UNIT 3

TRAFFIC ENGINEERING AND REGULATIONS

SIA GROUP

PART-A
SHORT QUESTIONS WITH SOLUTIONS

Q1. Define traffic volume and traffic density and speed.

Answer :

May-17, (R13), Q1(f)

(a) **Traffic Volume**

Traffic volume is the number of vehicles passing a given point or cross section of road per unit time at any selected period. It is expressed as vehicles per hour or vehicles per day.

(b) **Traffic Density**

It is the number of vehicles occupying a length of roadway in miles or kilometres at a given instant. Traffic density is expressed as vehicles per kilometre.

The highest traffic density will occur when the vehicles are not moving on a given lane.

For remaining answer refer Unit-III, Q9.

Q2. Define the following,

(a) Traffic capacity

(b) Practical capacity.

Answer :

Model Paper-III, Q1(a)

(a) **Traffic Capacity**

It is defined as the ability of a roadway to accommodate traffic volume. It is expressed as the maximum number of vehicles that can pass a given point during one hour i.e., vehicles per hour per lane on roadway. The capacity of a roadway depends on the number of prevailing roadways and traffic conditions.

(b) **Practical Capacity**

It is defined as the maximum number of vehicles passing a given point or roadways during one hour without traffic density. The practical capacity does not have effect of unreasonable delay, hazards or restriction to the drivers.

Practical capacity is also called design capacity since it is used in designing the road ways.

Q3. What are the objectives and uses of volume study?

Answer :

Model Paper-I, Q1(e)

The different objectives and uses of volume study are as follows,

1. For the purpose of justifying the priority for improvement and expansion, traffic volume is generally considered as true measure with reference to the relative significance of roads.
2. It is generally utilized in planning, traffic operation and volunteering the existing facilities. In certain cases, it is also used for planning and designing of upcoming facilities.
3. In the analysis of different patterns and trends of traffic, the volume study is beneficial.

4. For the purpose of structural design of pavements, geometric design and for estimating roadway capacity, classified volume study is used.
5. In order to plan one-way streets and other regulatory techniques, volume distribution study is advantageous.
6. For the purpose of intersection design, planning of signal timings, channelization and other different control equipments, turning movement study is used.
7. For the safety of pedestrians, side walks, cross walks subways and pedestrian signals are planned using pedestrian traffic volume study.

Q4. What are the various traffic studies design for future traffic control for safe and efficient traffic movements?

Answer : Model Paper-II, Q1(f)

The various studies that have been carried out for future traffic control for safe and efficient traffic movement includes.

- ❖ Traffic characteristics
- ❖ Regulation of traffic
- ❖ Planning and
- ❖ Geometric design of streets and highways.

Surveys have been conducted to analyse the data provided by the traffic features and the data collected is known as "traffic census".

Traffic Characteristics

This include,

- ❖ Traffic volume
- ❖ Traffic density
- ❖ Traffic capacity
- ❖ Practical capacity.

Q5. List the various types of on street and off street parking facilities.

Answer : May-17, (R13), Q1(h)

The following are the different types of on-street parking facilities:

1. Angle parking
2. Parallel parking

The following are the different types of off street parking facilities:

1. Ramp type parking garages
   (a) Clear way systems
   (b) Adjacent parking system.
2. Elevator type parking garages
3. Parking lots.

Q6. What are the various types of accidents?

Answer : Model Paper-I, Q1(f)

The various types of traffic accidents are as follows,

1. A moving vehicle colliding with a parked vehicle
2. Collision of two vehicles approaching from opposite directions generally considered as head-on-collision
3. Vehicles coming from various directions collide at an intersection
4. Collision of moving vehicle with a stationary object such as electric pole, tree or a rigid structure.

Q7. What are the applications of location files and spot maps?

Answer :

Location File

Location files are used for checking location of accident and to identify zones of high accident incidence.

For each police station, location fields should be maintained for the respective jurisdiction.

Spot Maps

Accident spot maps is one, which shows accident by symbols, posted spots or pins on the map at the location of accidents. The various shapes and sizes of spots are used to indicate different types and severity of accidents. The commonly used legend is as follows,

Type of Accident	Fatal	Non-fatal
Motor vehicle Vs pedestrian		
Motor vehicle Vs motor vehicle		

Different types of spot maps used are,

(a) Night accident spot map
(b) Pedestrian accident spot map
(c) School child accident spot map.

Q8. What are the advantages and disadvantages of traffic signals?

Answer : Model Paper-II, Q1(e)

Advantages of Traffic Signals

1. Heavy flow of traffic can move safely and orderly through an intersection
2. It increases the traffic handling capacity of intersection.
3. Reduces various type of accidents such as right angle collisions
4. These are more economical than manually operated signals due to its automatic control operations
5. Coordination of signals provide continuous moment and easy to cross the road
6. Increases the confidence of driver due to definite flow of traffic.

Disadvantages of Traffic Signals

1. It creates lot of confusion due to failure of power in automatic system
2. Increases rear end accidents
3. Traffic violation occurs due to improper design and location
4. It causes the road users to increase the use of alternate routes to avoid signals
5. Increases the travelling time by adding stop signals.

Q9. Define traffic speed and write the inter-relationship between traffic density, speed and volume.

Answer : Model Paper-III, Q1(f)

Traffic Speed

Traffic speed is defined as the number of vehicles moving at an average speed. In a stream of 'N' number of vehicles, the speed of a vehicle can be expressed in the following ways,

$$\text{Time mean speed, } U_{TMS} = \frac{\sum_{i=1}^{N} V_i}{N}$$

$$\text{Space mean speed, } U_{SMS} = \frac{3.6d.N}{\sum_{i=1}^{N} t_i}$$

Inter-relationship between Traffic Density, Speed and Volume

(a) For a specified average speed, the traffic volume increases with an increase in traffic density.

(b) If the density of traffic is low, then its volume is approximately proportional to density.

(c) For a roadway capacity, the traffic volume increases with a decrease in traffic speed, when there is an increase in traffic density.

Q10. Define : Spot speed, Running speed, Space-mean speed and Time-mean speed.

Answer : April-18, (R15), Q1(f)

Spot Speed

For answer refer Unit-III, Q15, Topic: (a).

Running Speed

The average speed that is maintained while the vehicle is in motion is called running speed.

Time Mean Speed

The average of spot speeds of observed vehicles at point over a period of time is known as time mean speed. It is given by the equation.

$$\bar{u}_{TMS} = \frac{\sum_{i=1}^{n} u_i}{N}$$

N – Number of vehicles observed.

u_i – Observed speed of i^{th} vehicle

Space Mean Speed

The average of spot speeds of observed vehicles at any instant of time with respect to space is known as space mean speed. It is given by the equation.

$$\bar{u}_{SMS} = \frac{1}{\sum_{i=1}^{n} \left[\frac{1}{u_i}\right] / N}$$

Q11. Draw a neat sketch of Condition and Collision diagram.

Answer : May-17, (R13), Q1(e)

For answer refer Unit-III, Q34, Topics: Figure (1), (2), (3) and (4).

PART-B

ESSAY QUESTIONS WITH SOLUTIONS

3.1 BASIC PARAMETERS OF TRAFFIC – VOLUME, SPEED AND DENSITY – TRAFFIC VOLUME STUDIES – DATA COLLECTION AND PRESENTATION

Q12. Write a short notes on:

(a) Desire lines

(b) PCU

(c) Level of service.

Answer :

(b) Desire Lines

Desire lines are drawn after the preparation of tables. These lines are the straight lines, which connect the point of origin and destination of vehicles and are presented in to different area groups. The width of the desire lines is kept proportional to the number of trips made by a vehicle while it moves in both directions. The map showing the desire lines helps to locate the route which is desired by the road users. These maps hence, can be employed to plan a new road network, a diversion, a bypass, a bridge etc based on the need of traffic flow. The existing routes can be compared with desire line map with the help of tracing sheets.

(b) PCU (Passenger Car Unit)

Passenger car unit is a common type of vehicle unit which is generally used to measure the highway capacity. Different types of vehicles possess differents speeds, dimensions etc.. Which creates a problem to determine the PCU. Under different traffic and geometric conditions, the equivalent factors for various vehicles are determined as follows.

Vehicle	Equivalent Factor of PCU
Car, Tempo and Auto Rikshaw	1.0
Bike, Cycle	0.5
Car, truck.	3.0

A single lane road should possess a capacity of 2,500 PCU and double lane road should possess a capacity of 10,000 PUC per day as per IRC recommendations.

(c) Level of Service

As per highway capacity manual (HCM), Level of service is defined as the design service volumes which are related to certain operating specifications. A curve is drawn between operating speed and volume/capacity ratio as shown in figure.

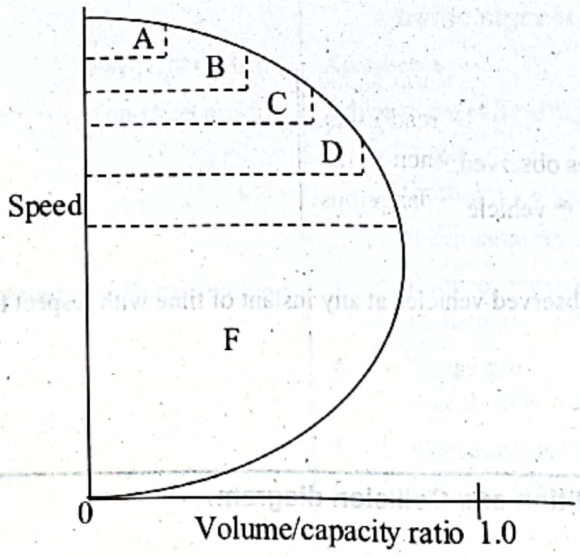


Figure: HCM Classification of Level of Service

Under different operating characteristics and traffic volume, LOS can be determined as follows,

1. Speed and travel time during travelling over a section of roadway
2. Traffic restrictions and interruptions i.e., delay due to change in speed and number of stops per Km
3. To maintain the desired operating speeds
4. Driving with comfort and convenience
5. Economy.

Q13. Write a note on various road user characteristics affecting the traffic.

Answer : May-17, (R13), Q7(a)

Following are the road user characteristics that influence the traffic on roads,

(i) Physical Characteristics

This type of characteristics may be temporary or permanent. The pavement characteristics are hearing, vision and strength.

Vision is very important in all of these. It includes the activity of vision, glare vision, peripheral vision and eye movement, glare recovery and depth judgment. Minimum stardards for acuity of vision are given by licensing authorities. Hearing helps drivers and is more important for cyclists and pedestrians. Lack of strength may make the parking maneouvers difficult.

