ABSTRACT

The major factors affecting the Road User Costs (RUC) are the speed coupled with traffic flow characteristics at which vehicles operate onroads, which in turn determines fuel consumption and other cost components per unit distance traveled. Considering this, the Governmentof India has been involved in roadway capacity augmentation by building multi-lane divided carriageways to link major cities through theimplementation of various projects, like, Golden Quadrilateral, North-South, East-West and Expressway Corridors during the last decade.These radical changes in road network coupled with radical advancements in vehicle technology have resulted in huge variations inspeed - flow characteristics, which necessitated the evolution of exclusive speed-flow equations and roadway capacity for multi-lanehighways. Accordingly, an attempt has been made in this Paper to explicitly study the speed- flow characteristics on varying types ofmulti-lane highways encompassing four-lane, six-lane and eight-lane divided carriageways in plain terrain. From the collected data, freespeed profiles and speed - flow equations for different vehicle types for varying widths of multi-lane highways in the country has beendeveloped based on traditional and microscopic simulation models and subsequently roadway capacity has been estimated. Further, the lanechange behavior of different vehicle types has been extensively studied and its impact on roadway capacity has been estimated on multi-lanehighways. Finally, the Design Service Volume for varying types of divided carriageways including four-lane, six-lane and eight-lane has been evolved with reasonable degree of authenticity under the prevailing heterogeneous traffic conditions on multi-lane highways in India.

In this study we are going to show that the behavior of speed flow relationship and capacity estimation on SH-41. For that we are choosing the highway road between Unjha to Mehsana. For that we are doing a different survey on this route and then after analysis. We conclude that whether it is feasible or not.

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CHAPTER: 1 INTRODUCTION

1.1 General

Highway capacity values and speed-flow relationships used for planning, design and operation of highways, in most of the developed countries, have been based on Manuals and Codes of practices, which are valid for fairly homogeneous traffic comprising vehicles of more orless uniform static and dynamic characteristics. Even under nearlyhomogeneous traffic conditions, it is necessary to convert heavy vehicles such as buses and trucks, which constitute a small proportion of traffic,into equivalent number of a standard type of vehicle (usually passengercars) to measure the traffic flow using a single unit. The road traffic inmost developing countries such as India comprise vehicles of wideranging physical dimensions, weight and dynamic characteristics. Also,the motorized and non-motorized vehicles share the same road spacewithout any segregation. The speeds of these vehicles vary from about5 to over 100 km/h. Due to the highly varying physical dimensions andspeeds; it becomes difficult to make the vehicles to follow traffic lanes.Consequently, they tend to choose any advantageous position on theroad based on space availability. Also, the extent of vehicular interactionsvaries widely with variation in traffic mix. Vehicles, which are less mobile in terms of maneuverability, cause significant level of friction to themovement of other vehicles in the traffic stream. The extent of friction realized by the different categories of vehicles depends on their static and dynamic characteristics. For example, at higher traffic volumes a large proportion of motorized two-wheelers and bicycles may be able to move with speeds closer to their free speeds because of their ability for utilizing smaller gaps in the stream for movement, while the large-size vehicles such as buses and trucks may be subjected to considerable speed reduction. Traffic engineers account for the impact on capacity from the different types of vehicles by assigning each class of vehicle a passenger car equivalent (PCE or PCU) value. This value represents the number of passenger cars that would consume the same percentage of the highway's capacity as the vehicles under consideration under prevailing roadway and traffic conditions. This study deals with development of a simulation model to replicate heterogeneous traffic flow on urban roads of developing countries such as India and the application of the model to derive PCU values for the different types of vehicles in heterogeneous traffic streams, and hence arrive at capacity standards.

1.2 Traffic Characteristics

The knowledge of traffic flow characteristics is useful to highway engineer in developing highway and transportation plans, performing economic analysis, establishing geometric design criteria, selecting and implementing traffic control measures and evaluating the performance of transportation facilities.

The traffic flow characteristics have been considered following measures of effectiveness.

- Composition of traffic
- Speed and travel time
- Traffic volume and rate of flow
- Traffic density
- Spacing and headways.
- Relation between speed-density-volume

1.2.1 Composition of traffic

Composition of traffic means different types of vehicles such as cars, buses, vans, trucks, auto rickshaws, motorcycle, pedal cycle, bullock carts etc. are found to use the common roadway facilities without segregation on most of the roads in developing country like India. The traffic flow with unrestricted mixing of different vehicle classes on the roadway forms heterogeneous traffic flow which is known as mixed traffic flow. The mixed traffic flows have a wide range of static characteristics such as length, width and weight of vehicles and dynamic characteristics such as speed, acceleration etc. therefore the mixed traffic flow conditions are very much complex when compared to homogeneous traffic consisting of passenger cars only. It is rather difficult to estimate the traffic volume and capacity of roadway facility under mixed traffic flow unless the different classes of vehicles are converted into one common standard vehicle unit.

It is a common practice to consider the passenger car as the standard vehicle class and this Unit is called as passenger car unit (PCU). Thus, in mixed traffic flow, the traffic volume and capacity are generally expressed as PCU per hour or PCU per lane per hour and the traffic density as PCU per km length of lane.

