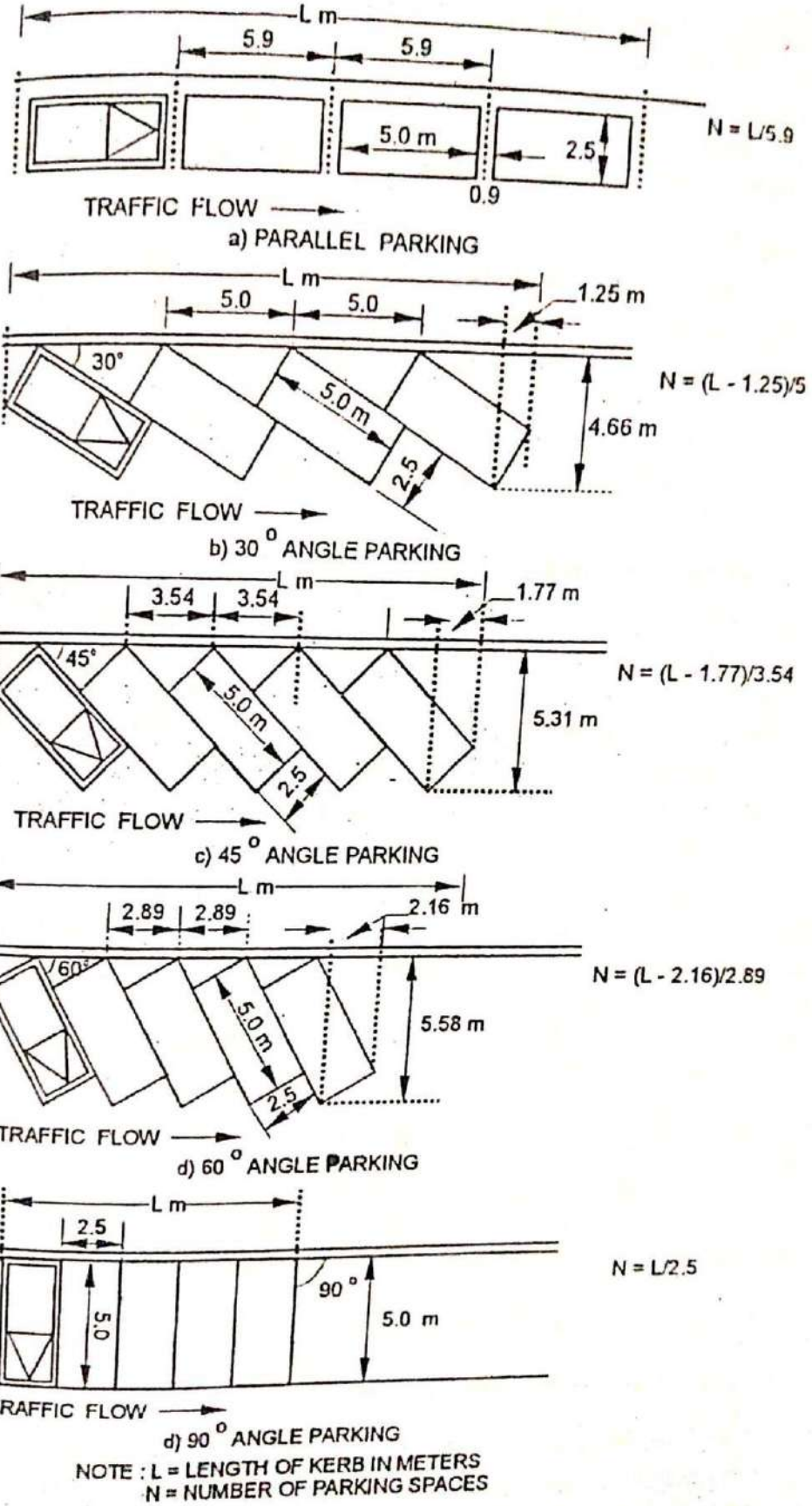
1. Parallel parking: The vehicles are parked along the length of the road. Here there is no backward movement involved while parking or un-parking the vehicle. Hence, it is the safest parking from the accident perspective.

