RAMA UNIVERSITY

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DEPARTMENT OF CIVIL ENGINEERING

FACULTY OF ENGINEERING & TECHNOLOGY

TRANSPORTATION ENGINEERING – I (Highway Engineering)

Topics to be covered:

- Origin and Destination Studies
- Desire Lines
- Traffic Flow Characteristics and Studies
- Traffic Capacity Studies
- Factors Affecting Capacity
- Parking Studies

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ORIGIN AND DESTINATION STUDIES :

➢In a transportation study, it is often necessary to know the exact origin and destination of the trips. The information yielded by O-D survey includes land-use of the zones of origin and destination, household characteristics of the trip making family, time of the day when journeys are made, trip purpose and mode of travel.

- Origin is defined as the place where the trip begins and destination is defined as the place where the trip ends.
- Origin-Destination (OD) studies are an important tool for transportation Professionals.

➢OD studies are conducted to understand the pattern of the movement of Persons and goods in a particular area of interest during a particular period of time.

- The origin and destination study is carried out mainly to know the origin and destination of various vehicles.
- In this study the data collected are, number of vehicles, their origin and destination number of passengers in each vehicle, route
- This study is carried out to :

a) To establish preferential routes for various categories of vehicles
b) To location of new proposed roads
c) To location of parking palaces
d) To locate expressway
e) To regulate movement of heavy vehicles
f) To locate new bridge as per traffic demands

METHOD OF ORIGIN & DESTINATION SURVEY :

There are various methods used for Origin & Destination Studies as :

1) ROAD SIDE INTERVIEW SURVEYS
2) HOME-INTERVIEW SURVEYS
3) TELEPHONE SURVEYS
4) TAXI SURVEYS
5) POST CARD QUESTIONNAIRE SURVEYS
6) REGISTRATION NUMBER SURVEYS
7) TAG SURVEYS
8) PUBLIC TRANSPORT SURVEYS
9 COMMERCIAL VEHICAL SURVEYS

ROAD SIDE INTERVIEW METHOD : In this method interview stations are previously decided on the roadway. The vehicles are stopped at the interview stations by a group of persons and the answers to prescribed questionnaire are collected on the spot. The information to be collected are :

a) Place and Time of Origin
b) Place and Time of Destination
c) Route
d) Purpose of The Trip
e) Types of Vehicles
f) Number of Passengers in Each Vehicle

Data is collected quickly in short duration. The vehicles are stopped for interview and there is delay to the vehicular movement.

Continued…….METHOD OF ORIGIN & DESTINATION SURVEY :

HOME-INTERVIEW SURVEY :

a) 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.

b) Detailed information regarding the trips made by the members is obtained on the spot.

c) The data collected may be useful either for planning the road network and other roadway facilities.

Continued…….. METHOD OF ORIGIN & DESTINATION SURVEY :

ADVANTAGES:

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

TELEPHONE SURVEY :

- This method interview are conduct with computer assisted telephone interview technology.
- A complete cati system might include automatic dialling of next household to the interviewer to ask the nest question.
- Automatic skipping and branching within the list of questions depending on the answer to the previous question ,immediate logic checks on answer provided.
- This method is Time-saving.
- The information response is not good and accurate.

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.

Continued……. METHOD OF ORIGIN & DESTINATION SURVEY :

POST CARD SURVEYS:

➢In this method reply-paid questionnaires are handed over to each of the drivers at the survey points and requesting them to complete the information and return by post.

- This method are simpler and cheaper than many others.
- It might not lead to good or satisfactory responses.

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.

- Such work does not interfere with the traffic in any way.
- A major drawback of the method is that large number of observers are needed for it.
- Analysis of the results can be complicated sometimes.

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.

➢This method is simple and error is not very large. However it is not possible to handle all the vehicles, sampling may be restored to done.

Continued……. METHOD OF ORIGIN & DESTINATION SURVEY :

PUBLIC TRANSPORT SURVEYS

- In this method interviewer may enter the vehicle and carry out the interviews when the vehicles is in motion.
- Post-card questionnaires eliminate delays, but are likely to evoke poor response or contain an element or bias.
- These questionnaires may also be collected at the stations inside the survey area.
- The major advantage of this method is that a good number of observations are recorded in a single trip.
- The record maintenance in a moving public vehicle is a hard nut to crack, it creates issue in the same.