(ii) Mental Characteristics

The road user characteristics are also affected by skill, knowledge, literacy and intelligence. Knowledge of rules of road, vehicle characteristics, driving practice, traffic behaviour and psychology of road users will be useful for safe traffic operations. Understanding the instruction, regulation of traffic and timely action is based on literacy and intelligence.

(iii) Psychological Characteristics

The emotional factors such as superstition impatience, attentiveness, fear anger, general attitude towards traffic and regulations affect reaction to traffic situations of road users. The attentiveness to traffic situations are reduced by non-traffic events and worries impatience can likely result to dangerous actions.

(iv) Environmental Factors

The behaviour of road user is affected by the various environmental conditions such as traffic stream characteristics, facilities to traffic, locality and atmospheric conditions. The adoptability to various traffic stream characteristics are based on the driver characteristics and motivation. The reason of entering the traffic stream can be business, social, routine movement, recreational or an emergency clash.

Q14. Indicate how the traffic volume data is collected (mechanical) and presented and how the results are used in traffic engineering?

Answer : Model Paper-III, Q7(a)

Traffic volume is the number of vehicles passing a given point of road per unit time at any selected period.

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

Mechanical Counters

Generally, these are either fixed type or portable type. The mechanical counters record the total number of vehicles by the effect of impulse or stimuli caused by traffic movements on a flexible pneumatic hose stretched across the road over which the vehicle passes or by providing sensor.

The other methods of working the mechanical detectors are by radar detector, photo electric cells and magnetic detector.

Advantage

Mechanical counters can work throughout day and night for desired period, recording total hourly volume.

Disadvantages

- The impulse caused by vehicles of light weight may not be enough to actuate the counters
- It is not possible to record pedestrian traffic by this method.

Presentation of Traffic Volume Data

The traffic volume data is presented in the following form,

1. Average Annual Daily Traffic (AADT) is the average of 24 hour counts collected every day of the year.

   AADTS are used in traffic analysis for,

   (a) Establishment of traffic volume trends

   (b) Estimation of highway user revenues.

2. Average Daily Traffic (ADT) is the average of 24 hours collected over number of days.

   ADTS is used in analysis for,

   (a) Measurement of current demand

   (b) Planning future expansion

   (c) Design and regulation.

3. Peak hour volume is the maximum number of vehicles that cross a section over a period of time on highways. PHVS are used for,

   (a) Capacity analysis

   (b) Development of parking regulation

4. Vehicle classification records the volume with respect to the type of vehicles.

5. Vehicle miles of travel is a measure of travel along a section of road. VMT's are used for allocating resources for maintenance and improvement of highways.

Result Analysis

The design hourly volume is found from the plot between hourly volume and the number of hours in an year as shown in figure.

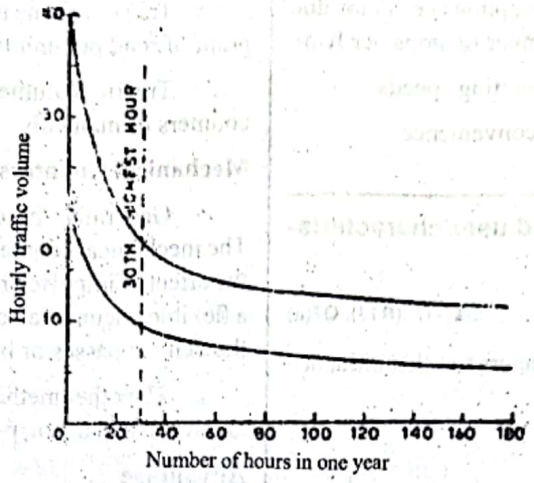


Figure: Hourly Traffic Volumes

The 30th highest hourly volume or design volume will be exceeded only 29 times in a year and all the volumes of year will be less than this value. If the highest or peak hourly volume is too high then it is not economical to design the facilities according to this volume. Thus the design should be based upon the 30th highest hourly volume.

Q15. Discuss briefly the various factors affecting the practical capacity of road.

Answer :

The various factors affecting the practical capacity of road are as follows,

1. Width of lane
2. Lateral clearance
3. Shoulders width
4. Commercial vehicles
5. Alignment
6. Existence of intersections at grade
7. Other factors.

1. Width of Lane

The capacity of road gets reduced with the reduction in the width of lane.

2. Lateral Clearance

The effective width of the road gets reduced due to the vertical obstructions like retaining walls or vehicles parked near the lane. This reduction in lane width decreases the capacity of the road. The driving comfort is highly influenced due to the limited lateral clearance.

3. Shoulders Width

When the shoulders are narrow, the effective width of traffic lanes get reduced due to which the vehicles tend to travel towards the pavement centre. Thus, reducing the capacity of the road.

4. Commercial Vehicles

Maximum space of the road is occupied by large commercial vehicles. These vehicles affects the other traffic coming in the same lane and also the vehicles in the adjoining lane.

5. **Alignment**

The capacity of the road decreases if the alignment and geometrics are of inappropriate standards. When the requirements corresponding to sight distance are restricted, the capacity is reduced. Steep and long grades highly influences the capacity.

6. **Existence of Intersections at Grade**

The free flow of traffic is highly restricted by the presence of intersections at grade, causing reduction in capacity of road.

7. **Other Factors**

The other important factors which influences the practical capacity of road are as follows,

(a) Speed of stream

(b) Traffic movement of one or two way

(c) Traffic lanes in large numbers

(d) Driver and vehicles features

(e) Volume and composition of traffic.

Q16. What are the different vehicular characteristics which affect the road design? Briefly explain.

Model Paper-I, Q6(a)

OR

Identify and explain by grouping the vehicular characteristics which affect the various elements of road design.

May-17, (R13), Q6(a)

Answer :

Vehicular Characteristics

While designing a road, it is required to know the vehicular characteristics before implementing,

The vehicular characteristics includes,

- Axle loads
- Axle spacings
- Wheel bases
- Overall lengths, widths and heights.

These standards must be flexible with the present roads.

IRC has specified some standards to design a road as follows,

Vehicular Characteristics – Maximum Dimension

1. Width – 2.44 m
2. Height
   - Single decked vehicle – 3.80 m
   - Double decked vehicle – 4.70 m
3. Length
   - Single unit with 2 axles – 10.7 m
   - Single unit with 2 or more axles – 12.2 m
   - Tractor semi-trailer combination – 15.2 m
   - Tractor trailer combination – 18.3 m

Width of Vehicle

The width of a vehicle affects the following,

- Lane width
- Width of shoulders and parking lots.

Length of Vehicle

It affects the following,

- Horizontal alignment
- Passing sight distance
- Road capacity
- Parking facility.

Height of Vehicle

It affects the following,

- Clearance provided under the structure such as electric or telephone lines, underbridge, overbridge etc.

Weight of Vehicle

It affects the following,

- Thickness of pavement
- Ruling and limiting gradient
- Bridge designs.

As per IRC recommendations, maximum permissible single legal axle load should be less than 8165 kg and maximum tandem axle load is 14.5 tonnes.

The gross load of any vehicle should be less than the weight, which is given as,

$$W = 465\,(24 + 3.28L) - 14.6L^2$$

Where,

W – Gross weight of vehicle (kg)

L – Distance between extreme axles.

$L > 2.44$ m

Vehicle Speed

It affects the following,

- Super elevation
- Horizontal and vertical alignment
- Limiting radius
- Sight distances
- Grades
- Pavement width
- Lane capacity
- Skid resistance
- Length of transition curve
- Intersection design and control

Vehicle Power

It affects the following,

- Braking distance
- Ruling and limiting gradient
- Vehicle speed.

Power of the vehicle is expressed as its acceleration ability.

Vision

This affects the following,

- Obstacle's perception time
- Glare.

Braking Capacity

It affects the following,

- Stopping distance
- Overtaking sight distance
- Traffic capacity.

Head Light

It affects the following,

- Night operation
- Number of accidents during night time.

Q17. Describe the basic relationships among various traffic stream parameters with neat sketch.

Answer :

Traffic Stream Parameters

The relationship between the fundamental stream flow variables is important in the operation and planning of traffic facilities.

Travel Time Vs Speed

Per unit length of road travel time is inversely proportional to the speed.

Let 'V' be the speed (kmph) and travel time be 'T'.

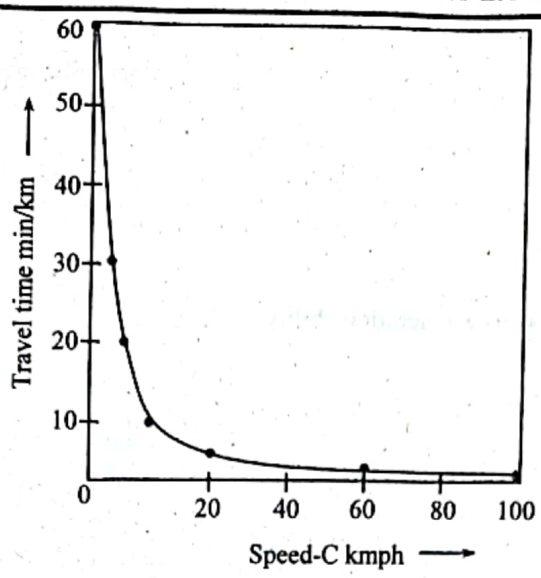
Then,

$$\text{Time} \propto \frac{1}{\text{Speed}}$$

$$T \propto \frac{1}{V}$$

$$T\,(\text{min/km}) = \frac{60}{V}$$

$$\boxed{T(\text{sec/km}) = \frac{3600}{V}}$$



Figure

Density Vs Speed

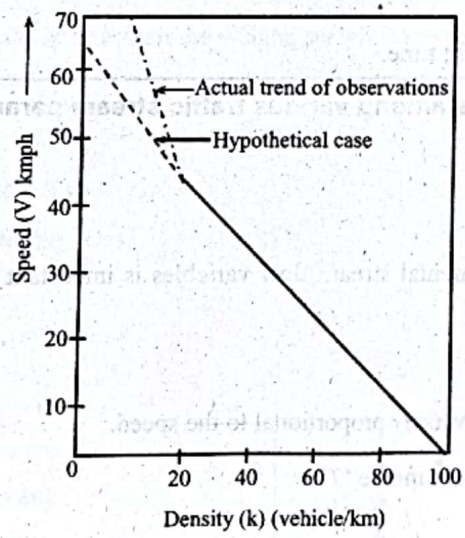
The relation between traffic volume, density and speed is given by the general equation of traffic.

$$q = k.V_s$$

Here k – Average density (veh./km)

V/s – Space mean speed of vehicles in a unit roadway length (kmph).

q – Average volume of vehicles passing a point.