2. 30◦ parking: In thirty degree parking, the vehicles are parked at 30◦ with respect to the road alignment. In this case, more vehicles can be parked compared to parallel parking. Delay caused to the traffic is also minimum in this type of parking.

3. 45◦ parking: As the angle of parking increases, more number of vehicles can be parked. Hence compared to parallel parking and thirty degree parking, more number of vehicles can be accommodated in this type of parking.

4. 60◦ parking: The vehicles are parked at 60◦ to the direction of road. More number of vehicles can be accommodated in this parking type.

5. Right angle parking: In right angle parking or 90◦ parking, the vehicles are parked perpendicular to the direction of the road. Although it consumes maximum width kerb length required is very little. In this type of parking, the vehicles need complex maneuvering and this may cause severe accidents. This arrangement causes obstruction to the road traffic particularly if the road width is less.

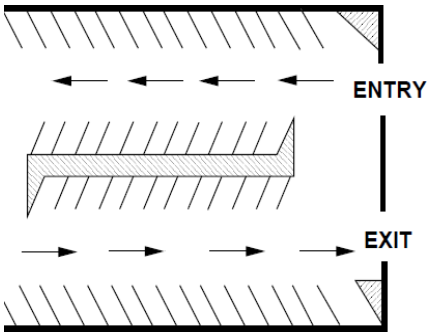


NOTE : L = LENGTH OF KERB IN METERS
N = NUMBER OF PARKING SPACES

Fig. 5.39 Patterns of kerb parking

Off street parking

In many urban centers, some areas are exclusively allotted for parking which will be at some distance away from the main stream of traffic. Such a parking is referred to as off-street parking.



Accident studies and Analysis

The problem of accident is very acute in road transportation due to

i) Complex flow patterns of vehicular traffic.
ii) Presence of mixed type of vehicles.
iii) Pedestrians on the roads.

Traffic accidents may involve property damages, personal injuries and also deaths. One of the main objectives of traffic engineering is to provide safe traffic movements.

The various objectives of accident studies may be listed as

a) To study the cause of accidents and to suggest corrective treatment at potential locations
b) To evaluate existing design, regulation and control measures.
c) To support proposed changes in design, regulation and control measure in the selected zone.
d) To carry out 'before and after studies' after implementing changes and to demonstrate the improvement in the accident problems'
e) To make computations of financial loss due to accidents.
f) To provide economic justification for the improvement measures suggested by the traffic engineer.

Causes of accidents

There are five basic elements in a traffic accident namely:

a) Road user-Responsible for the accident may be the driver of one or more vehicle involved, pedestrians or the passengers.
b) Vehicle-Vehicles involved in the accident may also be defective.
c) Road and its condition
d) Traffic flow and their characteristics could also cause undue strain in the driver
e) Environmental factors such as weather, visibility etc

Various causes of accidents may be listed as given below.

a) Drivers:
Excessive speed and rash driving, violation of traffic rules, failure to see or understand the traffic situation, sign or signal in adequate time, carelessness, fatigue, alcohol, sleep etc

b) Pedestrians
Violating regulations, carelessness while using the carriageway meant for vehicular traffic

c) Passengers

Alighting from or getting into moving vehicles

d) Vehicle defects

Failure of brakes, steering system or lighting system, tyre burst and any other defect in the vehicles.

e) Road condition

Slippery or skidding road surface, pot holes, ruts and other damaged conditions of the road surface, temporary obstruction to line of sight (caused by branch of tree or disabled vehicle) resulting in reduction in normal sight distance..

f Road design:

Defective geometric design like inadequate sight distance at horizontal or vertical curves, improper curve design, and inadequate width of shoulders, improper lightning and improper traffic control devices.

g) Traffic conditions

Other vehicles of the traffic stream such as vehicle moving ahead getting involved in accident, presence of disabled vehicle on the roadway.

h) Weather

Unfavourable weather condition like mist, fog, dust, smoke which restrict normal visibility and render driving unsafe.

i) Animals

Stray animals on the road

j) Other causes

Incorrect signs or signals, gate of level crossing not closed when required, ribbon development, badly located advertisement board or service station etc.

