

**QUESTION BANK**

**CE 6006 TRAFFIC ENGINEERING AND MANAGEMENT**

**UNIT II TRAFFIC SURVEYS**

**2 MARKS**

**1. What are the various traffic studies?**

The various traffic studies generally carried out are:

- a) Traffic volume study
- b) Speed and delay study
- c) Origin and destination (O&D) study
- d) Traffic flow characteristics
- e) Traffic capacity study
- f) Parking study
- g) Accident studies

**2. What are the methods of volume counting?**

The different methods of volume counting are:

- a) Manual methods
- b) Combination of manual and mechanical methods
- c) Automatic devices
- d) Moving observer method
- e) Photographic method

**3. Define - Traffic Volume and Density**

Volume, also known as flow, is the number of vehicles passing a specified point during a stated period of time. It is usually expressed in vehicles per hour. Density, also known as concentration, is the number of vehicles present in a stated length of road at an instant. It is usually expressed in vehicles per kilometre length of road per lane.

**4. What is meant by PCU?**

When the traffic is composed of a number of types of vehicles, it is the normal practice to convert the flow into equivalent Passenger Car Unit (PCU), by using certain equivalency

factors. The flow is then expressed as PCUs per hour or PCUs per day.

**5. Differentiate basic from possible highway capacity.**

<b>Basic capacity</b>	<b>Possible capacity</b>
The maximum number of passenger cars that can pass a point on a lane or a roadway during one hour under the most nearly ideal roadway and traffic conditions which can possibly be attained.	The maximum number of vehicles that can pass a given point on a lane or roadway during one hour, under prevailing roadway and traffic conditions.

**6. Define - Spot Speed**

Spot speed is defined as the instantaneous speed of a vehicle at a specified location.

**7. What are meant by 85th, 50th and 15th percentile speeds?**

85th percentile speed is the speed below which 85% of all the vehicle travel, and is used for determining the speed limits for traffic regulation. 50th percentile speed or the median speed, is the speed at which there are many vehicles going faster as there are going slower. 15th percentile speed is the speed below which 15% of all the vehicles travel.

**8. What is 98th percentile speed? State its significance.**

The 98th percentile speed is the speed below which, 98% of all the vehicle travel. Significance: 98th percentile speed is used as a design speed in geometric design.

**9. What are the methods of conducting origin destination survey?**

The following are the methods for conducting origin destination survey:

- a) Home interview survey
- b) Road-side interview
- c) Post-card questionnaire survey
- d) Registration number plate survey
- e) Tags on vehicles

**10. List out any two uses of origin and destination survey.**

The following are the uses of origin and destination survey:

- a) To determine the amount of by-passable traffic that enters a town, and thus establish the need for a bypass
- b) To develop trip generation and trip distribution models in transport planning process
- c) To determine the extent to which the present highway system is adequate and to plan for new facilities

**11. What is meant by the term desire line diagram?**

Desire line diagram is a pictorial representation in which, the trips between any pair of zones are represented by a straight line connecting the centroids of the two zones and having a band width drawn to a suitable scale to represent the actual volume count.

**12. What are the off - street parking facilities commonly considered?**

The off - street parking facilities commonly considered are:

- a) Surface car parks
- b) Multi - storey car parks
- c) Roof parks
- d) Mechanical car parks
- e) Underground car parks

**13. What are the statistical methods for analysis of accident data?**

The statistical methods for analysis of accident data are:

- a) Regression methods
- b) Poisson distribution
- c) Use of Chi-squared test for comparing accident data
- d) Quality control method

**14. List out classification of urban roads.**

In India, the classification of urban roads is as follows:

- a) Expressways
- b) Arterial streets
- c) Sub - arterial streets

d) Collector streets

e) Local streets

**15. Specify the minimum footway width recommended by IRC for urban roads in residential and industrial zones.**

Type of road	Recommended minimum footway width in residential zone	Recommended minimum footway width in industrial zone
District Distributor	2.4 m	2.7 m
Local Distributor	1.8 m	2.7 m
Access road	1.8 m	2.7 m

**16. Write the characteristics of level of service 'C' in traffic flow on the road.**

Level of service C is a zone of stable flow, but speeds and manoeuvrability are more closely controlled by higher volumes. Most of the drivers restricted in the freedom to select their own speed, lane changing or overtaking manoeuvres. A relatively satisfactory operating speed is still obtained with service volumes perhaps suitable for urban design practice.