Figure

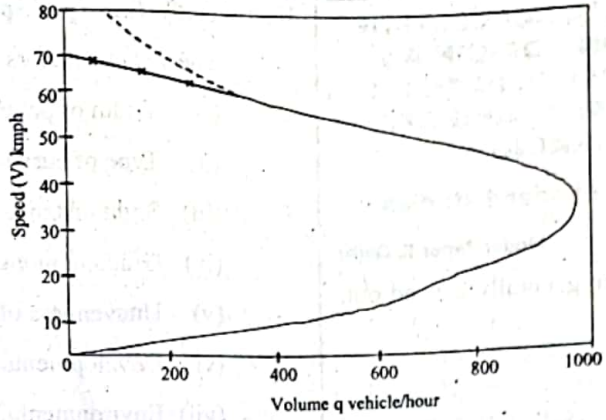
In an unit roadway length with increase in speed of vehicle the decrease in density is seen.

Speed Vs Volume

In general density cannot be measured directly and the relation between volume, density and speed is taken.

$$k \text{ (vehicle /km)} = \frac{q(\text{vehicle/hr})}{V(\text{km/hr})}$$

It is seen that, with low speed of traffic the volume will also be low.



Figure

Q18. Explain the manual method of conducting traffic volume studies.

Answer :

Manual Method of Conducting Traffic Volume Studies

In this method, the calculation of quantity of vehicles and their types moving on the road is carried out by individuals. Large quantity of manpower is required for this purpose. These studies are complicated to be conducted for the complete day. Generally, manual method is used due to its specific advantage over other methods. Initially the difference of traffic volume in a specific hour of the day and the daily difference of traffic volume are noticed. Then by selecting typical short count periods, traffic volume study can be estimated. With the help of this method, the type and direction of vehicles can be recorded by the team involved in the field.

A field sheet sample used for manual counting of traffic is listed below,

Enumelators Form

(i) Place of function
(ii) Classification of road
(iii) Approach name
(iv) Kilometeeage
(v) Date
(vi) Number of route
(vii) Starting hour
(viii) Ending hour
(ix) District
(x) State

Vehicles	Turning left		Moving straight		Turning right	
	Enumeration	Total	Enumeration	Total	Enumeration	Total
Buses						
Cars						
Cycles						
Jeeps						
Motorcycles						
Scooters						
Trucks						
Three wheelers						
Vans						
Vehicles for animals						
Others						

Table: Field Sheet Sample

3.2 SPEED STUDIES – DATA COLLECTION AND PRESENTATION – ORIGIN AND DESTINATION STUDIES, PARKING STUDIES – ON STREET AND OFF STREET PARKING

Q19. Explain the various types of speed studies.

Answer : Model Paper-II, Q6(b)

Two types of speed studies are generally carried out, they are,

(a) Spot speed study

(b) Speed and delay study.

(a) Spot Speed Study

Spot speed is defined as the speed of a moving vehicle at a particular section over the surface of the road. Spot speed studies are carried out to fulfill any one use of the traffic engineering problems listed below,

(i) Traffic control and regulation

(ii) Calculating the design speed

(iii) Re-designing of existing highways

(iv) Accident studies

(v) Traffic capacity studies

(vi) Comparision of drivers and vehicles.

Spot speed can be measured by many methods, the simplest method being the use of "enoscope". It consists of a mirror box positioned over a tripod stand. The procedure of calculating spot speed is as follows,

1. The observer is initially positioned at one side of the road while the enoscope is fixed at a distance of about 30 m from the observer
2. Enoscope is positioned in such a way that when the vehicle passes through the section, its image is clearly visible to the observer
3. The observer starts a stop watch just after a vehicle passes the section. The stop-watch is stopped as soon as the as the vehicle reaches the section, where the enoscope is placed
4. The time difference between these points is noted down.
5. The spot speed of the vehicle is then obtained by dividing the distance between the observer and enoscope (30 m) by the time required by the vehicle to travel that distance.

The various other equipments that can be employed to calculate the spot speed are,

(i) Graphic recorder

(ii) Electronic meter

(iii) Radar speed meter

(iv) Electric meter and

(v) Photograph method.

Factors affecting Spot Speed

The various factors which affect the spot speed are,

(i) Width of pavement

(ii) Type of curve

(iii) Sight distance

(iv) Gradient along the road surface

(v) Unevenness of pavement surface

(vi) Developments along the road side

(vii) Environmental conditions

(viii) Traffic characteristics

(ix) Efficiency of driver and vehicle

(x) Fuel used in vehicle.

(b) Speed and Delay Study

The speed and delay studies are carried out to calculate the running speeds of vehicles, overall speeds of vehicles, variation in speeds of different vehicles and also to obtain the delay time between two sections of a road, placed at a certain distance apart. These studies are also employed to determine the amount, position, duration, frequency and cause of delay of the moving traffic. The uses of speed and delay studies are,

1. To find out the exact location of the points of congestion
2. To calculate the time of travel
3. To carry out the benefit cost analysis
4. To determine the roadway efficiency.

There are two types of traffic delay over a specified period of time, they are,

(i) Fixed delays

(ii) Operational delays.

Fixed delays are caused because of the traffic signals available at the intersections. Operational delays may be caused by various factors such as turning vehicles, parked vehicles, pedestrians, inadequate road width, unexpected accidents, internal friction in the traffic stream etc.

The various methods used for carrying out the speed and delay studies are,

1. Floating car method
2. License plate method
3. Interview method
4. Elevated reading method
5. Photographic method.

The most commonly used method is the floating car method which is described below.

Floating Car Method

This method requires a test vehicle/floating car, group of observers and two stop watches. The procedure is as follows,

1. The test vehicle is made to travel along the inspection length and is maintained at a speed equal to the average speed of the floating stream.
2. An observer is made to sit in the vehicle and is provided with two stop watches. One stop watch is employed to obtain the time at different fixed points. The second stop watch is employed to record the duration of delay at each point.
3. Another observer records the given data in preprepared tabular forms or may record the data through voice recording.
4. The third observer records the number of vehicles which are overtaken by the test vehicle and also the vehicles which overtake the test vehicle.
5. Fourth observer notes the number of vehicles moving in the direction opposite to the direction of the test vehicle.
6. More number of observers may be required in case of mixed traffic flow.
7. The average journey time, t_{avg} is calculated for all the vehicles moving in the traffic stream along the direction of flow and is given by,

$$t_{avg} = \frac{t_1 - n_2}{q}$$

Where, $$q = \frac{n_1 + n_2}{t_2 + t_1}$$

q – Flow of vehicles along the direction of stream.

n_1 – Average number of vehicles recorded when the vehicle travels opposite to the direction of stream.

n_2 – Average number of vehicles recorded by substracting the number of overtaking vehicles and the number of overtaken vehicles along the direction of flow.

t_1 – Average journey time when test vehicle is moving in opposite direction to flow.

t_2 – Average journey time when test vehicle is moving along the stream.

Q20. Explain briefly the various aspects investigated during parking studies. What are the uses of these studies?

Answer : Model Paper-I, Q6(b)

The various aspects that are investigated during parking studies are as follows,

1. Parking demand
2. Parking characteristics
3. Parking space inventory.

1. Parking Demand

There are different methods by which the parking demand can be determined. In one particular method, initially the required area is selected and the corners of the area are counted. The outgoing traffic is subtracted from the volume of traffic entering the corners of the area. In this way, the accumulation of vehicles is recorded during the peak hours.

2. Parking Characteristics

In the parking studies, it is necessary to record the present parking methods and the common problems of parking in a specified area. The pattern of parking is to be studied in the case of kerb parking. Smooth traffic flow and the accidents during parking and unparking method are also required to be noted in kerb parking.

3. Parking Space Inventory

In order to satisfy the demands of parking, the area under study is completely surveyed and a map is drawn which includes all the places where the facilities of kerb parking and off-street parking can be provided effectively. It is required for a traffic engineer to design appropriate parking facilities by balancing the capacity and the parking demands.

Uses

1. These studies are used for estimating the facilities available.
2. These are conducted for evaluating the demand at an existing or new parking area.
3. The existing parking regulations are safety aspects of the parking area can be studied easily.
4. These are also conducted for checking whether the parking facility is according to local jurisdiction zoning codes or not.

Q21. Describe in detail the parking usage survey by patrolling method.

Answer :

(i) Purpose

The main purpose of parking usage survey is to achieve the information about extent of usage of parking spaces. In this survey, the parked vehicles are counted on peak periods of morning and evening at regular intervals. The parking accumulation and turnover is also taken into consideration. The survey can be conducted for both on-street and off-street parking. Both the surveys is similar with minor variations.

(ii) Street System Mapping

Initially, the map of the street system is prepared and is covered by patrol and their sub-division is shown into sections. The sections are determined by the street functions, which act as convenient points. The directions of travel should be shown clearly on the forms and map by the patrol-man.

(iii) Patrol Frequency

The maximum number of continuous patrols provide accurate data but the analysis and field work becomes complicated. For on-street parking, 30 minutes frequency can be assumed to be suitable and for off-street parking, 60 minutes frequency can be used. The short term parkers may be missed due to 30 minutes frequency. Thus, maximum number of patrols are required in specific areas.

(iv) Observation Method

Patrols are normally carried out by foot, but a moving car can also be used where the parking of vehicles is far from one another. The registration numbers of vehicles can be recorded by using a tape recorder.

(v) Survey Timing

This survey has to be performed on a day that is free from factors, which results in non-representative features. Normally, the survey takes 10 to 12 hours of period for covering the shopper and commuters.

(vi) Equipments

The equipments given to the observer is to watch the street map board, pencil and a supply of forms.

Q22. What are the different types of parking surveys and explain them in detail?

Answer : May-16, (R13), Q6(b)

Types of Parking Survey

The selection of parking survey depends on the area and its parking plan, data collected and the availability of funds. Parking surveys are classified into following four types. They are,

(i) Parking space inventory

(ii) Parking usage survey by patrol

(iii) Questionnaire type parking wage survey

(iv) Cordon count.

(i) Parking Space Inventory Survey

For answer refer Unit-III, Q20, Topic: Parking Space Inventory.

(ii) Parking Usage Survey by Patrol

For answer refer Unit-III, Q21.