1.2.2 Speed and Travel Time

Speed is defined as a rate of motion, expressed as distance per unit time, generally km per hour (km/hour). Speed of travel is simple and widely used measure of the quality of traffic flow. Basically speed is the total distance traversed divided by the time of travel. So, the travel time is reciprocal of speed and it is expressed as units of minutes per km.

There are three basic classes of speed:

- Spot speed.
- Overall speed.
- Running speed.

1.2.3 Traffic Volume and Rate of Flow

Traffic volume and rate of flow are two measures that quantify the amount of traffic passing a point on a lane or roadway during a designated time interval. The distinction between volume and rate of flow is an importance one. Volume is an actual number of vehicles observed or predicted to be passing a point during a time interval. Rate of flow represents the number of vehicle passing a point during a time interval less than one hour, but expressed as an equivalent hourly rate. A rate of flow is calculated by taking the number of vehicles observed in a sub hourly period and dividing it by the time (in hour) over which they were observed.

Two types of measures of traffic volume, special significance to the traffic and highway engineer are Average daily traffic (ADT) and design hourly volume (DHV). The average daily traffic is the number of vehicles that passes a particular point on a road way during a period of 24 consecutive hours averaged over a period of 365 days. ADT is a fundamental measure of traffic that is used for the determination of vehicle kilometers of travel on the various categories of highway systems. Vehicle kilometers are important for the development of highway financing or taxation schedules, the evaluation of safety programs, and as a measure of service provided by a highway transportation system. It is not feasible to make continuous counts 365 days a year along every section of highway system. Average daily traffic values for many road sections are therefore based on a

statistical sampling procedure. The design hourly volume is a future hourly volume that is used for design. It is usually the thirtieth highest hourly volume of the design year. Traffic volumes are much heavier during certain hours of the day or year, and it is for these peak hours that the highway is designed.

The term rate of flow accounts for the variably or the peaking that may occur during periods of less than one hour. The highway capacity manual uses a peak hour factor to relate peak rates of flow to hourly volume. The peak hour factor is defined as the ratio of total hourly volume to the maximum rate of flow within the hour. If there were not variability in flow rate during the hour, the peak hour factor would be 1.00. The typical peak hour factor for two lane road ways range is about 0.83 to 0.96.

1.2.4 Traffic Density

Traffic density or concentration is the number of vehicles occupying a unit length of road at an instant of time. The unit length is generally one kilometer. It is generally expressed in units of vehicles per kilometer. Density is expressed in relation to the width of the road such as per lane or per 2 lanes etc. when vehicles are in jam condition, the density is maximum. It is then termed as the jamming density.

Traffic density bears a functional relationship to speed and volume. Direct measurement of density in the field is difficult, requiring a vantage point from which significant length of highway can be photographed, videotaped, or observed. It can be computed, however, from the average travel speed and rate of flow, which are more easily measured.

$K=Q/V$

Where,

Q= Rate of flow, in v/h

V= Average travel speed, in km/h

K= density, in v/km

1.2.5 Spacing and Headways

Spacing of vehicles shows the way a driver evaluates the traffic stream congestion at any moment. It is also computed. The relationship between headway and spacing depends on the space mean speed and given by

Average headway (sec) = $\frac{Averagespacing\ (m)}{Spacemeanspeed\ (m/s)}$

1.2.6 Basic form of Speed-Flow-Density Relationship

Knowledge of relationship between speed, volume and density is very important in traffic studies. In this the speed-volume relationship is used to find the capacity of roads.

A. Speed-density relationship.

With increase in density the speed decreases. When there is no vehicle (density=0), the speed is maximum. This speed is called “Free speed”. At very high density, the vehicles approach zero speed. This density is called “Jam density”.

B. Speed-Flow relationship

At very low speeds the volume would also be low. With increasing speed, traffic volume also increases up to a certain limit, as headway initially decreases. But as the speed further increases the spacing between the vehicles increases and becomes so large that volume decreases. There is an optimum speed at which the flow is maximum.

C. Flow-density relationships

As the density increases from zero, volume increases up to the point of critical density. The density corresponding to maximum flow, it is called “Optimum density”. There after volume decreases as density continues to increases to a maximum value known as “Jam density” when all vehicles are stopped. As density increases the speed of vehicle is reduced, reducing the flow, till it reaches jam density when there is no movement or flow.

1.3 The Time-Space Diagram

Objects are commonly constrained to move along a one-dimensional guide way, be it, for example, a highway lane, walkway, conveyor belt, charted course or flight path. Thus, the relevant aspects of their motion can often be described in Cartesian coordinates of time, t, and space, x. Figure 6-1 illustrates the trajectories of some objects traversing a facility of length L during time interval T; these objects may be vehicles, pedestrians or cargo. Each trajectory is assigned an integer label in the ascending order that the object would be seen by a stationary observer. If one object overtakes another, their trajectories may exchange labels, as shown for the fourth and fifth trajectories in the figure. Thus, the 1th trajectory describes the location of a reference point (e.g. the front end) of object l as a function of time t, $x_l(t)$.

The characteristic geometries of trajectories on a time-space diagram describe the motion of objects in detail. These diagrams thus offer the most complete way of displaying the observations that may have actually been measured along a facility. As a practical matter, however, one is not likely to collect all the data needed to construct trajectories. Rather, time-space diagrams derive their (considerable) value by providing a means to highlight the key features of a traffic stream using only coarsely approximated data or hypothetical data from “thought experiments.”