### **16 MARKS**

#### **1.Explain The Methods Of Origin And Destination Surveys**

Floating car or riding check method

License plate or vehicle number method

Roadside Interview technique

Elevation observation

Photographic techniques

Various Origin Destination survey methods are described below:

##### **a) Roadside Interview**

This interview includes directing vehicles into a designated area and asking a series of sort questions. This technique is widely used and has a very high response rate but sometimes implementation is difficult due to disruption of traffic. In this method investment cost is low but requires high labour and personnel requirements. This method has a broad geographical coverage as it includes vehicles from outside the study area also, but implementation can be for limited locations and hence sampling may be biased.

**b) License plate Mail-out surveys**

The license plate mail-out survey involves recording license plate numbers of vehicles on a selected roadway, tracing vehicle ownership, and mailing a survey to owners. There are different methods for tracing the license plate number: taking a photo/video or manually recording the tag on vehicles. Photo/video are often used for high volume highways. Labour requirements are more for tracing the ownership of vehicles and also may be less accurate but no disruption of traffic occurs.

**Floating car or riding check method**

A test vehicle is driven over a given course of travel at a approximate average speed in the traffic stream. One observer is seated in the floating car with two stop watches. One stop watch is used to record the time at various control point like intersection, bridges etc. The other stop watch is used to find the duration of individual delay. The time, location and cause of these delays are recorded by the second observer on suitable tabular column. The number of vehicle overtaking the test vehicle and that overtaken by the test vehicle are noted in each trip. The number of vehicle travelling in opposite direction in each trip is noted by fourth observer. In mixed traffic more number of observer are required. More number of trips are recorded.

The average journey time  $t$  is given by

$$t = t_w - (n_y/q)$$

$$q = n_a + n_y / (t_a + t_w)$$

$q$  = flow of vehicle (volume per min)

$n_a$  = average number of vehicle counted in direction of stream when the test vehicle travels in opposite direction.

$n_y$  = average number of vehicle overtaking the test vehicle minus the number of vehicle over taken by the test vehicle.

$T_w$  = average journey time ,in minute when the test vehicle is travelling with the stream

$T_a$  = average journey time ,in minute when the test vehicle is running against the stream

**2. Write In Detail About Vehicle Volume Survey**

The variation of volume with time, i.e. month to month, day to day, hour to hour and within a hour is also as important as volume calculation. Volume variations can also be observed from season to season. Volume will be above average in a pleasant motoring month of summer. It will be more pronounced in rural than in urban area. Volume or flow is expresses in vehicles per hour or vehicles per day. In India the survey is to convert the mixed traffic into passenger car unit. Peak hour traffic is needed for the design of intersections, whereas for determine the number of lanes in the carriage way the daily traffic is needed. The traffic counts are taken by noting the number of vehicles of various classes that passes the count point in each direction during periodic time intervals. Traffic census is taken regularly on NH

network twice a year, for seven consecutive days in each round One round covers peak season and other the lean season. The average of seven days traffic is average daily traffic. If the traffic is taken continuously for all the days in a year the average traffic is known as AADT annual average daily traffic. The term traffic volume study can be termed as traffic flow survey or simply the traffic survey. It is defined as the procedure to determine mainly volume of traffic moving on the roads at a particular section during a particular time.

### **Types of volume measurements**

#### **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.

#### **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.

#### **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.

#### **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. Ways of conducting Traffic Survey / Methods of Traffic Volume Study

#### **Following are the means of conducting traffic survey:**

- 1) Manual methods.
- 2) Combination of manual and mechanical methods.
- 3) Automatic devices.
- 4) Moving observer method.
- 5) Photographic methods

### **Manual counts**

This method employs a field team to record traffic volume on the prescribed record sheets. In this method first the fluctuations of traffic volume during the hours of the day and the daily variations are observed.

### **Advantage**

Gives classification of vehicles and turning moments

**Disadvantage**

It cannot work throughout day and night

**Combination of Manual and Mechanical methods**

It is the multiple pen recorders. A chart moves continuously at the speed of a clock. Different pens record the occurrence of different events on the chart. A particular switch may be pressed whenever a particular class of vehicles arrives and this operates the pen on the channel which can be identified with the arrival of a particular class of vehicle

**Advantage**

The classification and vehicle count are performed simultaneously.