(iii) Questionnaire Type Parking Survey

In this type of survey the information about the usage of existing facilities, parking requirements, parking demand at different prices, etc is collected from the drivers, car owners by interviewing them. A sample of car owners are selected and enquires are made. Some of the questions are delivered and the information collected from the actual parkers includes the followings:

(a) Address of origin and destination of the trip

(b) Purpose of the trip

(c) Time of departure and arrival at the parking place.

(d) Type of parking space occupied and type of the vehicle.

(iv) Cordon Count

In this type of survey, counting stations are pointed with the help of cordon line made by the roads in the area. The number of vehicles leaving and entering that particular areas are counted and the difference between the gives the number of parked vehicles in the area. Manual or automatic counting can be carried out.

Q23. What are the various parking parameters about which data is collected in a parking study? Define and explain them. Explain clearly the method of parking inventory study on a road section.

Answer :

The various parking parameters are as follows,

(i) Parking index

(ii) Parking load

(iii) Parking accumulation

(iv) Parking turn-over

(v) Parking volume

(vi) Parking duration.

(i) Parking Index

It is the ratio between number of bays occupied and theoretical number of bays available. It is expressed in terms of percentages.

(ii) Parking Load

During a particular period, the area under the parking accumulation curve is known as parking load.

(iii) Parking Accumulation

During a particular period, the total number of vehicles parked in an area is known as parking accumulation.

(iv) Parking Turn-over

The rate of usage of the parking space available is known as parking turn-over.

(v) Parking Volume

In a specified area, the number of vehicles parked in a given time period is known as parking volume. Normally, it is measured in vehicles/day.

(vi) Parking Duration

In a parking space, the length of spent time is known as parking duration.

rking Space Inventory

In this survey the primary step is to collect information available amount of spaced for parking area and its type d location. Initially the surveying area is to be specified. The king survey is required for the area of central district and the rrounding area is also included in survey. The sub divisions survey area is carried out on the basis of street-by-street and marked on the map. Then, the street plans are prepared with e help of appropriate symbols, the recording of data related parking facilities should be done on sketch plans. The parameters to be recorded should consists of the following,

Width of street.

Measures related to traffic management such as exclusive bus lanes, prohibited turns, one way streets etc.

The alloted length which have no waiting or limited waiting restrictions and the total kerb length.

Un used or vacant land, which is appropriate on temporary space for parking.

Rear-access alleys, private streets and service.

The street should have maximum space for parking.

Location of taxi-stand, pedestrian crossings, loading zones, fire hydrants, bus stops, bus bays etc.

For parking regulation, different traffic signs and number should be designated appropriately.

224. Enlist the various methods of collecting the O and D data. Explain any two in detail.

Answer :

The following are the various methods adopted for collecting Origin and Destination data (O and D),

1. Road side interview method
2. License plate method
3. Return post card method
4. Tag-on car method
5. Home interview method
6. Work spot interview method.

Road Side Interview Method

In this method, the vehicles are stopped at certain predefined points on the roads and the drivers are asked several questions by a group of members. The questions may include the positions of origin and destination, route followed, position of intermediate stops, purpose of trip, vehicle type and number of passengers in each vehicle. A particular type of vehicle's owner is interviewed once and the vehicles of similar category are allowed to go through different lane by various warning signs with the help of police. Traffic volume studies are also carried out simultaneously and the percentage of each sample interviewed from the total traffic for a particular period is also noted.

The method of roadside interview is quick and requires simple field organisation. However, as the vehicles are stopped on the road for the interview, the movement of other vehicles may get blocked resulting in congestion of traffic.

License Plate Method

In this method, the area to be studied is divided into various parts or routes and a number of observers are positioned at entry, exit and intermediate points of all the routes. Each group of observers are provided with synchronized time machines. The license plate numbers and the time of entry and exit of each vehicle is noted for different routes. For a particular period of time, the recording of data is done in different sheets in different directions. After the completion of field work, the major work is done in office, which involves the analysis of each vehicle by tracking their registration numbers.

The license plate method is quick in field work but involves very complex computations in office. The route followed by the vehicles cannot be judged easily unless a large number of observations are recorded along a particular route. This method also requires a large number of observers and hence is preferable for small areas such as small business centre or an intersection.

Q25. Explain origin and destination study. What are the various uses of origin and destination studies?

Answer :

Origin and Destination Studies

The two basic and main reasons for carrying out the origination and destinations studies are,

(a) To plan a typical network of a road for maintenance of vehicular traffic

(b) To prepare a plan for transportation of various types of vehicles confirming to commuters demand.

For vehicular traffic, the origin and destination studies helps in determining the number of vehicles, the origin of each vehicle and destination of each vehicle for a particular zone. More data can also be supplemented such as the purpose of trip, number of passengers travelling in each vehicle, the positions of intermediate stops etc. Origin and destination studies also provide information about the direction of movement of vehicles, route selected and trip length. The studies can be employed for planning of facilities for new highways or to improve the already existing highway facilities. The basic data required for obtaining the desired flow directions (desire lines) is also acquired from origin and destination studies.

Origin and destination studies along with the socio-economic studies can be employed to estimate the traffic-needs in future.

Uses of Origin and Destination Studies

The uses of origin and destination studies are as follows,

1. The existing route's adequacy can be checked and new road network can be planned
2. The facilities of transportation systems can be provided with the proper planning of their routes and operation schedule
3. The express way and major routes can be located along the desire lines
4. Different routes for different vehicles can be planned
5. Terminals can be planned and located easily

6. Origin and destination studies also helps to locate new bridges for traffic demands and may be employed to locate intermediate stops
7. The design standards for various structures such as roads, bridges and culverts can also be obtained using origin and destination studies.

Q26. Describe the presentaion of O and D data.

Answer :

The origin and destination data can be represented by the following ways:

1. By preparing tables showing the trips made by the vehicles in different zones.
2. Desire lines are drawn after the preparation of tables. Desire lines are the straight lines, which connect the point of origin and destination of vehicles and are presented in to different area groups. The width of the desire lines is kept proportional to the number of trips made by a vehicle while it moves in both directions. The map showing the desire lines helps to locate the route which is desired by the road users. These maps hence, can be employed to plan a new road network, a diversion, a bypass, a bridge etc based on the need of traffic flow. The existing routes can be compared with desire line map with the help of tracing sheets.
3. With the help of pie charts, the relative magnitude of the traffic and the geometrical relationships of various zones can be represented. The circles, drawn in the pie charts have diameters proportional to the number of trips made by the vehicle.
4. Contour lines similar to the topographic contours are also drawn to obtain the traffic requirements of respective areas.

Q27. Discuss the "presentation of spot speed data".

Answer :

Presentation of Spot Speed Data

The spot speed data can be presented by the following ways,

(i) By average speed of vehicles
(ii) By cumulative speed of vehicles
(iii) By modal average method.

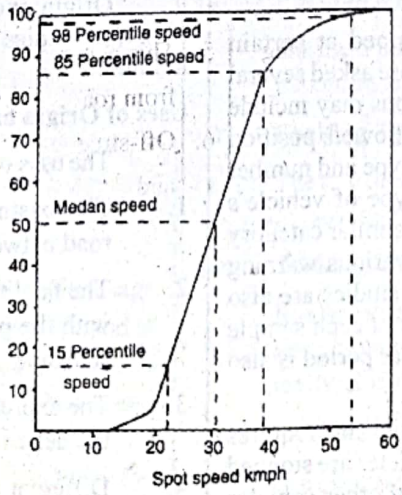
(i) By Average Speed of Vehicles

In this type of presentation, a frequency distribution table is prepared by grouping the spot speed data of certain samples. The grouping is done by considering a number of speed ranges and number of vehicles in each range. The final average speed is obtained by the arithmetic mean of these speeds. The frequency distribution table provides various informations such as speed maintained at a particular section; distribution pattern of speed etc.

(ii) By Cumulative Speed of Vehicles

A graph is drawn between the average values of each speed group and cumulative percent of vehicles travelled on x and y axis respectively. The 85th percentile speed is marked over the graph and is noted. This speed acts as a separator between the vehicles moving above or below the safe speed. The 15% vehicles which exceed this speed are considered to move faster than the safe speed at the section. When geometric design of highway is considered, 98th percentile speed is marked on the graph and this speed shows the safe speed at the particular section.

The 15th percentile speed can also be considered if it is required to obtain the number of vehicles that are moving too slow. These vehicles may cause delay and congestion. The graph showing the cumulative distribution of speed is given in figure(1).



Figure(1): Cumulative Speed Distribution

(iii) By Modal Average Method

A frequency distribution curve is drawn between the average speed values of each speed group and the percentage of vehicles in that particular group on x and y axis respectively. This graph is known as the "speed distribution curve". The speed distribution curve shows a peak value of speed over the section. This speed is termed as " modal speed". The modal speed represents the speed at which the maximum number of vehicles pass through the section. The speed distribution curve is shown in the figure (2).

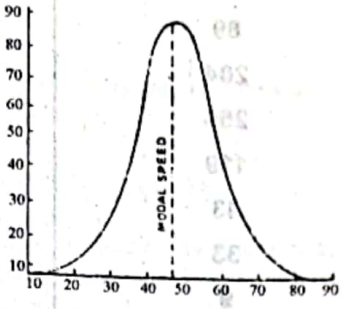


Figure (2)

Since every vehicle, generally does not travel with same speed over a certain section, the amount of speed dispersion affects both the capacity and safety of vehicles. Hence, for the vehicles to flow freely, the speed distribution should be a normal distribution curve.

Q28. What are the various types of parking facilities designed for traffic needs? Compare Kerb parking with off-street parking.

Answer :

There are two general types of parking facilities designed for traffic needs. They are,

(a) Kerb parking or on-street parking

(b) Off-street parking.

	On-street Parking		Off-street Parking
1.	In this type of parking, vehicles are parked over the Kerb which is already designed for parking.	1.	In this type of parking, the vehicles are parked over a place, which is at a certain distance from the kerb.
2.	Kerb parking needs to be preplanned and predesigned at the time of planning of town.	2.	Off-street parking can be designed or provided at any convenient place with considerable area.
3.	It causes congestion of road and decreases its width.	3.	It does not cause any affect on the width of the road as it is provided at a separate place.
4.	Kerb parking may be of either restricted or unrestricted type.	4.	Off-street parking is mostly of restricted type.
5.	Kerb parking may cause accidents as the parking is on the road.	5.	This parking is free from accidents as it is far away from road.
6.	Kerb parking is proved convenient if a person finds space at the place where he needs to go.	6.	Off-street parking is independent of the person's need and is fixed.
7.	The parking may be done either parallely or with an angle.	7.	The parking is generally done at a 90° angle.
8.	Kerb parking is preferred in conditions where the width of the street and that of the kerb parking are limited to a certain extent.	8.	The off-street parking is desirable at business centres as it can be constructed at close intervals.
9.	The parking and unparking operations are complicated and require frequent forward and reverse movements of vehicles.	9.	Due to a large space available and also because of systemised parking of vehicles, the unparking of vehicles is easy and doesn't require any efforts.