Accident studies and records

The various steps involved in traffic accident studies are

i) Collection of accident data

ii) Preparation of accident reports

iii) Preparation of location file

iv) Application of the above records for suggesting measures to prevent similar accidents at the same location.

i)Collection of accident data

The collecting of data has been suggested by the Indian road congress in IRC; 53-1982 as follows.

a) General: Date, Time, Persons involved in the accident and their particulars, classification of accidents like fatal, serious, minor, property damage only etc

b) Location: Description and details of the location of accident supported by diagrams

c) Details of vehicles involved-Registration number, and description of the vehicles, loading details, vehicular defects.

d) Nature of accident: Condition of vehicles involved, details of collision and pedestrians or objects involved, damages, injuries, casualty etc

e)Road condition: Details of road geometrics whether the road stretch is straight or curved, surface characteristics such as dry, wet or slippery etc.

f) Traffic condition: Type vehicles in the traffic flow, traffic volumes and density etc

g) Accident cost-The total cost of accident such as property damage, personal injuries and casualties computed in term of rupees.

Accident records

These are maintained giving all particulars of the accidents, location their details. The record may be maintained by means of location files, spot maps, collision and condition diagram as follows

a) Collision diagram:

Collision diagrams are used to display and identify similar accident patterns. They provide information on the type and number of accidents; including conditions such as time of day, day of week, climatic conditions, pavement conditions, and other information critical to determining the causes of safety problems.
Accident reports should be organized by year of occurrence and accident type for the analysis period. Accidents that occurred after significant changes in highway or local land use should not be included.

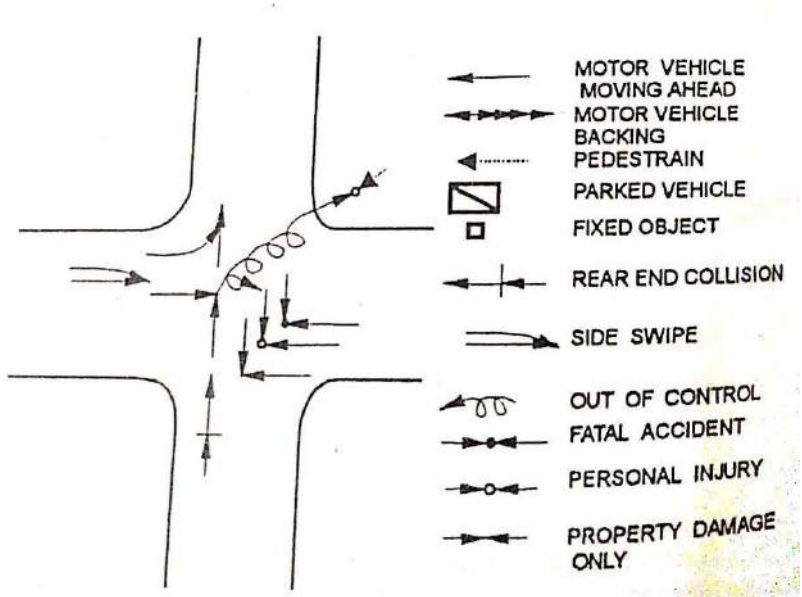
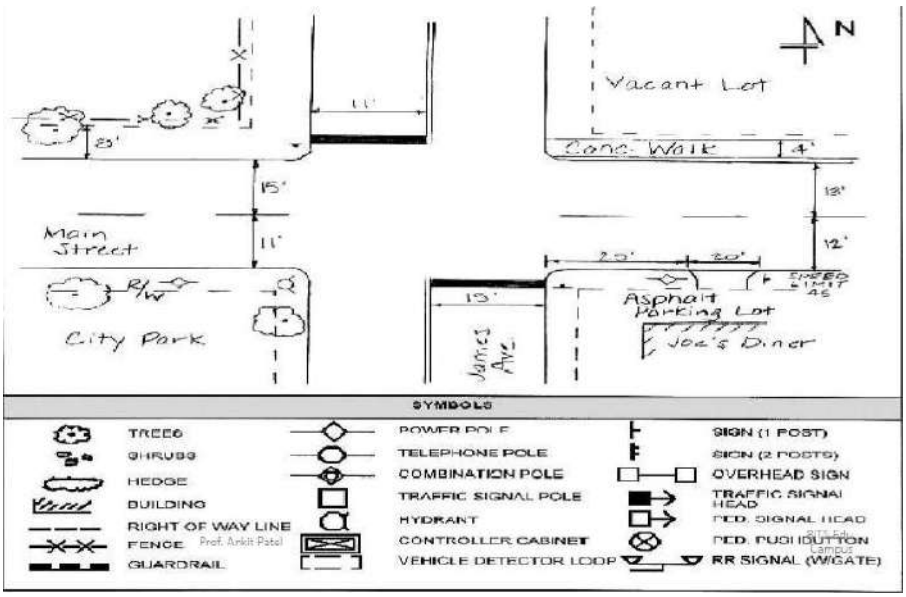