**Disadvantage**

It does not give turning moment of vehicle.

**3. Write Short Notes On Parking Survey**

Parking is one of the major problems that is created by the increasing road traffic. It is an impact of transport development. The availability of less space in urban areas has increased the demand for parking space especially in areas like Central business district. This affects the mode choice also. This has a great economical impact.

**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 unparking the vehicle. Hence, it is the most safest parking from the accident perspective. However, it consumes the maximum curb length and therefore only a minimum number of vehicles can be parked for a given kerb length. This method of parking produces least obstruction to the on-going traffic on the road since least road width is used. Parallel parking of cars is shown in figure 1.

**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. Also there is better maneuverability. 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., length of parking space available for parking number of vehicles in a given kerb is  $= 3.54 N + 1.77$

**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. length available for parking vehicles  $= 2.89N + 2.16$ .

**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. However, it can accommodate maximum number of vehicles for a given kerb length. Length available for parking number of vehicles is  $= 2.5N$ .

### **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. They may be operated by either public agencies or private firms.

### **Parking requirements**

There are some minimum parking requirements for different types of building. For residential plot area less than 300 sq.m require only community parking space. For residential plot area from 500 to 1000 sq.m, minimum one-fourth of the open area should be reserved for parking. Offices may require at least one space for every 70 sq.m as parking area. One parking space is enough for 10 seats in a restaurant where as theatres and cinema halls need to keep only 1 parking space for 20 seats. Thus, the parking requirements are different for different land use zones.

### **Ill effects of parking**

Parking has some ill-effects like congestion, accidents, pollution, obstruction to fire-fighting operations etc.

**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 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 stopping 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 firefighting vehicles. Sometimes they block access to hydrants and access to buildings.

### **Parking Studies**

Studies must be conducted to collect the required information about the capacity and use of existing parking facilities. In addition, information about the demand for parking is needed. Parking studies may be restricted to a particular traffic producer or attractor, such as a store, or they may encompass an entire region, such as a central business district.

Before parking studies can be initiated, the study area must be defined. A cordon line is drawn to delineate the study area. It should include traffic generators and a periphery, including all points within an appropriate walking distance. The survey area should also include any area that might be impacted by the parking modifications. The boundary should be drawn to facilitate cordon counts by minimizing the number of entrance and exit points. Parking surveys are conducted to collect the above said parking statistics. The most common parking surveys conducted are in-out survey, fixed period sampling and license plate method of survey.

#### **In-out survey**

In this survey, the occupancy count in the selected parking lot is taken at the beginning. Then the number of vehicles that enter the parking lot for a particular time interval is counted. The number of vehicles that leave the parking lot is also taken. The final occupancy in the parking lot is also taken. Here the labor required is very less. Only one person may be enough. But we won't get any data regarding the time duration for which a particular vehicle used that parking lot. Parking duration and turn over is not obtained. Hence we cannot estimate the parking fare from this survey. For quick survey purposes, a fixed period sampling can also be done. This is almost similar to in-out survey. All vehicles are counted at the beginning of the survey. Then after a fixed time interval that may vary between 15 minutes to 1 hour, the count is again taken. Here there are chances of missing the number of vehicles that were parked for a short duration.

#### **License plate method of survey**

This results in the most accurate and realistic data. In this case of survey, every parking stall is monitored at a continuous interval of 15 minutes or so and the license plate number is noted down. This will give the data regarding the duration for which a particular vehicle was using the parking bay. This will help in calculating the fare because fare is estimated based on the duration for which the vehicle was parked. If the time interval is shorter, then there are less chances of missing short-term parkers. But this method is very labor intensive.

**4. Explain In Detail About Causes Of Accidents ,Safetuy Measures And Accident Studies .**

The problem of accident is a very acute in highway transportation due to complex flow pattern of vehicular traffic, presence of mixed traffic along with pedestrians. Traffic accident leads to loss of life and property. Thus the traffic engineers have to undertake a big responsibility of providing safe traffic movements to the road users and ensure their safety. Road accidents cannot be totally prevented but by suitable traffic engineering and management the accident rate can be reduced to a certain extent. For this reason systematic study of traffic accidents are required to be carried out. Proper investigation of the cause of accident will help to propose preventive measures in terms of design and control.