Q29. Spot speed studies were carried out at a certain stretch of a highway with mixed traffic flow and the consolidated data collected are given below.

Speed range, kmph	No of vehicles observed
0-10	12
10 – 20	18
20 - 30	68
30 - 40	89
40 - 50	204
50 - 60	255
60 - 70	119
70 - 80	43
80 - 90	33
90 – 100	9

Answer :

May-17, (R13), Q6(b)

A table is to be prepared for the distribution of frequency of spot speed from the given data:

Range of Speed (kmph) (1)	Average Speed (kmph) (2)	Frequency f (3)	Percentage frequency $(4) = \frac{(3)}{850} \times 100$	Cumulative % of frequency (5)
0-10	5	12	1.41	1.41
10-20	15	18	2.12	3.53
20-30	25	68	8.00	11.53
30-40	35	89	10.47	22.00
40-50	45	204	24.00	46.00
50-60	55	255	33.00	76.00
60-70	65	119	14.00	90.00
70-80	75	43	5.06	95.06
80-90	85	33	3.88	98.94
90-100	95	9	1.06	100.00
	Total	850	100.00	

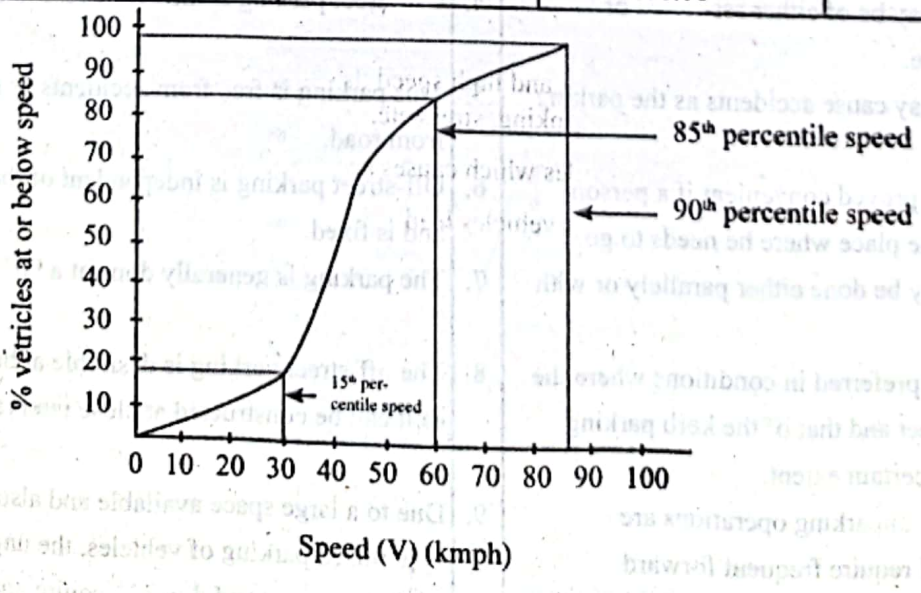


Figure: Cumulative Speed Distribution

The following are the results obtained from the graph:

(i) Upper limit of speed for regulation = 85th percentile speed
= 60 kmph

(ii) Lower limit of speed for regulation = 15th percentile speed
= 30 kmph

(iii) Check for speed of design elements = 98th percentile speed
= 84 kmph

Q30. Explain the survey procedure for speed studies and present the different forms of representation.

May-16, (R13), Q6(a)

Answer :

For answer refer Unit-III, Q19, Topic: Floating Car Method

The various methods used for carrying out speed and delay studies are,

(a) Floating car method

(b) License plate method

(c) Interview method

(d) Elevated reading method

(e) Photographic method.

Q31. Briefly explain the various objectives and methods of O and D studies.

May-17, (R13), Q7(b)

Answer :

For answer refer Unit-III, Q24 and Q25.

Q32. What are the details collected in origin and destination surveys? Explain the most commonly adopted methods of O&D survey.

April-18, (R15), Q6

Answer :

For answer refer Unit-III, Q25, Q26 and Q24.

3.3 ROAD ACCIDENTS – CAUSES AND PREVENTIVE MEASURES – ACCIDENT DATA RECORDING – CONDITION DIAGRAM AND COLLISION DIAGRAMS

Q33. Explain the various causes of road accidents.

(April-18, (R15), Q1(e) | Model Paper-III, Q6(b))

Answer :

The various causes of road accidents are as follows,

1. The main cause of road accidents is rash driving and high speed driving by drivers. The other reasons may be breaking of rules, violation of traffic signals, alcoholic drinking, stress etc.
2. Pedestrians may also break signals and other rules which causes accidents.
3. The passengers may try to get inside the moving vehicles leading to accident.
4. Due to the defects in vehicle such as brake failure, failure of steering, tyre puncture etc.
5. The roads with skidding surface, ruts, pot holes or any other defect may also cause accidents.
6. Geometric design, if not done properly also causes accidents. Insufficient sight distance, insufficient shoulder width, improper lighting and curve design etc., are some of the factors that indicates the defects in the geometric design.
7. Accidents may also occur due to the presence of mist, fog, dust, smoke, snow and many other factors which affect the normal eye sight to clearly observe the road ahead.
8. The various other causes of road accidents are the presence of stray animals on road, wrong working signals, inadequate positioning of sign boards and service centres, development of ribbons over the road surface etc.

Q34. Explain various measures that may be taken to prevent accidents. Write about condition and collision diagrams.

Answer :

The various measures to prevent accident rates may be divided into three groups,

1. Engineering
2. Enforcement
3. Education.

1. Engineering Measures

(a) Road Design

The geometric design of the road plays a vital role to decrease the accident rates. The geometric design features of road such as sight distances, horizontal and vertical alignment design, width of pavement are checked and maintenance steps should be taken to bring them upto the design standards. If necessary, bypasses should be constructed to separate through traffic from local traffic. To minimize time at the junctions, the fly overs may be constructed depending upon the flow of traffic.

(b) Preventive Maintenance of Vehicles

The steering, lighting and braking systems of vehicles should be checked at regular intervals and huge penalties should be charged on defective vehicle. These measures are necessary for public carriers.

(c) Road Lighting

During night, proper road lighting can decrease the rate of accidents. Proper lighting is required at desirable places such as junctions, bridge sites and the places where flow of vehicle movement is restricted.

2. Enforcement Measures

(a) Speed Control

High speeds are always associated with accidents. Speed limit selected should be realistic so that they are not disregarded by drivers. For this purpose, the limits should be appropriate to the conditions at site. The speed of all fast moving vehicles should be checked at selected locations (check points) and penalties must be imposed on those who violate the speed limit.

(b) Traffic Control Devices

Proper traffic control devices like signal systems, signs, marking should be installed so that there is a smooth flow of traffic or vehicles.

(c) Training and Supervision

The road transport authorities should be strict in issuing license to drivers. The drivers should be kept under supervision even after they passed the requisite tests and must be trained in proper defensive driving.

3. Educational Measures

(a) Education of Road Users

Road safety education occupies an important place in the prevention of accidents. School children who are particularly susceptible to accidents should be given the necessary training in the school about the rules of road and safety aspects.

(b) Safety Drives

Training courses should be conducted for professional driver of commercial vehicles and buses. Road users should be properly directed with the help of traffic police and transport staff at education places or locations.

Condition Diagram

A condition diagram is a plan or drawing to a scale (1:100 or 1:250) indicating all important physical conditions of an accident location. It helps to interpret the accident causation. Some of the important physical features shown in condition diagram are,

1. Geometric features of the location, street width, corner radii and curb lines
2. Property lines
3. Footways and driveways
4. Traffic signs, signals and markings
5. Street lighting
6. Bridges, culverts, overbridges, trees etc
7. Sight obstruction in roadway
8. Parking regulations.

The typical condition diagram is shown in figure.

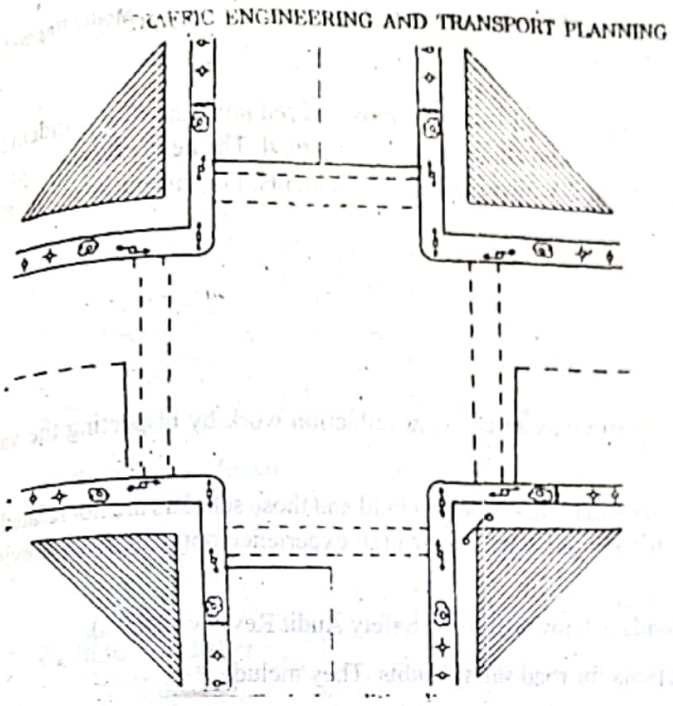


Figure (1): Typical Condition Diagram

Figure (2): Symbols for Condition Diagrams

Collision Diagram

A collision diagram is a schematic representation of all the accidents occurring at a particular location. These diagrams show the approximate path of vehicles and pedestrians involved in the accidents. A uniform system of symbols would be necessary to identify the full details and nature of accidents. Hence, collision diagrams are most useful to compare the accident patterns before and after the preventive measures have been taken.

A typical collision diagram is shown in figure.