The literature includes numerous illustrations of how these diagrams, even when drawn approximately, can be used in solving problems that frequently arise in transport. As examples, Daganzo (1997) shows how trajectory plots can help to select desirable scheduling policies in rail and in sea transportation; Newell (1979) used them in deriving expressions of airport runway capacity; and they are a widely used tool for synchronizing traffic signals along an arterial (Newell, 1989).

This chapter will frequently rely upon time-space diagrams to illustrate fundamental concepts. They are used immediately below to convey the precise meanings of some important properties of the traffic stream.

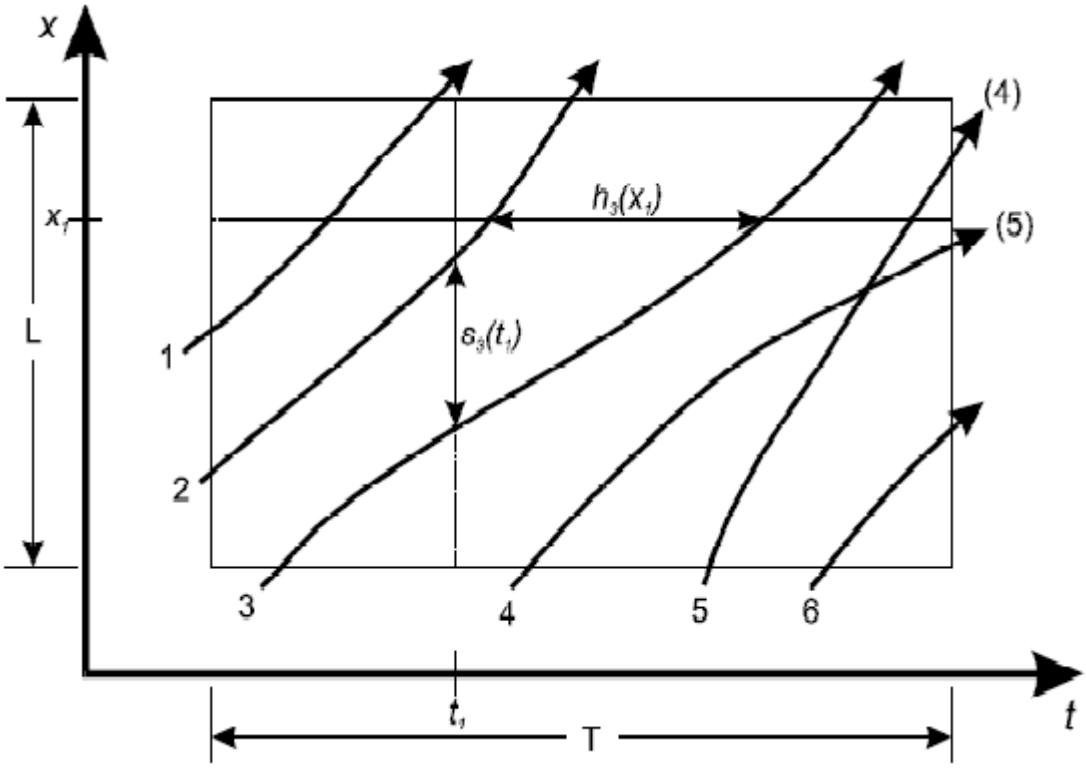


Fig.1.1 Time-space diagram

1.4 Various Mode of Transportation

- **Road transportation**: Road infrastructures are large consumers of space with the lowest level of physical constraints among transportation modes. However, physiographical constraints are significant in road construction with substantial additional costs to overcome features such as rivers or rugged terrain. While historically road transportation was developed to support non-motorized forms of transportation (walking, domestication of animals and cycling at the end of the 19th century), it is motorization that has shaped the most its development since the beginning of the 20th century. Road transportation has an average operational flexibility as vehicles can serve several purposes but are rarely able to move outside roads. Road transport systems have high maintenance costs, both for the vehicles and infrastructures. They are mainly linked to light industries where rapid movements of freight in small batches are the norm. Yet, with containerization, road transportation has become a crucial link in freight distribution.

- **Rail transportation**: Railways are composed of a traced path on which vehicles are bound. They have an average level of physical constrains linked to the types of locomotives and a low gradient is required, particularly for freight. Heavy industries are traditionally linked with rail transport systems, although containerization has improved the flexibility of rail transportation by linking it with road and maritime modes. Rail is by far the land transportation mode offering the highest capacity with a 23,000 tons fully loaded coal unit train being the heaviest load ever carried. However, vary around the world, often challenging theintegration of rail systems.

- **Maritime transportation**: Because of the physical properties of water conferring buoyancy and limited friction, maritime transportation is the most effective mode to move large quantities of cargo over long distances. Main maritime routes are composed of oceans, coasts, seas, lakes, rivers and channels. Maritime transportation has high terminal costs, since port infrastructures are among the most expensive to build, maintain and improve. High inventory costs also characterize maritime transportation. More than any other mode, maritime transportation is linked to heavy industries, such as steel and petrochemical facilities adjacent to port sites.

- **Air transportation**: Air transport constraints are multidimensional and include the site the climate, fog and aerial currents. Air activities are linked to the tertiary and quaternary sectors, notably finance and tourism, which lean on the long distance mobility of people. More recently, air transportation has been accommodating growing quantities of high value freight and is playing a growing role in global logistics.