Fig. 5.8 Collision diagram and symbols

b) Condition diagram

The purpose of the Condition Diagram is tob show the intersection and the conditions within the surrounding area as it exists. The diagram should include the intersection alignment, items such as buildings, sidewalks, trees, lighting poles, water hydrants, stop signs, number of lanes, and lane use if required, associated with the streets forming the intersection. When applicable, the Condition

Diagram shall show the length of all exclusive lanes. The Condition Diagram provides the engineer with details of field conditions and helps investigate the need for changes to existing traffic control devices. The diagram should also be part of an intersection crash analysis.



Level of service

It is defined as the qualitative measure of operational condition of traffic flow and the perception of traffic flow by the motorists and passengers.

The operationg conditions is grade from best to worst desgnated by alphaber A to F

Purpose of Level of service

It gives an indication of service measures such as speed and travel time,freedom to maneuvre,traffic interruptions,comfort and convenience.

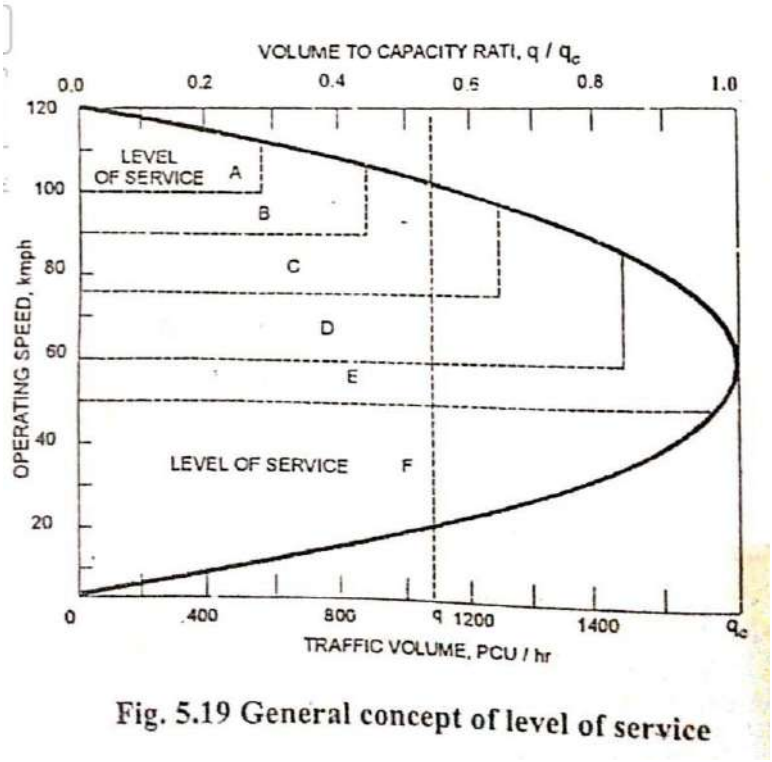


Fig. 5.19 General concept of level of service

LOS	REMARKS
A-Free flow	• Low volumes, densities and high speeds. • Drivers can maintain their desired speed with little or no delay
B-Stable flow	• Operating speeds with little restrictions, • Normal traffic volume with operating speed limit. • Little traffic restrictions and delays
C-Stable flow	• Stable flow wit controlled speeds, due to the high volume of traffic. • Drivers are mostly restricted due to select their own speed

	• Limited operating speed due to the increased traffic volume and moderate road restrictions
D-Approaching unstable flow	• Un-stable flow with tolerable operating speeds • Fluctuations in volume and temporary restrictions • Drivers comfort and convenience are low.
E-Unstable flow	• Lower operating speeds • High traffic volume • More traffic restrictions
F-Forced flow	• Forced flow operations at lower speeds • Speed and volume can drop to zero • Stop of vehicles occur for long periods.

Parking studies

NEED FOR PARKING

• Though the roadway width including the number of lanes are decided based on the design traffic flow or volume, all the vehicle's do not keep moving during the entire day.
• Some portion of the traffic will need to stop or park at the desired locations for different durations.
• For example, those who use their vehicles for travel to a market area may need parking facility for short durations until they complete the purchases; but those who work in the shopping establishments will need parking facility for long duration.