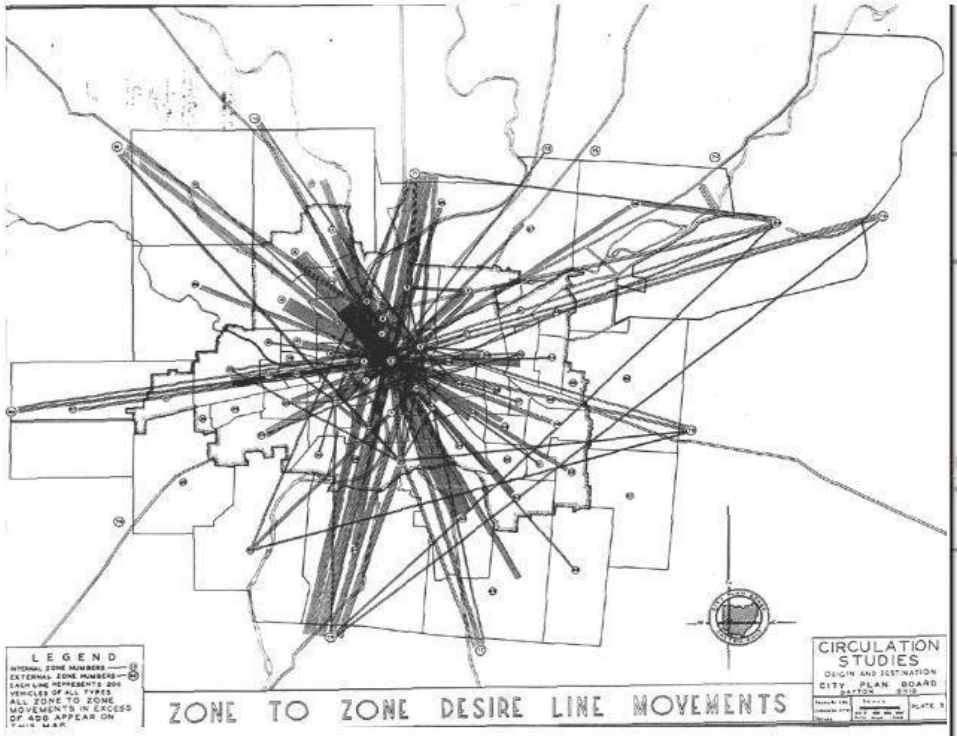


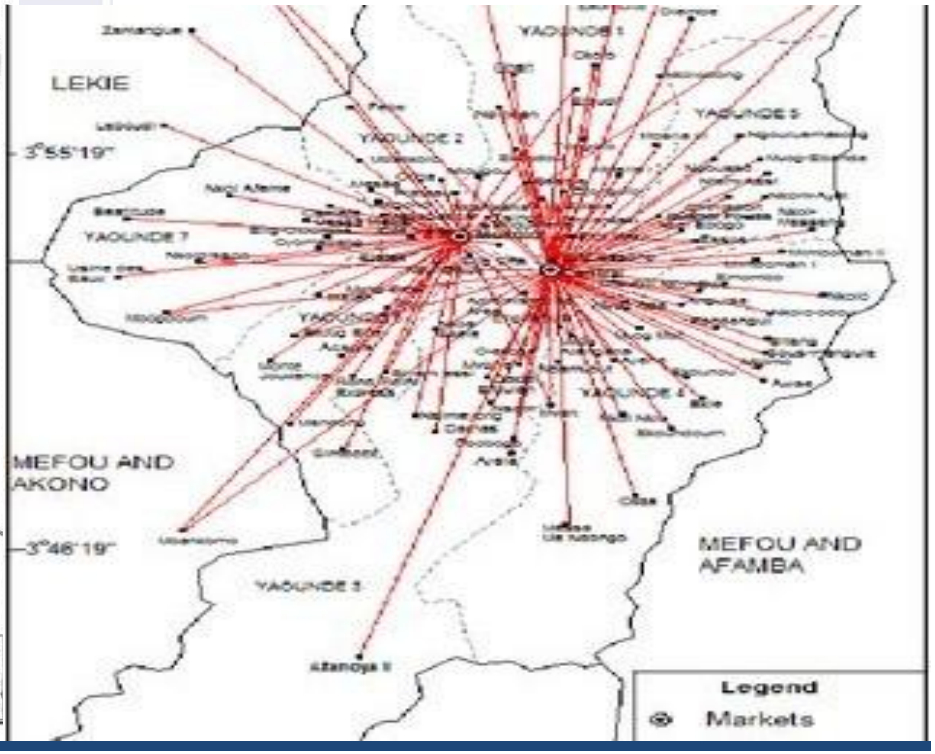
COMMERCIAL VEHICAL SURVEYS :

- Commercial vehicle surveys are conducted to obtain information on journeys made by all commercial vehicles based within the study area.
- The addresses of the vehicles operators are obtained and they are contacted.
- Form are issued to drivers with a request that they record particulars of all the trips they would make.

DESIRE LINES :

- OD study is to determine the travel pattern of an area/city. We can find out the origin (start point of travel) and destination (end point of travel) for each person in the city.
- This will help in analysis of the travel pattern observed in the city.
- The travel pattern is determined by desire lines which shows us the number of people going from one origin to another destination in the form of lines with varying thickness.
- Obviously, the thicker the line, more people are travelling along that particular corridor - probably the metro can be planned along that route and attract a lot of people.
- Desire lines are used to illustrate on a map the flows of people or goods from point to point based on the values from a matrix.





TRAFFIC FLOW CHARACTERISTICS AND STUDIES :

- The basic traffic manoeuvres are diverging, merging, crossing and weaving.
- **Traffic Flow (q):-** The rate at which vehicles pass at a fix point (vehicles per hour)= N(3600/t).
- **Traffic Density (k):-** No. of vehicles(N) over a stretch of roadway(L) i.e. vehicles per kilometres = N/L
- **Time Headway :-** Time interval between the passage of the fronts of the successive vehicles at a specified point.
- **Average Time Headway=** Average travel time per unit distance x average space headway.
- **Space Headway :-** Distance between front of successive vehicles.
- **Average Space Headway** = Space mean speed x average time headway
- **Flow Density Relationship :**

→ Flow densit space mean speed

q = K x V

→ Density = 1/ space headway

K = 1 / hs

→ Space mean speed = flow x Space headway

V = q x hs

→ Density = flow x time per unit distance

K = q x t

TRAFFIC CAPACITY STUDIES :

TRAFFIC CAPACITY:

- The ability of a roadway to accommodate traffic volume.
- It is expressed as the maximum number of vehicle in a lane or a road that can pass a given point in unit time, usually an hour.
- Volume represent an actual rate of flow where as capacity indicates a maximum rate of flow with a certain level of service.
- Traffic capacity and traffic volume has same units, difference between the two is that traffic volume represents the actual rate of flow of the traffic and responds to the variation in the traffic demand, while capacity indicates a capability or maximum rate of flow with a certain level of service characteristics that can be carried by the road.
- Traffic capacity of a roadway depends upon a number of prevailing roadway and traffic conditions.