1.5 Objectives

- Collection of data for existing condition.
- To study the effect of influencing parameters like gradient,lane width, shoulder width, traffic composition, directionalsplit and pavement surface roughness on capacity of roads under mixed traffic conditions.
- To determine capacity of road using speed-flow relationship.
- To quantify Average Speed, Travel Time, Gap and Headway on SH-41.

1. 6 Scope of the study

- In view of constraints, like computational facilities, time and information resource. The study is dedicated to the only SH-41(Unjha-Mehsana) and determines Capacity of road using speed-flow relationship. Based on which alternatives for improvements can be suggested.

CHAPTER: 2 LITERATURE REVIEW

2.1 General and some common terms

- **Speed:** speed is the rate of movement of traffic or distance covered in unite time expressed in km/h (distance/Time)
- **Spot-speed: -** The speed of a vehicle as it passes a spot or point on a highway.
- **Volume (q):-** volume is the number of vehicle passing a given point during a specified period of time expressed as vehicle/hr.
- **Density (k):** Density is the number of vehicle occupying a unite length of the moving lane of a roadway at a given instant expressed as vehicle/km
- **Pedestrians:** Any person other than a driver or passenger
- **Driver:**Any person who drives a vehicle or rides a pack or saddleanimal.
- **Passenger:**Anyperson, otherthan driver,whoisinoronavehicle.
- **Roadaccident:**An accident (collision, overturning or slipping) whichoccurred or originated on a road open to public traffic resulting in either injury or loss of life, or damage of property; in which at leastone movingvehiclewasinvolved.
- **Journey Speed of Cars:** As cars have the highest free speed, they encounter lot of Interactions. This speed is significantly affected by the flow level.
- **Journey Speed of Motorized Two Wheelers:** The free speed of these vehicles is slightly lower than that of cars. As these vehicles are narrow they are able toperform moreManeuverings in the heterogeneous traffic mix. Further the proportion of these vehicles isalso significant in the traffic mix. The journey speed of non-motorized vehicle does notreally define the quality of service as they are able to move at speeds closer to the freeSpeeds.
- **Concentration:** Concentration defined in terms of number of vehicles per kilometerdefines the longitudinal spacing between the vehicles. Ability to overtake/pass dependsupon the spacing between the vehicles in its neighborhood. Congestion is directly definedby the concentration level.
- **Road Occupancy:** This is the physical area of the vehicles in the road section relative to the road area. This measure is adopted as the vehicles of heterogeneous traffic mix haveWide variations in their dimensions.

2.2 Types of Traffic Flow:-

2.2.1 Uninterrupted Flow:

In this condition vehicle are free to move and are not required to stop by any cause external to the traffic stream. Such condition generally occurs on rural roads or outer urban highways, where the influence of interference or intersections is not there. Such roads are called “Free- ways”.

2.2.2 Interrupted Flow:

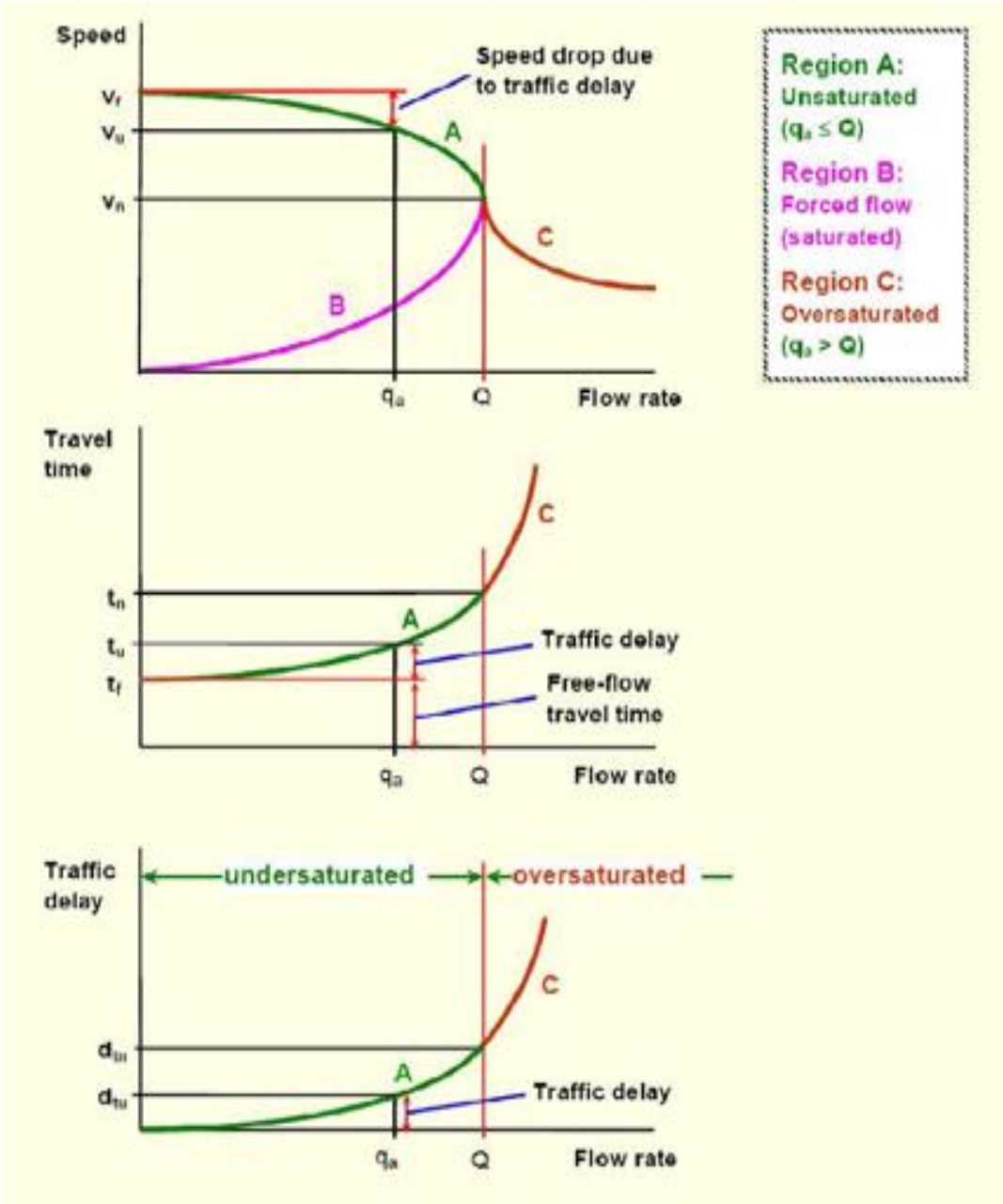
In this condition vehicle are required to stop by causes outside the traffic streams such as signs, traffic signals, and abutting land uses etc. stoppage of vehicles by causes internal to the traffic stream does not constitute interrupted flow.