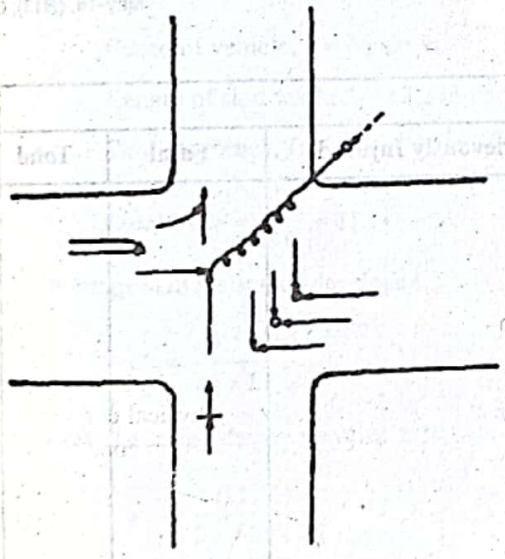


Figure (3) : Typical Collision Diagram at a Junction

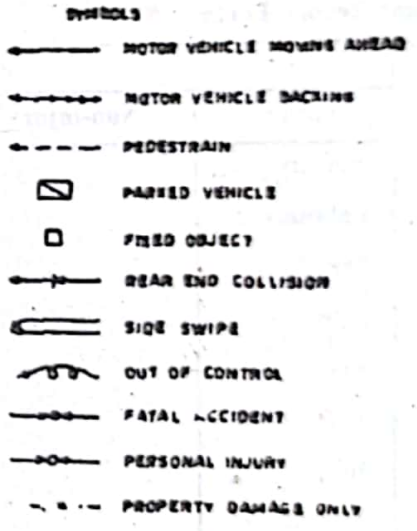


Figure (4) : Symbols Employed in Collision Diagram

The collision diagram are used to,

1. Study accident patterns
2. Determine remedial measures
3. Study the results of application of remedial measures.

Q35. Write explanatory notes on road safety audit.

Answer : Model Paper-II, Q7(a)

Road Safety Audit

Road safety audits are the methods and implementations carried out for preventing and reducing the road accidents. This can be done by examining the road before it is been opened or examining an already existing road. The newly constructed roads are checked for any defects in the highway design (geometric design) which may cause accidents. For this purpose, the RSA is carried out in three stages as follows,

(i) After the completion of preliminary design

(ii) After the finishing of detailed design

(iii) After the structure or road is constructed completely.

For the already existing roads, the road safety audit is carried as an accident reduction work by inspecting the various spots of previous accidents and defects in road, if any.

The persons employed for RSA work are qualified scholars in highway design field and those scholars are not related with the project. They locate the areas, which may be hazardous for accidents with their high experience obtained from previously inspected works and research in the design field.

The road safety audit, when carried out for existing roads is known as Road Safety Audit Review (RSAR).

The Indian government have given certain recommendations for road safety audits. They include,

(a) Improvement of signs on roads

(b) Proper road marking

(c) Provision of lighting on highways

(d) Positioning of delineators

(e) Proper inspection of intersection and

(f) Elimination of hazards on roads such as trees and hoardings.

Q36. Present on accident record form and different processing diagrams to analyze accidents.

Answer : May-16, (R13), Q7(a)

Accident Record Form

	Accidents				
Month	Non-injury	Minor Injury	Grievously Injured	Fatal	Total
January					
February					
March					
April					
May					
June					
July					
August					
September					
October					
November					
December					
Total					

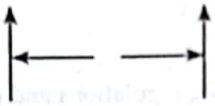
Different Processing Diagrams to Analyze Accidents

(i) Head on collision

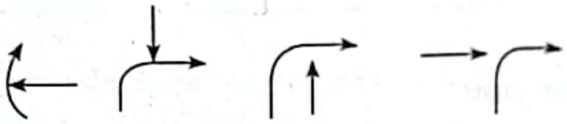
(ii) Rear and collision

(iii) Brush/side swipe

(iv) Right angled collision



(v) Right turn collision



For remaining answer refer Unit-III, Q34, Topic: Collision Diagram.

Q37. A vehicle moving at 40 kmph speed was stopped by applying the brake and the length of skid mark was 12.2 m. If the average skid resistance of the pavement is known to be 0.70, determine the brake efficiency of the test vehicle.

Answer :

Given that,

Speed of vehicle, $u = 40$ kmph

Length of skid mark, $L = 12.2$ m

Skid resistance, $f = 0.70$

Velocity, $V = \frac{40}{3.6} = 11.11$ m/sec

Average skid resistance developed,

$$f' = \frac{V^2}{2g \times L} \quad \ldots (1)$$

By substituting the above value in equation (1), we get,

$$f' = \frac{(11.11)^2}{2 \times 9.8 \times 12.2}$$

$$f' = 0.516$$

$$\therefore \text{ Brake efficiency} = \frac{100 f'}{f}$$

$$= \frac{100 \times 0.516}{0.70}$$

$$= 73.71\ \%$$

3.4 TRAFFIC SIGNS – TYPES AND SPECIFICATIONS – ROAD MARKINGS – NEED FOR ROAD MARKINGS – TYPES OF ROAD MARKINGS

Q38. With neat sketches, show various types of traffic signs, classifying them in proper groups with appropriate specification.

OR

Model Paper-III, Q6(a)

What are the different traffic signs and their relevance?

May-16, (R13), Q1(e)

Answer :

According to Indian Motor Vehicles Act, traffic signs are divided into the following three categories,

1. Regulatory signs
2. Warning signs
3. Informatory signs.

1. Regulatory Signs

Regulatory signs are used to inform certain laws, regulations and prohibitions to the public. These signs are also known as mandatory signs and are sub-divided into the following regulatory signs,

(i) Stop and give-way signs
(ii) Prohibitory signs
(iii) No-parking and No-stopping signs
(iv) Speed limit and vehicle control signs
(v) Restriction ends sign
(vi) Compulsory direction control and other signs.

(i) Stop and Give-way Signs

Stop Sign

Stopping the vehicle is represented by 'stop sign'. The shape of stop sign is octagonal and it is in red colour with white border.

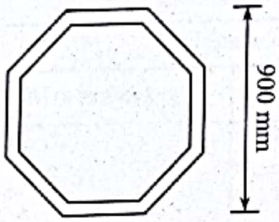


Figure: Stop Sign

Give-way Sign

Give-way sign is used to control the vehicles on the roadway. It is in triangular shape having white colour with red borders.

Figure: Give-way Sign

(ii) Prohibitory Signs

Prohibitory signs are used to prohibit certain traffic moments such as straight prohibited, no entry, one-way, vehicles prohibited in both directions, all motor vehicles prohibited, truck prohibited, cycle prohibited, right and left turn prohibited, U-turn prohibited, overtaking prohibited and horn prohibited.

Signs	Symbols
Straight prohibited or no entry	
One way sign	
Vehicles prohibited in both directions	
Right turn prohibited	
U-turn prohibited	
Over taking prohibited	

(iii) **No-parking and No-stopping Signs**

Prohibit parking of vehicles is indicated by no-parking or no-stopping signs. It is in circular shape having blue background and red border.

Figure: No-Stopping or No-Standing

Figure: No-Parking

(iv) **Speed Limit and Vehicle Control Signs**

These signs are used to restrict the speed of vehicles on a particular stretch of a road.

Speed Limit

Height Limit

Width Limit

Axle Load Limit

These are in circular shape having white background with red border and black numerals.

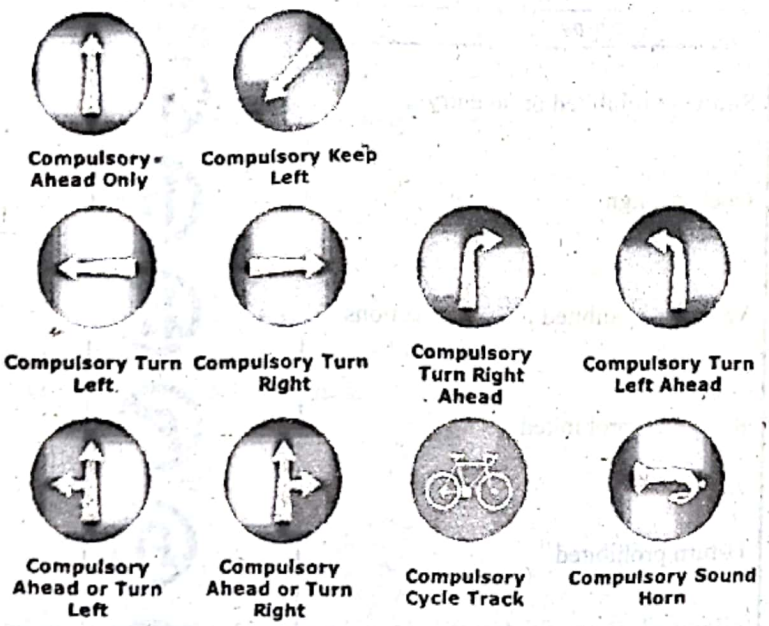
(v) **Restriction Ends Sign**

The representation of a point at which all prohibitions notified by prohibitory signs for moving vehicles.

Figure: Restriction Ends Sign

(vi) **Compulsory Direction Control and other Signs**

These signs are represented by arrows, appropriate directions in which vehicles are obliged to proceed, on only that directions on which they have to proceed. These are in circular shape having blue background with white direction arrows. The following are the compulsory direction controls,

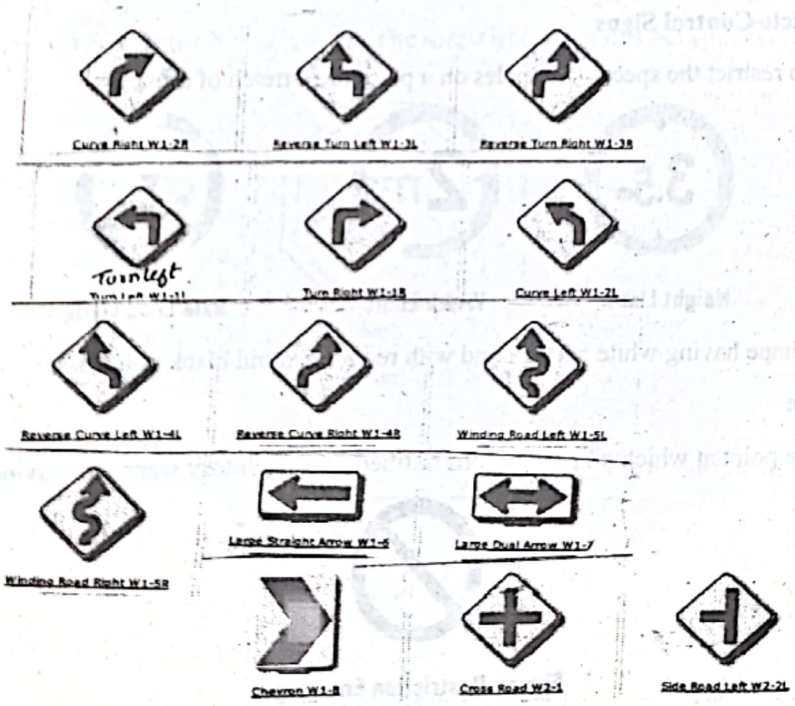


2. Warning Signs

Warning signs are used to warn the peoples against hazardous conditions. These signs are placed at sufficient distances such as 120 m, 90 m, 60 m and 40 m on National or State highways, major district roads and village roads etc.