TYPES OF TRAFFIC CAPACITY :

BASIC CAPACITY : It is the maximum number of vehicles(PCU) that can pass a given point on a lane or roadway during one hour under the most nearly ideal roadway and traffic conditions which can possibly be attained. Two roads have same physical features will have same basic capacities irrespective of the traffic conditions.

POSSIBLE CAPACITY : It is the maximum number of vehicles which can pass a given point on a lane or highway during one hour under the prevailing roadway and traffic conditions. This means that the possible capacity of a highway will always be lower than the basic capacity unless the prevailing conditions of the traffic, approach the ideal conditions. Therefore the possible capacity may vary from 0 to the maximum, i.e., Basic capacity.

PRACTICAL CAPACITY : It is the maximum number of vehicle that can pass a given point on a lane or roadway during one hour, without traffic density being so great as to cause unreasonable delay, hazard or restriction to the driver's freedom to man- oeuvre under the prevailing roadway and traffic conditions.

TRAFFIC CAPACITY STUDIES :

DESIGN CAPACITY: It is the practical capacity or a smaller value determined for use in designing the highway to accommodate the design hourly volume (D.H.V). It is a term, normally, applied to existing highways.

THEORETICAL CAPACITY : The theoretical capacity is the number of vehicles passing any point in one hour per lane. It depends upon the average length of the vehicle and the average spacing of the moving vehicles. Mathematically, theoretical capacity,

C = 1000 V / S

V = Design Speed of the vehicle in kmph

S = Centre to centre spacing of moving vehicle

= Reaction distance + Average Length of Vehicle

IMPORTANCE OF THE CONCEPT OF HIGHWAY CAPACITY:

The concept of highway capacity is important for the following reasons:

1. The capacity of a highway should be adequate to serve the needs of the projected traffic.
2. The class of highway, lane width, number of lanes and intersections are dependent on capacity.

3.Improvements on geometric elements, traffic control devices and traffic management measures can be effectively planned based on the studies of highway capacity.

4.The adequacy of the existing highway network for the existing traffic volume can be assessed by capacity studies; transportation planning can be done effectively using this information.

TRAFFIC CAPACITY STUDIES :

It(Practical Capacity) is the practical capacity which is of primary interest to the designers who strive to provide adequate highway facilities and hence this is also called the design capacity.

DETERMINATION OF THEORETICAL MAXIMUM CAPACITY :

Using the relation: **C = 1000 . V / S**

one can easily determine the theoretical Maximum Capacity; Here,

C = Capacity of a single lane, vehicle per hour

V = Speed, kmph

S = Average centre to centre spacing of vehicles, when they follow one behind the other as a queue or space headway, m.

Thus capacity depends upon the Speed and Spacing.

Spacing is governed by the safe stopping distance required be the rear vehicle in case the vehicle ahead stops suddenly.

Numerically spacing is given by,

$$S = Sg + L$$

Where Sg is the space gap(Head to rear) between the vehicles and L is the average length of the vehicle, both combined makes the center to center spacing of the vehicles.

Here, $Sg = 0.278\ V\ .\ t$, where V is in Kmph and Sg in m.

t is the total reaction time of the driver, generally assumed to be equal to 0.70 to 0.75 sec.

Assume t = 0.70;

$$S = (0.7v + L) = (0.2V + L), m$$

Thus knowing the design speed, the spacing S can be found and thus the theoretical capacity of the lane can be found.

TRAFFIC CAPACITY STUDIES :

PEAK-HOUR FACTOR :

- It is basically represent the variation in traffic flow with in an hour.
- Observations of traffic flow consistently indicate that the flow rates are found in the peak.
- A 15 minute period within an hour is not sustained through out the entire period and that is why we need to use the peak-hour factor.
- Normally on freeways the peak-hour factor values range from 0.80 to 0.95.

PASSENGER CAR UNIT (PCU) :

- The different vehicle classes have a wide range of statics characteristics and dynamic characteristics, apart from these the driver behaviour of the different vehicle classes is also found to vary considerable.
- Therefore mixed traffic flow characteristics are very much complex when compare to homogeneous traffic and it is difficult to estimate the traffic volume, capacity of roadway under the mixed traffic flow, unless the different vehicle classes are converted to one common standard vehicle unit.
- Therefore it is a common practice to consider the passenger car as the standard vehicle unit to convert the other vehicle classes and this unit is called passenger car unit.
- PCU value depends upon the several factors, such as:

a) Vehicle characteristics
b) Transverse and longitudinal gaps or clearance between moving vehicles.
c) Speed distribution of the mixed traffic stream, volume to capacity ratio.
d) Roadway characteristics.
e) Regulation and control of traffic.
f) Environmental and climatic conditions.

TRAFFIC CAPACITY STUDIES :

➢If the addition of one particular vehicle per hour of a certain class affects the traffic flow to the same extent as the addition of x passenger cars, that particular vehicle is considered equivalent to x PCU.