**Objectives of accident studies**

Some objectives of accident studies are listed below:

- 1.To study the causes of accidents and suggest corrective measures at potential location
- 2.To evaluate existing design
- 3.To compute the financial losses incurred
- 4.To support the proposed design and provide economic justification to the improvement suggested by the traffic engineer
- 5.To carry out before and after studies and to demonstrate the improvement in the problem.

**Causes of road accidents**

The various causes of road accidents are:

- 1.Road Users - Excessive speed and rash driving, violation of traffic rules, failure to perceive traffic situation or sign or signal in adequate time, carelessness, fatigue, alcohol,sleep etc.
- 2.Vehicle - Defects such as failure of brakes, steering system, tyreburst,lighting system .
- 3.Road Condition - Skidding road surface, pot holes, ruts.
- 4.Road design - Defective geometric design like inadequate sight distance, inadequate width of shoulders, improper curve design, improper traffic control devices and improper lighting,.
- 5.Environmental factors -unfavorable weather conditions like mist, snow, smoke and heavy rainfall which restrict normal visibility and and makes driving unsafe.
- 6.Other causes -improper location of advertisement boards, gate of level crossing not closed when required etc.

**Accident data collection**

The accident data collection is the first step in the accident study. The data collection of the accidents is primarily done by the police. Motorist accident reports are secondary data which are filed by motorists themselves. The data to be collected should comprise all of these parameters:

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- 1.General - Date, time, person involved in accident, classification of accident like fatal, serious, minor
- 2.Location - Description and detail of location of accident
- 3.Details of vehicle involved - Registration number, description of vehicle, loading detail, vehicular defects
- 4.Nature of accident - Details of collision, damages, injury and casualty
- 5.Road and traffic condition - Details of road geometry, surface characteristics,type of traffic, traffic density etc..
- 6.Primary causes of accident - Details of various possible cases (already mentioned) which are the main causes of accident.
- 7.Accident cost - Financial losses incurred due to property damage, personal injury and casualty

These data collected need proper storing and retrieving for the following purpose. The purposes are as follows:

- 1.Identification of location of points at which unusually high number of accident occur.
- 2.Detailed functional evaluation of critical accident location to identify the causes of accidents.
- 3.Development of procedure that allows identification of hazards before large number of accidents occurs.
- 4.Development of different statistical measures of various accident related factors to give insight into general trends, common casual factors, driver profiles, etc.

### **Accident investigation**

The accident data collection involves extensive investigation which involves the following procedure:

- 1.Reporting: It involves basic data collection in form of two methods:

- 1.Motorist accident report - It is filed by the involved motorist involved in all accidents fatal or injurious.
- 2.Police accident report - It is filed by the attendant police officer for all accidents at which an officer is present. This generally includes fatal accidents or mostly accidents involving serious injury required emergency or hospital treatment or which have incurred heavy property damage.
- 2.At Scene-Investigation: It involves obtaining information at scene such as measurement of skid marks, examination of damage of vehicles, photograph of final position of vehicles, examination of condition and functioning of traffic control devices and other road equipments.
- 3.Technical Preparation: This data collection step is needed for organization and interpretation of the study made. In this step measurement of grades, sight distance, preparing drawing of after accident situation, determination of critical and design speed for curves is done.

4. Professional Reconstruction: In this step effort is made to determine from whatever data is available how the accident occurs from the available data. This involves accident reconstruction which has been discussed under Section No.7 in details. It is professionally referred as determining “behavioral” or “mediate” causes of accident.

5. Cause Analysis: It is the effort made to determine why the accident occurred from the data available and the analysis of accident reconstruction studies..

### **Safety measures**

The ultimate goal is to develop certain improvement measures to mitigate the circumstances leading to the accidents. The measures to decrease the accident rates are generally divided into three groups engineering, enforcement and education. Some safety measures are described below:

#### **Safety measures related to engineering**

The various measures of engineering that may be useful to prevent accidents are enumerated below

#### **Visual guidance to driver**

There is consecutive change of picture in driver's mind while he is in motion. The number of factors that the driver can distinguish and clearly fix in his mind is limited. On an average the perception time for vision is , for hearing is and for muscular reaction is . The number of factors that can be taken into account by organs of sense of a driver in one second is given by the formula below. where, = No. of factors that can be taken into account by the organ of sense of driver for m long, = speed of vehicle in m/sec. Factors affecting drivers' attention when he is on road can be divided into three groups:

1. Factors relating to the road – elements of road that directly affect the driving of a vehicle are traffic signs, changes in direction of road, three legged intersection and various other things.
2. Factors connected with traffic – Other vehicles, cycles, pedestrians.
3. Factors related indirectly to the vehicle motion – Building and structures that strike the eye, vegetation, landscape, etc.