• The commercial vehicles need space near the destination for loading/unloading operations.
• The demand by automobile users for parking space is one of the major problems of highway transportation, especially in metropolitan cities.
• In industrial, commercial and residential places with multi-storied buildings, parking demand is particularly high

Effect of parking

- *Congestion*
- *Accidents*
- *Obstruction to fire fighting operations*
- *Effect on environment*

1. **Congestion:** Parking takes considerable street space leading to the lowering of the road capacity. Hence, speed will be reduced, journey time and delay will also subsequently increase. The operational cost of the vehicle increases leading to great economical loss to the community.
2. **Accidents:** Careless maneuvering (movement) of parking and unparking leads to accidents which are referred to as parking accidents. Common type of parking accidents occur while driving out a car from the parking area, careless opening of the doors of parked cars, and while bringing in the vehicle to the parking lot for parking.
3. **Environmental pollution:** They also cause pollution to the environment because stop- ping and starting of vehicles while parking and unparking results in noise and fumes. They also affect the aesthetic beauty of the buildings because cars parked at every available space creates a feeling that building rises from a plinth of cars.
4. **Obstruction to fire fighting operations:** Parked vehicles may obstruct the movement of fire-

fighting vehicles. Sometimes they block access to hydrants and access to buildings.

General Terms of Parking Facilities

- ***Parking Accumulation :-***The total number of vehicles parked in an area at a specified moment.
- ***Parking volume:-***The number of vehicles parked in a particular area over a given period of time. It is usually measured in vehicles per day. This does not account for repetition of vehicles. The actual volume of vehicles entered in the area is recorded.
- ***Parking load:-***Parking load gives the area under the accumulation curve. It can also be obtained by simply multiplying the number of vehicles occupying the parking area at each time interval with the time interval. It is expressed as vehicle hours.
- ***Parking duration:-***The length of time spent in a parking space.
- ***Parking turn over:-***It is the ratio of number of vehicles parked in a duration to the number of parking bays available. This can be expressed as number of vehicles per bay per time duration