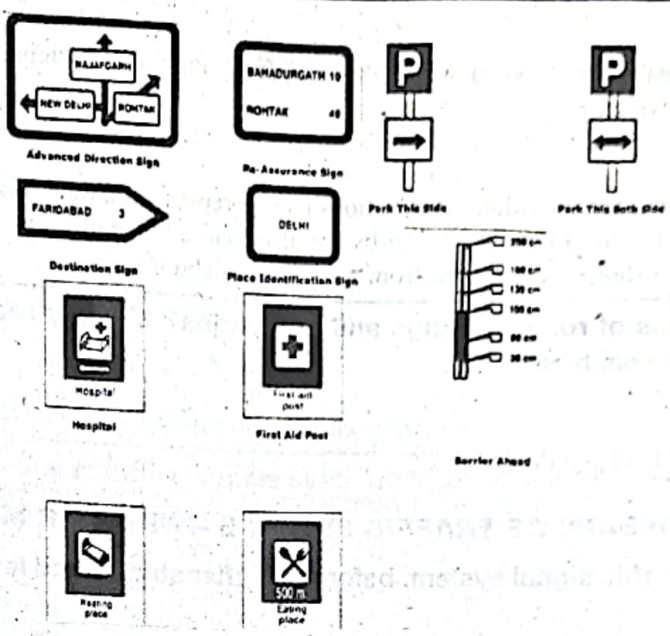
The few warning signs which are commonly used are right hand or left hand curve, right hair pin bend or left hair pin bend, right or left reverse bend, steep accent or descent, Narrow bridge or road ahead, gap in median, slippery road, cycle crossing, pedestrian crossing, school zone, men at work, ferry, cross road, side road, T-intersection, Y-intersection, major road ahead, round about, dangerous dip, hump or rough road, barrier ahead, unguarded railway crossing, guarded railway crossing and falling rock etc. For of warnings are shown below,

Warnings Traffic Signs



3. Informatory Signs

Informatory signs are used to guide road users along the routes, inform them about destination, distance and provide other information that will make the road travel easier, safe and pleasant few informatory signs are shown below.



Q39. What is road marking? What is the need for road markings? What are the types of road marking? Discuss.

Model Paper-I, Q7(a)

OR

Present different types of road markings, their specifications and their relevance.

Answer :

May-16, (R13), Q1(f)

Road Marking

The provision of lines, patterns, words, symbols or reflectors on the pavement, kerb sides of islands or on the stationary objects within or near the roadway is referred as road marking or traffic marking.

Need of Road Marking

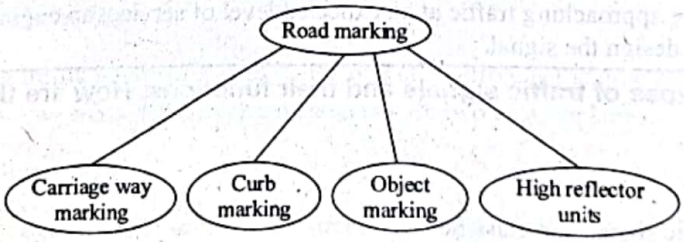
(i) Road marking is needed to achieve the higher degree of self discipline by road users

(ii) Road marking is necessary to control and regulates the traffic

(iii) It is also necessary to attracts the road users, which can be done by using the light reflecting paint on road marking.

Types of Road Marking

Road marking can be catagorized into four groups,



1. **Carriage Way Marking**

This type of marking can be done by using white paint carriage way marking includes the marking of centre lines, division of lane lines, overtaking regions, marking of curves and turns, provision of stop lines at intersections, cross walk lines, specifying space limits for parking etc. The lane lines on straight road is made up of 10 cm and thick 5 m long. The distance between each lane live is 8 m.

2. **Curb Marking**

The provision of road curbs on straight road are marked by white paint whereas on curves it is marked by black and white colour. The proper marking of road curbs represents the ment limit and very helpful in night time.

3. Object Marking

It is used to prevent physical obstruction on or near the roadway. It includes the signs, signals, level crossing gates, traffic is land, narrow bridge, culverts, etc.

4. Reflector Units

In this case of road marking, the hazardous obstructions can be represented by fixing reflector units. The reflector units reflects the yellow light at night. In streets the curbs are also marked by reflecting units to represents pavement limit, traffic island, etc. The light should be reflected from a distance of about 150 m.

Q40. What are the objectives of road markings and road signs? Classify road markings and traffic signs giving two examples in each category.

Answer : April-18, (R15), Q7

For answer refer Unit-III, Q39 and Q38.

3.5 DESIGN OF TRAFFIC SIGNALS – WEBSTER METHOD

Q41. Write short notes on traffic signal system, before and after studies and level of service.

Answer :

Traffic Signal System

The traffic signals are control devices used for directing the traffic either to stop or proceed at intersections utilizing red and green automating traffic light signals. They provide organized movement of traffic and also increases the traffic handling capacity of interrections at grade. These signals permit safe crossing of the heavy traffic flow.

The different types of traffic signal system are as follows,

1. Simultaneous system
2. Alternate system
3. Simple progressive system
4. Flexible progressive system.

Before and After Studies

The collision and condition diagrams are utilized for recording the accidents and their patterns at various places. When the improvements in design and enforcing regulation is completed, it is essential to collect and maintain, the accident records 'before and after' the application of preventive measures for studying their efficiency.

Level of Service

Level of service is a qualitative measure of the effect of a number of factors including speed and travel time, traffic interruptions, maneuver freedom, safety, comfort and convenience during driving and operating cost. The level of service is generally measured by delay of vehicles, length of queue and the number of vehicles that enter the intersection in the first green phase. In order to serve the entire approaching traffic at an expected level of service, an engineer should consider the sequence and duration of each phases and design the signal.

Q42. Explain the various types of traffic signals and their functions. How are the signal timings decided?

Answer :

Types of Traffic Signals

The various types of traffic signals are classified as,

1. Manually Operated Light Signals

In this type of signals, light signal posts are fixed on the left side of the vehicles at all the entering points to the intersection. The light signal posts are provided with red, yellow and green lights. The lights are arranged in such a way that they can be switched ON or switched OFF by operating a single common point.

2. Fixed-Time Automatic Signals

This automatic signals are also called as pretimed traffic signals. These signals are arranged to repeat at regular intervals in a specified sequence of signal indication. The time of each phase of cycle is computed depending upon the traffic studies. Fixed time signals are automatically operated signals. They can be operated by using an electronic control.

Traffic Actuated Signals

3. In actuated signals, the time of the phase and the cycle can be varied according to the traffic needs. The dectors in fully-actuated signals are placed on each approach which assigns the right way to various traffic movements on the basis of demand. If there is no traffic on main road, the signal indication will change only one time from the cross street.

Signal Timings

1. Time alloted for yellow signal varies from 3 to 5 seconds. If the speed is high, high values will be adopted. This time can be determined based on time required for stopping the vehicle at stop line and the time required to clear the intersection from the vehicles which are already entered before the signal change.
2. Time alloted for green signal may be nearly 20 seconds.
3. Time alloted for red signal is generally less compared to the green signal time.

Q43. What are the different types of traffic signals system? Mention the warrants for the signal installation.

Answer : Model Paper-II, Q6(a)

The various types of traffic signal system are described below,

1. **Simultaneous System**

In this coordinate system, all the signals along a given route displays the same coloured lights at the same time. This system produced high speeds of the vehicle between stops but at the same time it decreases the overall speed of the vehicle.

2. **Alternate System**

In alternate system, all the signals change their signs at sometime but adjacent group of signals displays the opposite colour on a road. This system is mostly suitable on a single road. It is also works effectively for controlling traffic in business districts.

3. **Limited Progressive System**

In this traffic signal system, a common cycle length is maintained but, if provides 'go' indication separately at each intersection point. Limited progressive system allows the continuous or nearly continuous flow of vehicle groups at a planned speed. It also allow to discourage the speed between the signals.

4. **Flexible Progressive System**

In flexible progressive system, the length of the cycle, cycle division and the time schedule at each intersection can be varied automatically. It is the most economical system among all the systems. The cycle length of whole system can be increased at peak hours to increase the capacity and decreased at slack traffic timings to decrease delays.

Warrants for Signals Installation

1. **Reduction in Vehicular Volume Warrant**

It indicates that the average traffic volume for eight hours on both approaches should be 650 motor vehicles per hour. On major street with single lane whereas 800 vehicles on streets with two or more lanes.

2. **Interruption of Traffic Flow**

If this fact is considered to be continuous on the major street with 1000 to 1200 vehicles per hour then there is under delay or dangerous to traffic on minor road with a traffic of 100 to 150 vehicles per hour in one direction only.

3. **Minimum Pedestrians Volume Warrant**

This warrant shows that 150 or more pedestrians per hour crosses a major street with over 600 vehicles per hour on both approaches.

4. **Accident Experience Warrant**

It shows the failure of other measures which decreases the accident frequency.

Q44. Describe the phasing diagram and timing diagram used in traffic signal design.

Answer :

Phasing Diagram

A phasing diagram illustrates the complete movements that are made in specified phase within a single block diagram. In this diagram, a phase consisting of two opposite movements are shown in one block of a phase diagram. The most commonly used plan is the simple two-phase signalization. The main aim of phase design is to separate the conflicting movements in an intersection into various phases. Thus, due to the phase design there exists no conflicts in the movements of a phase.

Timing Diagram

When the entire signal parameters are estimated, the timing diagram is produced in which all the numerical values are displayed. In the later stages, this diagram is applied to the signal controller.