So using the laws of visual perception certain measures have been suggested:

1. Contrast in visibility of the road should be achieved by provision of elements that differ from its surrounding by colors, pattern such as shoulder strips, shoulder covered with grass, edge markings.
2. Providing road side vegetation is an effective means.
3. The visibility of crown of trees from a distant location is also very useful in visual guiding.
4. The provision of guard rails of different contrasting colors also takes drivers attention and prevent from monotonous driving.

when the direction of road has a hazardous at-grade intersection trees are planted in such a way that it seems that there is dense forest ahead and driver automatically tends to stop or reduce the speed of the vehicle so that no conflicts occur at that point.

Driver tends to extrapolate the further direction of the road. So it is the responsibility of the traffic engineer to make the driver psychologically confident while driving that reduces the probability of error and prevent mental strain.

### **Road reconstruction**

The number of vehicles on the road increases from year to year, which introduces complications into organization of traffic, sharply reduces the operation and transportation characteristic of roads and lead to the growth of accident rate. This leads to the need of re constructing road. The places of accidents need to be properly marked so that the reconstruction can be planned accordingly.that there were too many conflict points before which reduced to a few number after construction of islands at proper places. Reconstruction process may also include construction of a new road next to the existing road, renewal of pavement without changing the horizontal alignment or profile of the road, reconstruction a particular section of road. Few more examples of reconstruction of selected road section to improve traffic safety

### **Channelization**

The Channelization of traffic at intersection separates the traffic stream travelling in different direction, providing them a separate lane that corresponds to their convenient path and spreading as far as possible the points of conflict between crossing traffic streams. The traffic lanes are separated by marking relevant lines or by constructing slightly elevated islands as shown in Figure 15. Proper Channelization reduces confusion. The number of decision required to be made by the driver at any time is reduced allowing the driver time to make next decision. The principles of proper channelized intersection are:-

- 1.The layout of intersection should be visibly clear, simple and understandable by driver.
- 2.Should ensure superiority to the vehicles using road of higher class.
- 3.Layout of intersection makes it necessary for a driver running through it to choose at each moment of time one of not more than two possible direction of travel. This is achieved by visual guidance, islands and markings.
- 4.The island provided should separate high speed, through and turning traffic flows.
- 5.The width of traffic lane should ensure unhampered turning to the big vehicles. Width of straight section without kerb should be 3.5 m and that of traffic lane near island is 4.5-5 m at entry and 6 m at exit.
- 6.Pedestrian crossing should be provided

### **Road signs**

Road signs are integral part of safety as they ensure safety of the driver himself (warning signs) and safety of the other vehicles and pedestrians on road (regulatory signs). Driver should be able to read the sign from a distance so that he has enough time to understand and respond. It is essential that they are installed

and have correct shape, colour, size and location. It is required to maintain them as well, without maintenance in sound condition just their installment would not be beneficial.

### **Other methods**

Various other methods of traffic accident mitigation are described below:

#### **1.Street lighting**

Street lightning of appropriate standard contributes to safety in urban area during night time due to poor visibility. Installation of good lighting results in 21% reduction in all accidents, 29% reduction in ``all casualty" accidents, 21% reduction in ``non pedestrian casualty" accidents, and 57% reduction in ``pedestrian casualty" accidents.

#### **2.Improvement in skid resistance**

If road is very smooth then skidding of the vehicles may occur or if the pavement is wet then wet weather crashes occur which account about 20-30%. Thus it is important to improve the skid resistance of the road. Various ways of increasing the skid resistance of road are by constructing high-friction overlay or cutting of grooves into the pavement.

#### **3.Road markings**

Road markings ensure proper guidance and control to the traffic on a highway. They serve as supplementary function of road sign. They serve as psychological barrier and delineation of traffic path and its lateral clearance from traffic hazards for the safe movement of traffic. Thus their purpose is to provide smooth and safe traffic flow.

#### **4.Guide posts with or without reflector**

They are provided at the edge of the roadway to prevent the vehicles from being off tracked from the roadway. Their provision is very essential in hilly road to prevent the vehicle from sliding from top. Guide posts with reflector guide the movement of vehicle during night.