2.3 Research Paper:

2.3.1 Speed-flow analysis for interrupted oversaturated traffic flow with heterogeneous structure for urban roads(hemantkumarsharma, mansha swami, bajranglal swami) (reference-9)

Speed–flow functions have been developed by several transportation experts to predictaccurately the speed of urban road network. HCM Speed-Flow Curve, BPR Curve, MTC Speed-Flow Curve, Akçelik Speed-Flow Curve are some extraordinary efforts to define the shape of speed-flow curve. However, the complexity of driver’s behavior, interactions among different type of vehicles, lateral clearance, co-relation of driver’s psychology with vehicular characteristics and interdependence of various variables of traffic has led to continuous development and refinement of speed-flow curves. The problem gets more tedious in case of urban roads with heterogeneous traffic, oversaturated flow and signalized network (which includes some un-signalized intersections as well). This paper presents speed-flow analysis for urban roads with interrupted flow comprising of heterogeneous traffic. Model has been developed for heterogeneous traffic under constraints of roadway geometry, vehicle characteristics, driving behavior and traffic controls. The model developed in this paper shall predict speed, delay, average queue and maximum queue estimates for urban roads and quantify congestion for oversaturated condition. The investigation details oversaturated portion of flow in particular.

Traffic streams are described by three variables: density (k), speed (v), and flow (q), measured respectively in vehicles per lane per km, km per hour, and vehicles per lane perhour. At the macroscopic level, these variables are defined under stationary conditions at each point in space and time, and are related by the identity $q = k \times v$. Driver behaviorcreates a second functional relationshipbetween the three variables. Though studied for several decades; understanding about the shape of this curve continues to evolve. The precise shape on a given road segment depends on various factors. These include the number and width of traffic lanes, grade, road curvature, speed limit, location vis-à-vis entrance and exit ramps, weather, mix of vehicle types, proportion of drivers who are the local driving population (Lindsey et al., 1999; Akçelik, 2003; Dowling, 2004; Roux et al., 2002).



Source: Akçelik (2003)

Fig. 2.1 Speed, Travel Time and Delay as a Function of Flow Rate for Uninterrupted Traffic Streams

In Fig. 1 region A represents under-saturated conditions with arrival flows (qa) below capacity (qa ≤ Q) which is associated with uninterrupted travel speeds. Uninterrupted travel speed at a given flow rate (vu) is between vf and vn (vf ≥ vu ≥ vn) where vf is the free-flow speed and vn is the speed at capacity. With increasing flow rate in Region A, speeds are reduced below the free-flow speed due to traffic delays resulting from

interactions betweenvehicles. Region B represents the forced (congested) flow conditions with flow rates reduced below capacity (q < Q) which are associated with further reduced speeds (v <vn) as observed at a reference point along the road. In this region, flow rates (q) are reduced flow rates due to forced flow conditions, not demand flow rates (qa). Region C represents oversaturated conditions, i.e. arrival (demand)flow rates above capacity (qa> Q) which are associated with reduced travel speeds (v<vn) observed by travel through the total section, e.g. by an instrumented car. In this case, the flow represents the demand flow rate which can exceed the capacity value as measured at a point upstream of the queuing section (Akçelik, 2003).