➢ The values for PCU as per IRC : 86-1983 are given below in tables as :

Serial No.	VEHICLE CLASS	Equivalence Factor
1	Motor Cycle, Scooter and Pedal Cycle	0.5
2	Passenger Car, Tempo, Auto Rickshaw, Agricultural Tractor, Pick-Up Van	1.0
3	Cycle – Rickshaw	1.5
4	Truck, Bus, Agricultural Tractor-Trailer	3.0
5	Horse-Drawn Vehicle	4.0
6	Small Bullock-Cart and Hand-Cart	6.0
7	Large Bullock-Cart	8.0

The Highway Capacity Manual (HCM), USA, defines the ideal conditions for uninterrupted flow as follows:

1. Traffic flow, free from interference of vehicles and pedestrians from the side
2. In-stream flow of passenger cars
3. Traffic lanes of adequate width and shoulders with no lateral obstructions within 1.8m from the edge of the carriageway
4. Horizontal and vertical alignment suitable for an average speed of 100km/h on multi-lane highways in rural areas.

LEVEL OF SERVICE (LOS) : It is define as a qualitative measure describing the operational condition within a traffic stream, and their perception by motorist and passengers.

LOS DEFINITIONS :

Level A: Free flow, low traffic, high speed

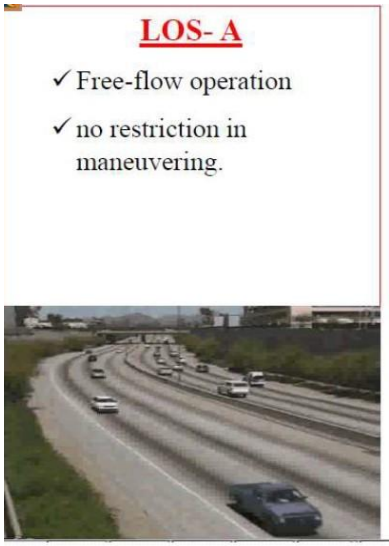
Level B: Stable flow, noticeable traffic

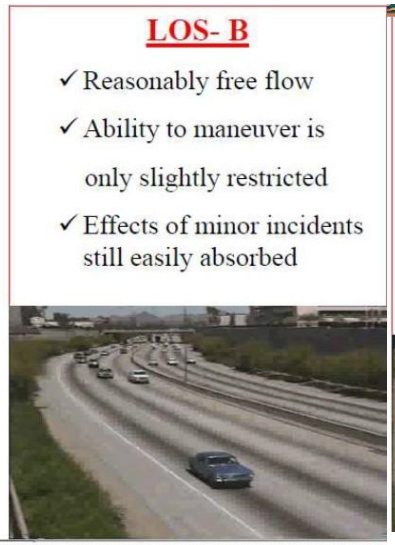
Level C: Stable flow, traffic interactions,

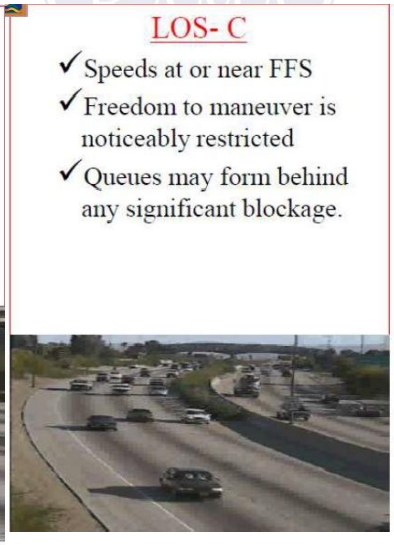
Level D: Unstable flow, High density, movement restrictions

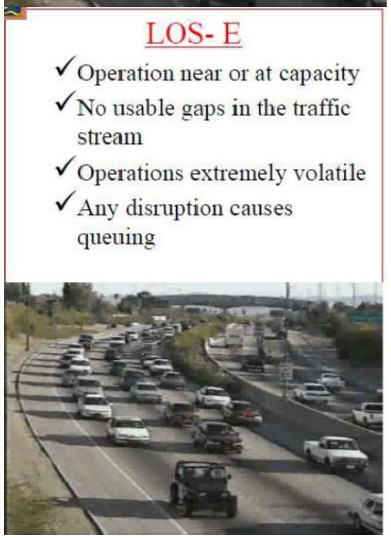
Level E: Unstable flow, lower speed, volume is nearly equal to capacity, little freedom

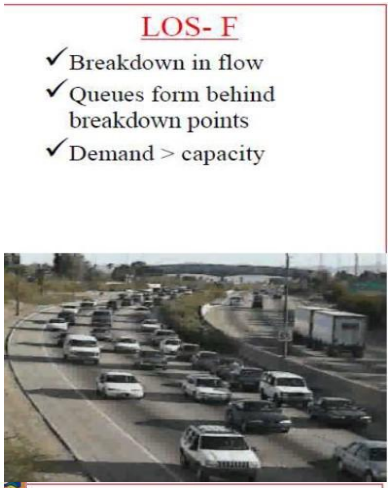
Level F: Unstable flow, no freedom, traffic volume can drop to zero, stop & go











TRAFFIC CAPACITY STUDIES :

THE OPERATING CONDITIONS FOR THE SIX LEVELS OF SERVICE: (Level A represents the highest and level F the lowest)

LEVEL A – Free flow, with low volumes and high speeds low traffic density speed controlled by driver's desires and physical roadway conditions. There is no restriction on manoeuvrability due to thepresence of other vehicles.

LEVEL B – Zone of stable flow, operating speeds beginning to be restricted by traffic conditions. There is reasonable freedom to select speed and lane. The lower limit of this level (lowest speed and highest volume) is associated with service volume used in the design of rural highways.

LEVEL C – Still in the zone of stable flow, but speeds and manoeuvrability more closely controlled by higher volumes. Drivers are restricted regarding speeds lane changes and overtaking manoeuvres. A relatively satisfactory operating speed is still obtained, with service volumes suitable for urban design practice.