#### **5.Guard rail**

Guard rail have similar function as of guide post. On high embankments, hilly roads, road running parallel to the bank of river, shores of lake, near rock protrusion, trees, bridge, abutments a collision with which is a great hazard for a vehicle. It is required to retain the vehicle on the roadway which has accidentally left the road because of fault or improper operation on the part of the driver. Driver who has lost control create a major problem which can be curbed by this measure.

#### **6.Driver reviver stop**

Driver reviver stop are generally in use in countries like U.S.A where driver can stop and refresh himself with food, recreation and rest. They play a very important part in traffic safety as they relieve the driver from the mental tension of constant driving. These stops are required to be provided after every 2 hour travel time.

### **7. Constructing flyovers and bypass**

In areas where local traffic is high bypasses are required to separate through traffic from local traffic to decrease the accident rate. To minimize conflicts at major intersections flyovers are required for better safety and less accident rate

### **8. Regular accident studies**

Based on the previous records of accidents the preventive measures are taken and after that the data related to accidents are again collected to check the efficiency of the measures and for future implementation of further preventive measures.

### **Safety measures related to enforcement**

The various measures of enforcement that may be useful to prevent accidents at spots prone to accidents are enumerated below. These rules are revised from time to time to make them more comprehensive.

#### **Speed control**

Checks on spot speed of all vehicles should be done at different locations and timings and legal actions on those who violate the speed limit should be taken

#### **Training and supervision**

The transport authorities should be strict while issuing licence to drivers of public service vehicles and taxis. Driving licence of the driver may be renewed after specified period, only after conducting some tests to check whether the driver is fit

#### **Medical check**

The drivers should be tested for vision and reaction time at prescribed intervals of time. Safety measures related to education: The various measures of education that may be useful to prevent accidents are enumerated below.

#### **Education of road users**

The passengers and pedestrians should be taught the rules of the road, correct manner of crossing etc. by introducing necessary instruction in the schools for the children and by the help of posters exhibiting the serious results due to carelessness of road users.

#### **Safety drive**

Imposing traffic safety week when the road users are properly directed by the help of traffic police as a means of training the public. Training courses and workshops should be organized for drivers in different parts of the country.

**5. Define Level Of Service And Write Down Their Characteristics**

**Level of Service** The level-of-service concept was introduced in the 1965 HCM as a convenient way to describe the general quality of operations on a facility with defined traffic, roadway, and control conditions. Using a letter scale from A to F, a terminology for operational quality was created that has become an important tool in communicating complex issues to decision-makers and the general public. The HCM 2000 defines level of service as follows: "Level of service (LOS) is a quality measure describing operational conditions within a traffic stream, generally in terms of such service measures as speed and travel time, freedom to maneuver, traffic interruptions, and comfort and convenience." A term level-of-service closely related to capacity and often confused with it is service volume. When capacity gives a quantitative measure of traffic, level of service or LOS tries to give a qualitative measure. Service volume is the maximum number of vehicles, passengers, or the like, which can be accommodated by a given facility or system under given conditions at a given level of service. Level of service (LOS) qualitatively measures both the operating conditions within a traffic system and how these conditions are perceived by drivers and passengers. It is related with the physical characteristics of the highway and the different operating characteristics that can occur when the highway carries different traffic volumes. Speed-flow-density relationships are the principal factor affecting the level of service of a highway segment under ideal conditions. For a given road or facility, capacity could be constant. But actual flow will be different for different days and different times in a day itself. The intention of LOS is to relate the traffic service quality to a given flow rate of traffic. It is a term that designates a range of operating conditions on a particular type of facility. Highway capacity manual (HCM) provides some procedure to determine level of service. It divides the quality of traffic into six levels ranging from level A to level F. Level A represents the best quality of traffic where the driver has the freedom to drive with free flow speed and level F represents the worst quality of traffic.

**Level of Service A:** This represents free-flow conditions where traffic flow is virtually zero. Only the geometric design features of the highway may limit the speed of the car. Comfort and convenience levels for road users are very high as vehicles have almost complete freedom to maneuver.

**Level of Service B:** Represents reasonable free-flow conditions. Comfort and convenience levels for road users are still relatively high as vehicles have only slightly reduced freedom to maneuver. Minor accidents are accommodated with ease although local deterioration in traffic flow conditions would be more discernible than in service A.