The HCM classifies urban and suburban roads with signalized intersections spaced at less than 3 km as urban streets. The speed of vehicles on urban street is influenced mainly by street environment, vehicle interaction and traffic control. Flows may be classified as uninterrupted flows and interrupted flows. In uninterrupted flow, traffic flow condition results from interactions among vehicles in traffic stream between vehicles and the geometric and environmental characteristics of the roadway. These flows do not have external elements such as traffic signals which might interrupt the traffic flow. However, interrupted-flows have controlled and uncontrolled access points that can interrupt the traffic flow. These access points include traffic signals, stop signs, yield signs and other types of control that stop traffic periodically or slow it significantly, irrespective of amount of traffic (Transportation Research Board, 2001). So far, urban roads have not been the priority of researchers and investigations are more confined to freeways and highways. There is a need to further investigate the shape of speed-flow curves for the urban road scenario which comprises of heterogeneous traffic, interrupted flows and have demand more than volume (oversaturated condition) most of the times. An investigation of oversaturated flow is very much relevant for developing countries. This paper presents speed-flow curves, delay estimates, maximum queue and average queue estimates for a representative urban road network. The curve of congestion isalso developed. Thus, speed, delay, maximum queue, average queue, congestion and capacity of urban roads can be calculated for these curves.

2.3.2 Simulation of heterogeneous traffic to derive capacity and service volume standards for urban roads. (Dr. V. Thamizharasan, reebuzachariahkoshy) (reference-10)

Highway capacity is the maximum number of vehicles that can reasonably be expected to pass a section of road in unit time under prevailing roadway, traffic and control conditions; whereas, service-volume is the maximum number of vehicles that can be accommodated at a specified Level of Service (LOS). The performance of urban road networks depends on the practical capacity and actual volume of traffic on each of the links that constitute the network. The heterogeneous traffic existing on urban roads of developing countries like India is characterized by the presence of vehicles of wide ranging static and dynamic characteristics.The unrestricted movement of these vehicles on road space makes the lane concept and expression of flow values, based on standard lane width, invalid. Also, when different types of vehicles share the same road space without any physical segregation, the extent of vehicular interactions varies widely with variation in traffic mix. To arrive at an estimate of practical capacity of road links, it is necessary to study the influence of roadway, traffic and other relevant features on vehicular movement using appropriate techniques. Modeling of traffic flow is the widely accepted technique for studying the flow characteristics over a wide range of the involved variables. Hence, there is a need for development of models to replicate heterogeneous traffic flow; and such models would be of significant assistance to traffic planners while making key decisions. The design service volumes recommended for urban roads are for a LOSof C (about 0.7 times the maximum capacity). Capacity and servicevolumes beingexpressed in Passenger Car Units (PCU), the PCU values for the different types of vehicles are needed for quantifying traffic flow corresponding to LOS C.

Simulation, from microscopic through macroscopic, is increasingly becoming a popular traffic-flow modeling tool for analyzing traffic operations and highway capacity. This paper deals with the development and application of a heterogeneous traffic-flow simulation model to develop capacity and service-volume standards for urban roads. The simulation model was first validated and used to estimate PCU values of different categories of vehicles, applicable to traffic flow at LOS C. These PCU values have then been used to convert heterogeneous traffic streams of varying compositions to equivalent homogeneous (passenger-cars-only) streams. The results were found to be consistent;

establishing the credibility of the PCU values derived using the model. Service volumes for 7.5 m and 11.0 m wide urban roadways were also arrived at, as an illustration of the application of the model. Development of a general purpose traffic simulation model to replicate the lane-less nature of heterogeneous traffic flow for comprehensive study of the traffic flow characteristics, and application of the model to derive relatively accurate PCU values to develop capacity standards are the uniquefeatures of the research study presented here.

With the increasing urbanization, improved transportation technology and an expanding economy, additional roads and highways are built, in an effort to balance roadway capacity and demand. At the same time, traffic volumes and travel distances continue to increase, and the new roadway facilities get filled up shortly after completion. Traffic congestion and safety are serious problems, impacting on the economy, environment and quality of life in our cities. In designing highways, traffic engineers must anticipate the amount and type of traffic that will use the road, in order to make the highway match its anticipated use. The capacity of a highway is defined as the number of vehicles that can reasonably be expected to pass a point or section of the highway during a given period of time under prevailing roadway, traffic, and control conditions. Highway capacity is usually expressed in terms of number of vehicles per hour. Knowledge of capacity of a road is essential in planning, design and operation of roads. Capacity refers to the rate of flow during a specified period; and any change in the prevailing conditions results in a change in the capacity of the facility. Also, capacity is assumed to be stochastic in nature because of differences in individual driver behavior and changing roadway and weather conditions (Minderhoud, *et al.* 1997).

The concept of level of service (LOS) describes operating conditions within a traffic stream, and their perception by motorists and passengers. A level-of-service definition generally describes these conditions in terms of such factors as speed, travel time, freedom to man oeuvre, traffic interruptions, comfort and convenience, and safety. The *HighwayCapacity Manual* special report 209 of Transportation Research Board (TRB), USA defines six levels of service. They are given letter designations from A to F with a representing the best operating conditions and F representing the worst. Very often, the flow reflects the quality of traffic movement on a road. When traffic volumes approach

the capacity of a road, traffic becomes congested and the flow of traffic is considered undesirable. LOS is thus one mechanism used to measure the quality of traffic flow.

Another mechanism used to measure the quality of traffic flow is the volume-to-capacity (V/C) ratio. It is a measurement of traffic service or flow quality that compares the number of vehicles using or expected to use a given road or segment of a road during a single hour with the number of vehicles that the facility is designed to handle safely in a single hour. Use of V/C ratio for analysis allows the evaluation of potential demand compared to the capacity of the facility in question. Volume can never exceed the capacity of the facility, yet demand can. If the demandfor a facility is greater than the capacity, a break down situation occurs.