LEVEL D – Approaches unstable flow, the operating speed is tolerable, but considerably affected by changes in operating conditions. Fluctuations in volume and restrictions to flow may cause substantial drops in operating speed. Drivers have little freedom to manoeuvre. Comfort and conveniencare low but can be tolerated for short periods.

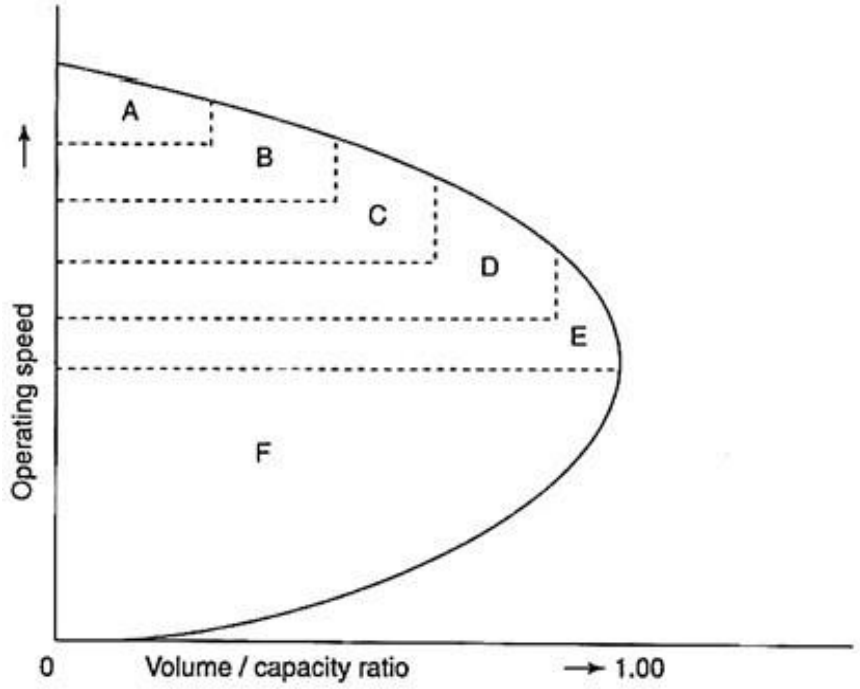
LEVEL E – This level cannot be described by speed alone. It is also determined by volumes at or near highway capacity. Typical speeds are 50km/h. Flow is unstable and there may be stoppages of shortdurations.

LEVEL F – At this level, there are forced operations at low speeds resulting in volumes below capacity. Queues of vehicles piling up from a restriction downstream serve as a storage area during peak hour. Substantial reduction in speeds and stoppages may occur for short or long duration because of downstream congestion. In the extreme, both speed and volume can drops to zero.

TRAFFIC CAPACITY STUDIES :

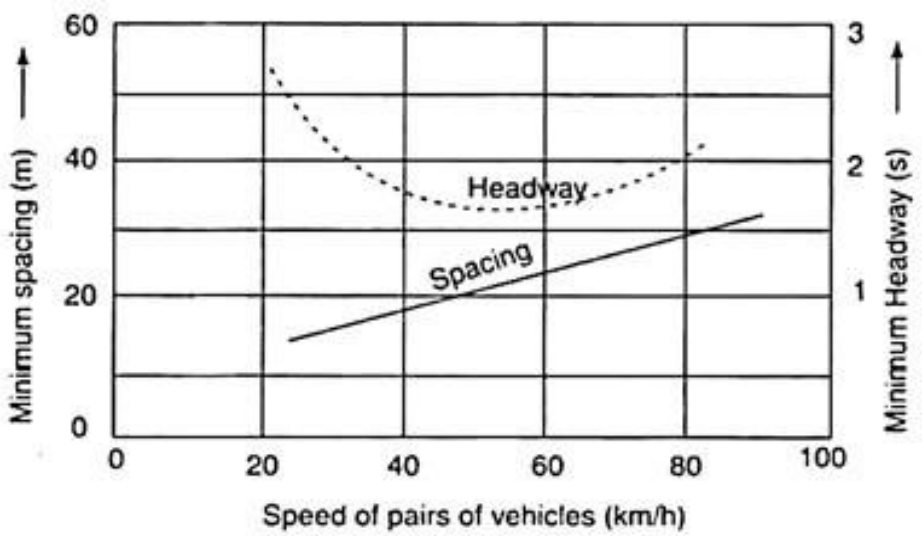
The traffic volume that can be served at each level of service is known as the ‘service volume’. After selecting a level of service for design purposes, the corresponding service volume logically becomes the design volume or design capacity. If this volume is exceeded, the operating conditions will fall below the level of service selected. The highway capacity manual makes no recommendations regarding the level of service to be selected for the design of different types of highways. The choice is left to the designer to select an appropriate level of service based on economy and need.

Figure shows the typical relationship between operating speed and volume/capacity ratio. The zones where the different levels of service occur are shown in this figure, which pertains to a multi-lane highway.



TRAFFIC CAPACITY STUDIES :

This is similar to speed-volume function. Initially, the volume increases as the speed increases up to a certain limit; beyond this, as speed increases the driver's freedom to manoeuvre decreases and the volume tends to decrease. Thus, there will be an optimum operating speed at which the volume will be maximum.



FACTORS AFFECTING CAPACITY AND LEVEL OF SERVICE:

The factors affecting capacity and level of service fall under two heads:

(a) ROADWAY CONDITIONS : Lane width, Lateral clearance, Shoulders, Horizontal alignment, Gradient, Pavement surface condition , Intersections-at-grade.