**Level of Service C:** Delivers stable flow conditions. Flows are at a level where small increases will cause a considerable reduction in the performance or 'service' of the highway. Transport Engineering [Highway capacity and level of service] There are marked restrictions in the ability to maneuver and care is required when changing lane. While minor incidents can still be absorbed, major incidents will result in the formation of queues. The speed chosen by the driver is substantially affected by that of the other vehicles. Driver comfort and convenience have decreased perceptibly at this level.

**Level of Service D:** The highway is operating at high density levels but stable flow still prevails. Small increases in flow levels will result in significant operational difficulties on the highway. There are severe restrictions on a driver's ability to maneuver, with poor levels of comfort and convenience.



**Level of Service E:** Represents the level at which the capacity of the highway has been reached. Traffic flow conditions are best described as unstable with any traffic incident causing extensive queuing and even breakdown. Levels of Basic Elements of comfort and convenience are very poor and all speeds are low if relatively uniform.

**Level of Service F:** Describes a state of breakdown or forced flow with flows exceeding capacity. The operating conditions are highly unstable with constant queuing and traffic moving on a 'stop-go' basis.

**Factors affecting level of service**

One can derive from a road under different operating characteristics and traffic volumes. The factors affecting level of service (LOS) can be listed as follows:

1. Speed and travel time
2. Traffic interruptions/restrictions
3. Freedom to travel with desired speed
4. Driver comfort and convenience
5. Operating cost.

Transport Engineering [Highway capacity and level of service] Factors such as lane width, lateral obstruction, traffic composition, grade and driver population also affect the maximum flow on a given highway segment. The effect of each of these factors on flow is discussed.

**• Lane Width.**

Traffic flow tends to be restricted when lane widths are narrower than 12 ft (3.65m). This is because vehicles have to travel closer together in the lateral direction, and motorists tend to compensate for this by driving more cautiously and by increasing the spacing between vehicles, thus reducing the maximum flow on the highway.

**• Lateral Obstruction.**

In general, when roadside or median objects are located too close to the edge of the pavement, motorists in lanes adjacent to the object tend to shy away from the object, resulting in reduced lateral distances between vehicles. This lateral reduction in space also results in longer spacing's between vehicles and a reduction in the maximum flow on the highway. This effect is eliminated if the object is located at least 6ft (1.8m) from the edge of the roadway. Note, however, that lateral clearances are based mainly on safety considerations and not on flow consideration.

**• Traffic Composition.**

The presence of vehicles other than passenger cars-such as trucks, buses, and recreational vehicles-in a traffic stream reduces the maximum flow on the highway because of their size, operating characteristics, and interaction with other vehicles.

- **Grade.**

The effect of a grade depends on both the length and the slope of the grade. Traffic operations are significantly affected when grades of 3 percent or greater are longer than 1/4 mi (400m) and when grades are less than 3 percent and longer than 1/2 mi (800m). The effect of heavy vehicles on such grades is much greater than that for passenger vehicles.

- Speeds, Space mean speed, are also used in level-of-service analysis because flow has a significant effect on speed.

- **Driver Population.**

Under ideal conditions, a driver population consisting primarily of weekday commuters is assumed. However, it is known that other driver populations do not exhibit the same behavior.

## **6.Explain In Detail About Travel Time And Delay Study.**

### **Purpose**

(1) The purpose of a Travel Time and Delay Study is to evaluate the quality of traffic movement along a route and determine the locations, types, and extent of traffic delays by using a test vehicle, vehicle observation or probe vehicle.

(2) This study can be used to compare and evaluate operational conditions before and after roadway or intersection improvements have been made. It can also be used as a tool to assist in prioritizing projects by comparing the magnitude of the operational deficiencies (such as delays and stops) for each project under consideration.

(3) The Travel Time and Delay Study can also be used by planners to monitor system performance measurements for local government comprehensive plans.

(4) The methodology presented herein provides the quantitative information with which the analyst can develop recommendations for improvements such as traffic signal retiming, safety improvements, turn lane additions, and channelization enhancements.

### **Study Procedures**

(1) Test vehicle, vehicle observation, and probe vehicle are among the most common methods to conduct a Travel Time and Delay Study. The selection of the study method depends on the purpose of the study, roadway characteristics, length of segment, study period of interest, personnel, equipment and resources available.