Highway capacity values and speed-flow relationships used for planning, design and operation of highways, in most of the developed countries, have been based on Manuals and Codes of practices, which are valid for fairly homogeneous traffic comprising vehicles of more or less uniform static and dynamic characteristics. Even under nearly homogeneous traffic conditions, it is necessary to convert heavy vehicles such as buses and trucks, which constitute a small proportion of traffic, into equivalent number of a standard type of vehicle (usually passenger cars) to measure the traffic flow using a single unit. The road traffic in most developing countries such as India comprises vehicles of wide ranging physical dimensions, weight and dynamic characteristics. Also, the motorized and non-motorized vehicles share the same road space without any segregation. The speeds of these vehicles vary from about 5 to over 100 km/h. Due to the highly varying physical dimensions and speeds, it becomes difficult to make the vehicles to follow traffic lanes. Consequently, they tend to choose any advantageous position on the road based on space availability. Also, the extent of vehicular interactions varies widely with variation in traffic mix. Vehicles, which are ‘less mobile’ in terms of maneuverability, cause significant level of friction to the movement of other vehicles in the traffic stream. The extent of frictionrealized by the different categories of vehicles depends on their static and dynamic characteristics. For example, at higher traffic volumes a large proportion of motorized two-wheelers and bicycles may be able to move with speeds closer to their free speeds because of their ability for utilizing smaller gaps in the stream for movement, while the large-size vehicles such as buses and trucks may be subjected to considerable speed reduction. Traffic engineers account for the impact on

capacity from the different types of vehicles by assigning each class of vehicle a passenger car equivalent (PCE or PCU) value. This value represents the number of passenger cars that would consume the same percentage of the highway's capacity as the vehicles under consideration under prevailing roadway and traffic conditions. This study deals with development of a simulation model to replicate heterogeneous traffic flow on urban roads of developing countries such as India and the application of the model to derive PCU values for the different types of vehicles in heterogeneous traffic streams, and hence arrive at capacity standards.

2.3.3 Study of the effect of traffic volume and road width on PCU value of vehicles using microscopic simulation. (v. Thamizharasan, k. Krishnamurthy) (reference-8)

The knowledge of traffic volume is an important basic input required for planning, analysis and operation of roadwaysystems. Expressing traffic volume as number of vehicles passing a given section of road or traffic lane per unit time will be inappropriate when several types of vehicles with widely varying static and dynamic characteristics are comprised in the traffic. The problem of measuring volume of such heterogeneous traffic has been addressed by converting the different types of vehicles into equivalent passenger cars and expressing the volume in terms of Passenger Car Unit (PCU) per hour. The vehicles of highly heterogeneous traffic with widely varying physical and operational characteristics such as the oneprevailing on Indian roads, occupy based on the availability of space, any convenient lateral position on the road without any lane discipline. The interaction between moving vehicles under such heterogeneous traffic condition is highly complex. The results of the study, provides an insight into the complexity of the vehicular interaction in heterogeneous traffic.The PCU estimates, made through microscopic simulation, for the different types of vehicles of heterogeneous traffic, for a wide range of traffic volume and roadway conditions indicate that the PCU value of a vehicle significantly changes with change in traffic volume and width of roadway.

The information on traffic volume is an important input required for planning, analysis, design and operation of roadway systems. Highway capacity values and speed-flowrelationships used for planning, design and operation of highways, in most of the developed countries, pertain to fairly homogeneous traffic conditions comprising vehicles of more or less uniform static and dynamic characteristics. But the traffic scenario in

developing countries like India differs significantly from the conditions of developed countries in many respects. In Indian road traffic, the heterogeneity is of high degree with vehicles of widely varying static and dynamic characteristics. Under this condition, it becomes difficult to make the vehicles to follow traffic lanes. Consequently, the vehicles tend to choose any advantageous lateral position on the road based on space availability. Under the said traffic conditions expressing traffic volume as number of vehicles passing a given section of road per unit time will be inappropriate and some other suitable base needs to be adopted for the purpose. The problem of measuring volume of such heterogeneous traffic has been addressed by converting the different types of vehicles into equivalent passenger cars and expressing the volume in terms of Passenger Car Unit (PCU) per hour. The PCU is the universallyadopted unit of measurement of traffic volume, derived by taking the passenger car as the 'standard vehicle'. The interaction between moving vehicles in a traffic stream is highly complex and is influenced by a number of roadway and traffic factors. The accurate estimation of the magnitude of vehicular interaction for different roadway and traffic conditions is the prerequisite for better operation and management of roadway facilities in their prevailing conditions.

Since the traffic flow phenomenon is influenced by several stochastic variables of random nature, micro-simulation technique has been found to be a versatile tool to model complex traffic systems for study of their characteristics over a wide range of operating conditions. The present study is aimed at studying the vehicular interactions in heterogeneous traffic under different roadway and traffic conditions and hence checks for the accuracy of the available PCU estimates for the different categories of vehicles on Indian roads for a range of traffic volume and roadway conditions.