(b) **TRAFFIC CONDITIONS :** The capacity and level of service are affected by the composition of different types of vehicles in the stream, variation of traffic flow, traffic interruption, and lane distribution. The number of traffic lanes, vehicular and driver characteristics, and one- or two-way traffic movements have a direct bearing on the lane or highway capacity.

CAPACITY OF RURAL ROADS:

The latest IRC recommendations for design service volumes are given below:

Design service volumes (IRC: 64-2009)

S. No	Terrain	Design service volume (PCU/day)
	Single-lane roads	
1	Plain	5000
2	Rolling	5000
3	Hilly	4000
	Two-lane roads	
1	Plain	21400
2	Rolling	15700
3	Hilly	10000

For four-lane divided roads, the design service volumes range from 47,000 to 1, 05,000 PCU/day depending upon the terrain, shoulder-type and the level of service (B or C).

CAPACITY OF URBAN ROADS :

Capacity values for urban roads (between intersections suggested by the IRC are given below:

S.No	Traffic flow	No. of traffic lanes and widths	Capacity in PCU/hour
1	One-way	Two-lane (7 to 7.5m)	2400
2	Two-way	Two-lane (7 to 7.5m)	1500
3	One-way	Three-lane (10.5m)	3600
4	One-way	Four-lane (14.0m)	4800
5	Two-way	Four-lane (14.0m)	4000
6	Two-way	Six-lane (25.0m)	6000

Maximum flow occurs when the speed is Vsf/2 and the density is Kj/2

$$q_{max} = \frac{V_{sf} \times K_J}{4}$$

Where,

K_j= jam density= 1000/spacing of vehicle

V_{sf}= free mean speed

K= q/v

q= average volume of vehicle, (vehicle / hour)

V= space mean speed of vehicle, kmph

PARKING STUDIES :

- One of the problems created by road traffic is parking.
- Not only do vehicles require street space to move about, but also do they require space to park where the occupants can be loaded and unloaded.
- The period over which a car is parked is very great compared with the time it is in motion.
- Every car owner would wish to park the car as closely as possible to his destination so as to minimize his walking.
- Travelling vehicles at one time or another will need to park for short or long times.
- Need for parking spaces is great in areas where land uses include (business, residential, or commercial).
- In high density areas spaces are very expensive, thus the space provided for automobiles usually has to be divided between their movement and parking.
- An vehicle wil at one time be parked short time or longer time, provision of parkin facilities is essentia .
- Need for parking spaces is usually very great in areas of business, residential, or commercial activities.
- Park-and-ride.
- Providing adequate parking space to meet the demand for parking in the Central Business District (CBD)
- This problem usually confronts a city traffic engineer.
- Solution is not simple, Parking studies are used to determine the demand for and the supply of parking facilities.

Parking studies are important to carry out for proper designing against:

a) Congestion
b) Accidents
c) Obstruction to fire fighting operations
d) Ill-Effect on environment

PARKING STUDIES :

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.

ACCIDENTS: Careless manoeuvring of parking and un-parking 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.

ENVIRONMENTAL POLLUTION: They also cause pollution to the environment because stop- ping and starting of vehicles while parking and un-parking 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 buildingrises from a plinth of cars.

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.

PARKING STUDIES :

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 : The complete Parking system is sub-divided into two parts as On-Street Parking and Off-Street Parking.

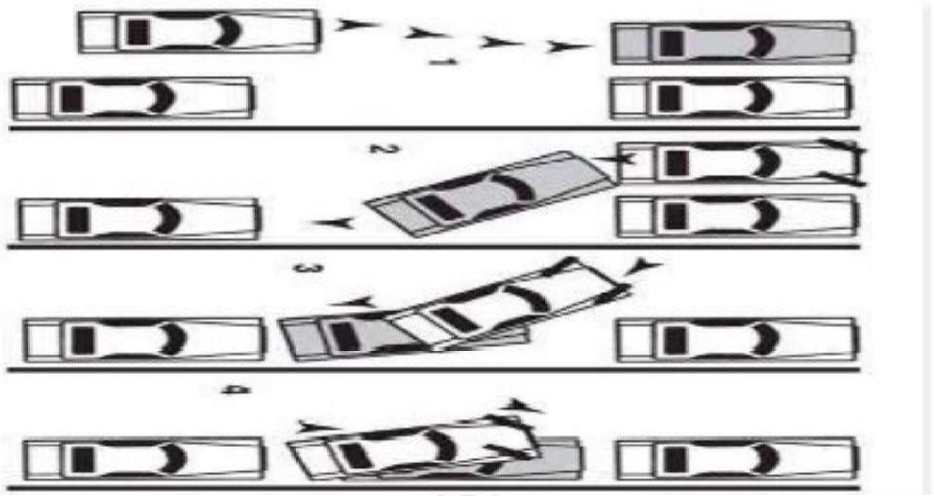
ON STREET PARKING: On street parking means the vehicles are parked on the sides of the street itself. This will be usually controlled by government agencies itself. Common types of on-street parking are as listed below. This classification is based on the angle in which the vehicles are parked with respect 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. It is also known as curb facilities. Parking bays are provided alongside the curb on one or both sides of the street. The Salient features of this parking are:

- unrestricted parking.
- limited to specific times for a maximum duration.
- bus stops
- unlimited and free.
- may or may not be free.
- loading bays.
- Restricted parking facilities.
- handicapped parking