(2) To conduct a Travel Time and Delay Study, one must first define the study area by selecting all control points before beginning the study. The time periods recommended for studies are A.M. and P.M. peak hours as well as off peak hours in the direction of heaviest traffic movements (other times may be requested by the District Traffic Operations Engineer).

(3) These studies should be made during reasonably good weather so that unusual conditions do not influence the study. Also, since crashes or other unusual delays will produce erroneous results, any runs

made during such an occurrence should be terminated and another run conducted. These studies should be conducted during average or typical weekday traffic conditions.

Test vehicle

(1) When conducting a Travel Time and Delay Study using the test vehicle method, there are three techniques that can be used:

(a) Average-Car: the speed of travel is determined by the driver's judgment of the average speed of the traffic stream.

(b) Floating-Car: the driver floats with traffic by passing as many vehicles as pass the test car. The idea is to emulate an average driver for each section of roadway.

(c) Maximum-Car: the speed of travel is the posted speed limit unless impeded by safety considerations or actual traffic conditions.

(2) This method is most widely used on arterial streets with at-grade intersections, although, is applicable to any type of route. The selection of the technique is based on the purpose of the study and which technique best reflects the traffic stream being studied.

(3) The following attributes can be determined along the study route when using the test vehicle method: travel time, running time, type, location, duration, and cause of traffic delays, distance traveled, and space-mean speed (SMS).

(4) A minimum of 1 mile is recommended for the total route length to be studied. In order to determine the number of runs required for statistical significance, the engineer/analyst should follow the Sample Size Requirements method described below.

Travel Time and Delay Studies shall be conducted using either the manual method or the computerized method which are explained in the following section.

### **Data Collection**

(1) To conduct test vehicle runs, incident-free conditions along a representative lane are necessary. Use the second lane from median for roadways that have two lanes in the direction of travel, and use the middle lane for roadways with three lanes in the direction of travel. The run duration will determine the number of test vehicles needed and the desired run interval. For personnel and equipment requirements

Equipment and personnel requirements for the Test Vehicle Method Data Collection

Personnel

Equipment

Optional Manual Driver and observer recorder

Test vehicle

Two stopwatches

Data collection forms

Distance measuring Instrument

Odometer

Voice recorder (notes of queues or other incidents)

Video camera (photographs or videos of unusual events)

Automatic Driver Test vehicle

GPS Field forms

Approved computerized system (GPS)

Automatic Data Collection

(1) The automatic method requires a test vehicle, driver, observer, GPS device, GPS connector to laptop, laptop computer, and approved data collection software. Computer software exists automatically identifying the GPS location by time interval. This information can be automatically summarized to

obtain vehicle location as a function of time. Key locations along a corridor can also be identified and recorded by tapping a computer key during the data collection process.

(2) Calibrate the GPS device before arriving at the field and ensure it is placed within the vehicle at a location receiving a clear satellite signal. The duties of the driver and observer (if required) should be reviewed prior initiation of the study. Ensure the laptop computer is connected to the GPS device. Thus the computer program has constant input from the GPS device. All the data should be recorded by the laptop computer for data analysis and the printing of a report.

(3) Place the test vehicle upstream of the begin point. Turn on the data recording equipment. Conduct a dry run and input the necessary information to the data recorder (beginning, ending and control points).

(4) From the data collected an analysis program determines the time spent stopped and the speed at any time or distance. The program is thus able to calculate average speed, running speed, amount of delay, number of stops, distance and time between traffic signals, fuel consumption, and miles per gallon.

(5) These outputs must then be analyzed, and engineering judgment should be applied to the numbers and graphs to determine if problem areas exist. If they do, then the appropriate corrective action must be determined.

### **Manual Data Collection**

(1) The manual method requires a test vehicle, driver, observer, two stopwatches or one stopwatch with double sweep, odometer, scaled plans or maps, and two field forms.

(2) The Travel Time and Delay Study can be conducted manually by using the following procedures. There are two different areas of this study, the field form is used to collect field data and the field summary is used to perform the required calculations and analysis. The instructions noted below should be followed when completing this study.

(3) There are six runs per field form. The rows of run data are filled in from the left to right as the run is being conducted. If more than six control points are identified, at least two more field forms must be used. The first control point on Sheet Two must be the same as the last control point on Sheet One, this will allow space for the delays to be recorded. The number of sheets used for the data collection shall be specified under the General Information section.