Q45. Explain the design procedure of traffic signals according to webster's method.

Answer :

The design procedure of traffic signals to be followed by using webster's method are as given below,

1. A proper phasing plan decision is made
2. The length of the intergreen period for each cycle phase is determined
3. The minimum green time for each approach is calculated which mainly depends upon the crossing time of the pedestrians
4. The saturation flow rate (S) for each approach of the water section is measured
5. The design flow or normal flow (q) for each approach is determined.
6. The critical movements or lanes is to be found out then critical flow ratio's are calculated using the formula below,

$$\text{i.e., } y_1 = \frac{\text{Normal flow on the approach road 1}}{\text{Saturation flow on the approach road1}}$$

$$\text{and} \quad y_2 = \frac{\text{Normal flow on the approach road 2}}{\text{Saturation flow on the approach road 2}}$$

7. The optimum signal cycle (C_0) is determined and is given by webster's method as,

$$C_0 = \frac{1.5L + 5}{1 - y}$$

Where, total lost cost time/cycle, $L = 2\,n + R$

n – number of phase

R – all red time

and $y = y_1 + y_2$

Also, green phase, $G_1 = \frac{y_1}{y}\,[C_0 - L]$

Green phase, $G_2 = \frac{y_2}{y}\,[C_0 - L]$

8. Finally, the intersection capacity approaches is calculated and if necessary, depending on the capacity, the cycle time scheme is adjusted.

Q46. Design the timings of an isolated signal to be installed at a right angled intersection when roads P and Q cross. The data available are,

	Road P	Road Q
Width, metre	14.0	10.5
Peak hour traffic volume, vehicles per hour per lane	200	120
Approach speed, kmph	50	35

Model Paper-III, Q7(b)

Answer :

The following are the steps for the design of timing of an signal.

Step-1

Selection of Amber Periods

The amber period can be assumed based on the approach speed as, with approach speed 50 kmph

Amber period for road A with approach speed 50 kmph, $A_A = 4$ sec

Amber period for road B, with approach speed 35 kmph $A_B = 3$ sec

Step-2

Calculation of Pedestrian Clearance time

Assuming the pedestrian walking speed as 1.2m/s

The pedestrian clearance time for road $A = \frac{14}{1.2} = 11.667$s

The pedestrian clearance time for road $B = \frac{10.5}{1.2} = 8.75$s

Step -3

Calculation of minimum red time of traffic signal

Assuming the initial walk-period as 7 seconds.

Minimum red time for road $A = 11.667 + 7 = 18.667$ seconds

Minimum red time for road $B = 8.75+7 = 15.750$ seconds

Step -4

Calculation of minimum green time for traffic signal based on pedestrian criterion.

Minimum green time for road $A = 15.750 - 4 = 11.750$ seconds ($\therefore A_A = 4$ sec)

Minimum green time for road $B = 18.667 - 3 = 15.667$ seconds ($\therefore A_B = 3$ sec)

Step -5

Actual green time based on volume of approach.

If G_A and G_B are the green times, V_A and V_B are approach volume per hour per lane then we have,

$$\frac{G_A}{G_B} = \frac{V_A}{V_B}$$

Taking $G_B = 15.667$ seconds

$$G_A = \frac{V_A}{V_B} \times G_B = \frac{200}{120} \times 15.667 = 26.112 \text{ seconds}$$

Step - 6

Calculation of total cycle length

We know that total cycle length $= G_A + A_A + R_A = G_{AT} + A_A + G_B + A_B$

$= 26.112 + 4 + 15.667 + 3 = 48.779$ seconds

Adopting the cycle length of 50 seconds and distributing the additional period (50-48.779 = 1.221s) to green timings in proportion to approach traffic volume

$$G_A = 26.112 + \left(\frac{200}{200+120}\right) \times 1.221 = 26.875 \text{ seconds}$$

$$G_B = 15.667 + \left(\frac{120}{200+120}\right) \times 1.221 = 16.430 \text{ seconds}$$

$$R_A = G_A + A_A = 26.875 + 3 = 29.875 \text{ seconds}$$

$$R_B = G_B + A_A = 16.430 + 4 = 20.430 \text{ seconds}$$

Q47. Design a two phase traffic signal by using webster's method when the average normal flow of traffic on cross roads 1 and 2 during design period are 400 and 250 P.C.U/hr respectively. Also the saturations flow values are estimated as 1250 and 1000 P.C.U/hr and the all-red time required for crossing of pedestrian is 12 seconds.

Answer : Model Paper-II, Q7(b)

Given that,

$q_1 = 400$ P.C.U/hr

$q_2 = 250$ P.C.U/hr

$S_1 = 1250$ P.C.U/hr

$S_2 = 1000$ P.C.U/hr

$n = 2$

$R = 12$ seconds

The critical flow ratio at cross-road 1 is given as,

$$y_1 = \frac{q_1}{S_1} = \frac{400}{1250} = 0.32$$

Critical flow ratio at a cross-road 2 is given as,

$$y_2 = \frac{q_2}{S_2} = \frac{250}{1000} = 0.25$$

$$\therefore y = y_1 + y_2 = 0.32 + 0.25 = 0.57$$

$$L = 2n + R = 2(2) + 12 = 16 \text{ seconds}$$

$\therefore$ The optimum signal cycle is given by,

$$C_0 = \frac{1.5L + 5}{1 - y}$$

$$= \frac{1.5(16) + 5}{1 - 0.57}$$

$$= \frac{29}{0.43} = 67.44 \text{ seconds}$$

$$G_1 = \frac{y_1}{y}[C_0 - L] = \frac{0.32}{0.57}[67.44 - 16]$$

$$= 28.88 \cong 29 \text{ seconds}$$

$$G_a = \frac{y_a}{y}(C_o - L)$$

$$= \frac{0.25}{0.57}(67.44 - 16)$$

$$= 22.56 \approx 23 \text{ seconds}$$

Thus, there is a all red time of about 12 seconds for the pedestrians and an amber time of 2 seconds.

Total cycle time $= G_a + G_b + 12 + 2$ (2)

$= 29 + 23 + 16$

$= 68$ seconds

Q48. The average normal flow of traffic on cross roads A and B during design period are 400 and 250 PCU per hour. The saturation flow values on these roads are estimated as 1250 and 1000 PCU per hour respectively. The all red time required for pedestrian crossing is 12 sec. Design two phase traffic signal by Webster's method.

Answer : [Nov./Dec.-15, Sub.-6, Set(b) | Model Paper-I, Q7(b)]

Given that,

Average normal flow at cross road "A" is,

$q_a = 400$ PCU per hour

Saturation flow at road "A" is $S_a = 1250$ PCU per hour

Average normal flow at cross road "B" is,

$q_b = 250$ PCU per hour

Saturation flow at road "B" is given as,

$S_b = 1000$ per hour

All red time required for pedestrian crossing is,

$R = 12$ secs.

$$y_a = \frac{q_a}{S_a}$$

$$y_a = \frac{400}{1250} = \frac{8}{25}$$

$$= 0.32$$

Similarly,

$$y_b = \frac{q_b}{S_b}$$

$$= \frac{250}{1000}$$

$$= \frac{1}{4}$$

$$= 0.25$$

$$Y = y_a + y_b$$

$$Y = 0.32 + 0.25 = 0.57$$

Total lost time per cycles,

$$L = 2n + R$$

Where,

$n = 2$ [$\because$ Given two phase traffic signal]

$R = 12$ sec

$\therefore L = 2n + R$

$= 2(2) + 12$

$= 4 + 12$

$\therefore L = 16$ secs.

$\therefore$ Optimum signal cycle is given by,

$$C_o = \frac{1.5L + 5}{1 - y}$$

$$= \frac{1.5 \times 16 + 5}{1 - 0.57}$$

$$= \frac{24 + 5}{0.43}$$

$$= \frac{29}{0.43}$$

$\therefore C_o = 67.44$ approximating and taking as 67.5 secs.

$\therefore$ Optimum signal cycle, $C_o = 67$ secs.

$$G_a = \frac{y_a}{y}(C_o - L)$$

$$= \frac{0.32}{0.57}(67.5 - 16)$$

$$= 0.5614\,(51.5)$$

$$= 28.9121 \approx 29 \text{ secs.}$$

$$G_b = \frac{y_b}{y}(C_o - L)$$

$$= \frac{0.25}{0.57}(67.5 - 16)$$

$$= 0.438 \times (51.5)$$

$$= 22557 \approx 22.5 \text{ secs.}$$

Given all the red time for crossing pedestrian is $R = 12$ secs.

Taking/provide amber time $A_1 = 2.0$ sec $= A_2$ for each clearance.

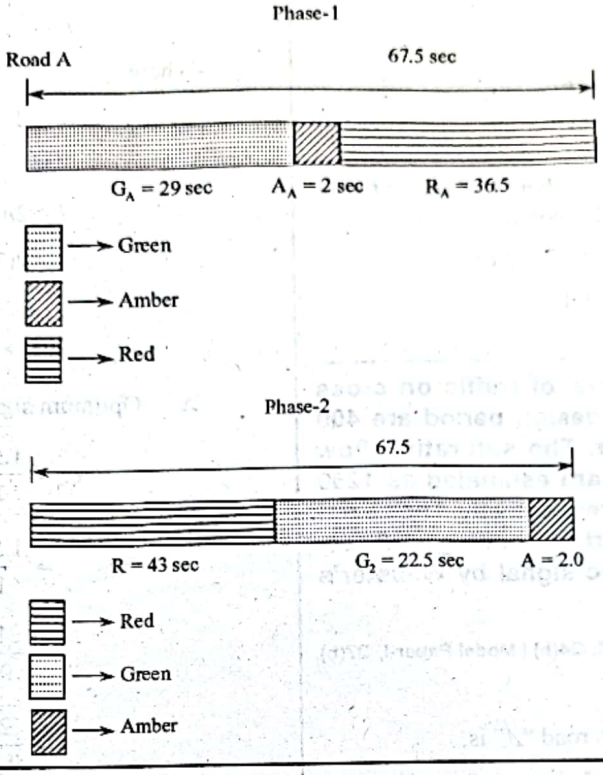
Given two phase $A = A_1 + A_2 = 4$ sec

$\therefore$ Total cycle time $= G_a + G_b + A + R$

$= 29 + 22.5 + 4 + 12$

$= 67.5$ secs.

Design Phase 4 Details of Signals Timings



Q49. Present the design procedure of isolated traffic signal.

May-16, (R13), Q7(b)

Answer :

For answer refer Unit-III, Q45.