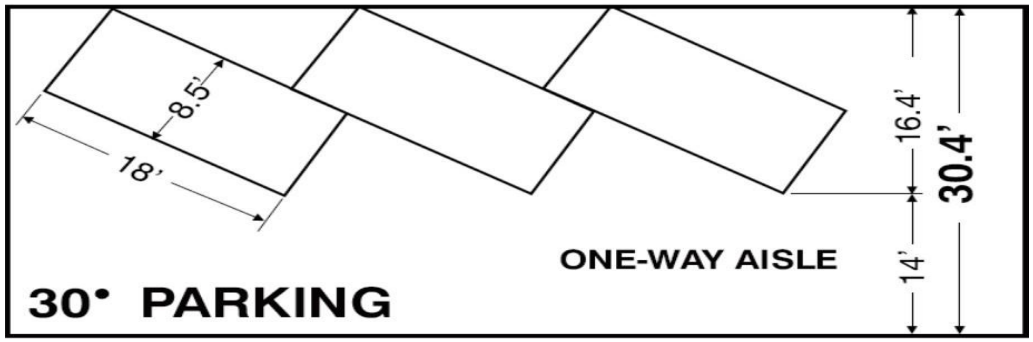
PARKING STUDIES :

A few examples of On-Street Parking are :

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 most safest parking from the accident perspective.

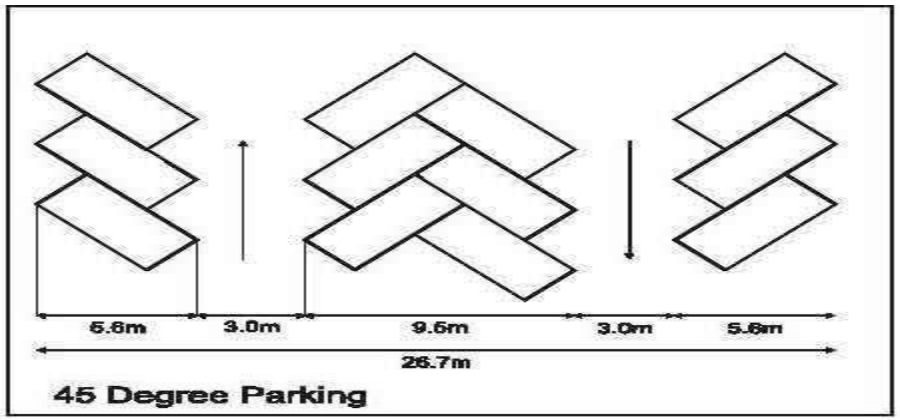


30◦ PARKING: In thirty degree parking, the vehicles are parked at 30◦ with respect to the road alignment. In this case, more vehicles can be parked compared to parallel parking. Delay caused to the traffic is also minimum in this type of parking.

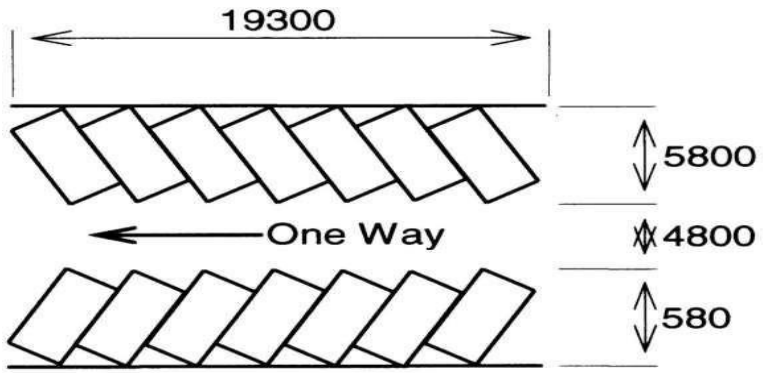


PARKING STUDIES :

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.

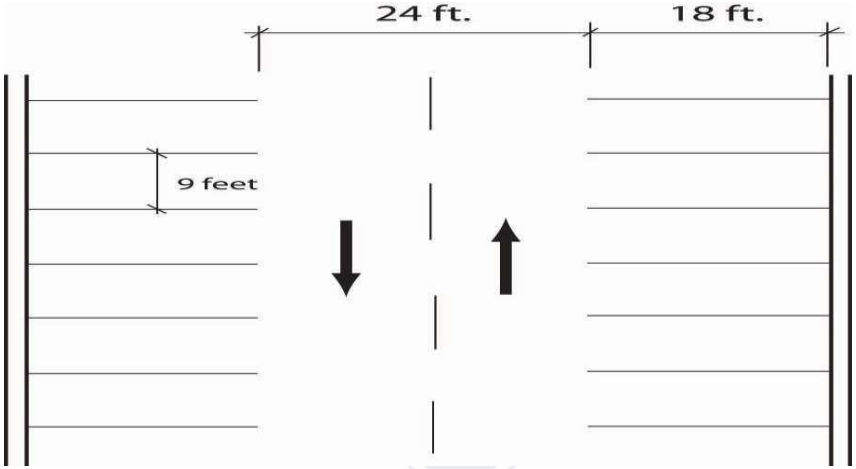


60◦ PARKING: The vehicles are parked at 60◦ to the direction of road. More number of vehicles can be accommodated in this parking type.



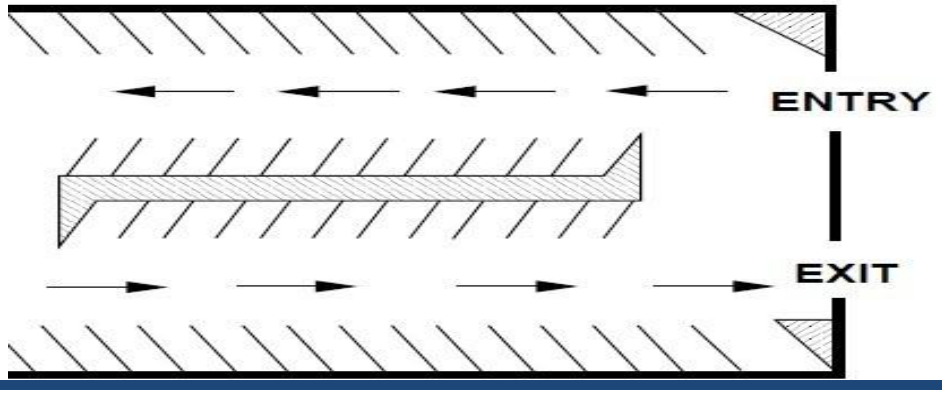
PARKING STUDIES :

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 manoeuvring and this may cause severe accidents. This arrangement causes obstruction to the road traffic particularly if the road width is less.



OFF-STREET PARKING : In many urban centres, 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. They may be operated by either public agencies or private firms.

i. Privately or publicly owned;
ii. Surface lots and garages.
iii. Self-parking garages
iv. Attendant-parking garages



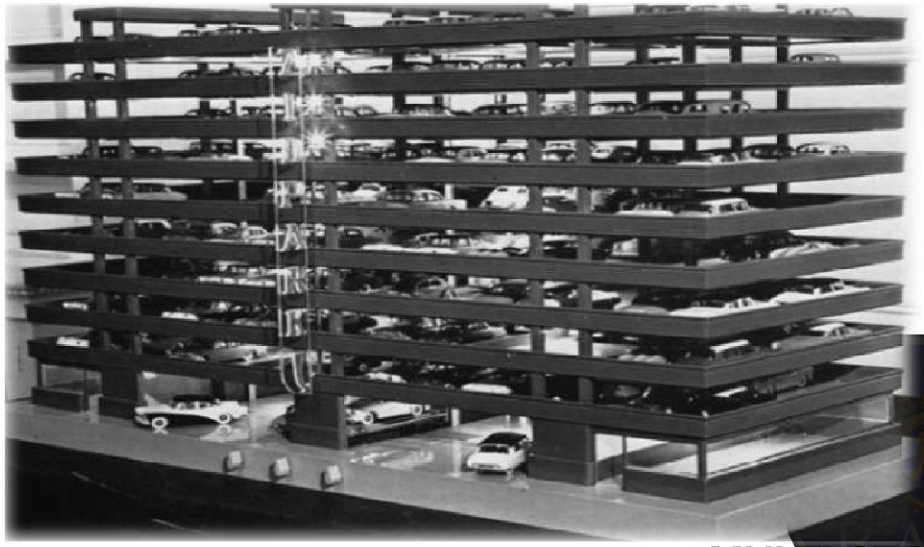
PARKING STUDIES :

OFF-STREET PARKING can further be classified as :

a) Surface Parking
b) Multi-Storey Parking
c) Roof Parking
d) Mechanical Parking
e) Under-Ground Parking

SURFACE PARKING

PARKING STUDIES :

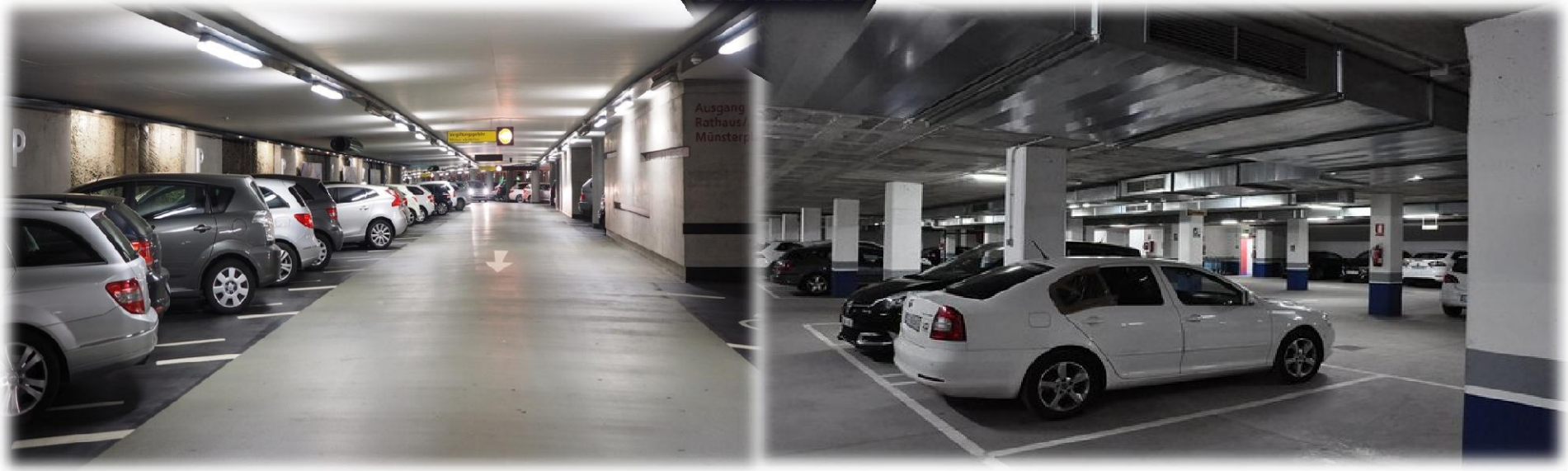


MULTI-STOREY PARKING

ROOF PARKING

PARKING STUDIES :

MECHANICAL PARKING



UNDERGROUND CAR PARKING

"Thank you"

Have Any Query ?

Ask us @ shashikant.fet@ramauniversity.ac.in or shashikantchitransh3@gmail.com