2.3.4 Reliability of freeway traffic flow: a stochastic concept of capacity. (wernerbrilon, justingeistefeldt, matthiasregler) (reference-7)

The paper introduces a new understanding of freeway capacity. Here capacity is understood as the traffic volume below which traffic still flows and above which the flow breaks down into stop-and-go or even standing traffic. It is easy to understand that a capacity in this sense is by no means a constant value. Empirical analysis of traffic flow patterns, counted at 5- minute intervals over several months and at many sites, clearly shows that this type of capacity is Weibull-distributed with a nearly constant shape parameter, which represents the variance. This was identified using the so-called Product

Limit Method, which is based on the statistics of lifetime data analysis. It is demonstrated that this method is applicable to all types of freeways.

The stochastic methodology allows for a derivation of a theoretical transformation between capacities identified for different interval durations. The technique can also be used to identify effects of different external conditions like speed limits or weather on the capacity of a freeway.

The statistical distribution of capacity directly indicates the reliability of the freeway section under investigation. This distribution for one section is then transformed into statistical measures of reliability for larger parts of a network composed of sections of different capacity. Thus, the stochastic concept is also expanded into reliabilities of freeway networks. It is found that a freeway operates at the highest expected efficiency if it is only loaded to 90 % of the conventionally estimated (constant-value) capacity.

On the one hand, the paper quotes some real world results from German freeways. On the other hand, the reliability-based analysis leads to a new sophisticated concept for highway traffic engineering.

Conventional measures of effectiveness for freeway facilities usually reflect travel time in the form of e.g. travel velocity or delay. Recently it has been becoming more and more obvious that these parameters are not sufficient for freeway traffic performance assessment since they place great emphasis on smaller differences in travel time, whereas the more significant difference between flowing traffic and congestion is not adequately represented. In addition, traditional quality assessment fails whenever demand exceeds capacity because it will simply attest a failure in this case. However, temporary freeway overloads are quite common. This is why quality assessments for different degrees of freeway congestion are required as well (cf. Shaw, 2003).

The capacity of a freeway is traditionally treated as a constant value in traffic engineering guidelines around the world, such as the HCM (2000). Doubts about this nature of capacities as constant values were raised by Ponzlet (1996) who demonstrated that capacities vary according to external conditions like dry or wet road surfaces, daylight or darkness, and prevailing purpose of the freeway (long distance or metropolitan commuter traffic). Moreover, several authors affirmed that even under constant external conditions,

different capacities can be observed on freeways in reality (Elefteriadou et al., 1995; Minderhoud et al., 1997; Persaud et al., 1998; Kuehne and Anstett, 1999; Lorenz and Elefteriadou, 2000; Okamura et al., 2000). Most of these authors only observed traffic breakdowns at different flow rates to demonstrate the variability of flows preceding abreakdown. For a more systematic analysis, however, a comprehensive theoretical concept is required.

2.3.5 Derivation of Capacity Estimates for Urban Expressway Using Computer Simulation. (Ravikiran Puvvala, Balaji Ponnuand Shriniwas S Arkatkar) (Reference-6)

Expressways in India are vastly different from other roads of the country as vehicles such as bicycles, two-wheelers, three-wheeler sand bullock carts are not allowed in these roads and additionally, there is no strict lane discipline. Nevertheless, there is not much research literature specific to these categories of roads. Hence, this work aims to model traffic flow on Indian Expressways and estimate its capacity using the micro-simulation model, VISSIM.

An urban expressway is defined as an arterial highway for motorized traffic, with divided carriageways for high speed travel, with full control of access and usually provided with grade separators at location of intersections. They are the highest class of roads in the Indian Road Network. Higher design speeds, restriction on slow moving vehicles, varied trafficcomposition with high amount of cars characterize these roads. With such operational difference and with many urban expressways such as Delhi-Gurgaon,Eastern and Western Express Highways in Mumbaibeing in existence and more number of them such as the Yamuna and Kundli-Manesar-Palwal Expressways being built, a thorough understanding of their operation assumes high importance. The traffic flow characteristics on expressways can be understood very well by developing relationships among fundamental parameters and also by determining the capacity and Level-of-Service (LOS) by modeling the system using appropriate analytical techniques, which will enable the study of the characteristics over a wide range of the influencing factors. Additionally, there is a very less literature available on capacity of expressways which has also found a mention in the 11th Five Year plan(2007-2012) report. Considering all the above, it is imperative and timely to initiate a study on the capacity and LOS criteria of expressways depending upon the carriageway/roadway widths and other relevant parameters. Thus this

study is aimed at developing capacity estimates for urban expressway segments under varying roadway and traffic conditions, which will help in meeting the country's need for design, analysis, operations and management of expressways.To this end, the traffic flow on the Delhi-Gurgaon Expressway has been studied and modeled through both empirical and simulation approaches.

2.4 Level of Service Concept in HCM

When a road is carrying traffic equal in volume to its capacity under ideal roadway and traffic conditions, operating condition become poor,speed drops down and the delay and frequency of stops mount up. The service which a roadway offers to the road user can vary under different volumes of traffic. The Highway Capacity Manual has introduced the concept of "Level of Service" to denote the level of facility one can derive from a road under different operating characteristics and traffic volumes. The concept of level of service is defined as a qualitative measure describing the operational conditions within a traffic stream, and their perception by motorists and/or passengers.

The Following are the factors which might be considered in evaluating the level of service:

1. Speed and travel time, including the operating speed and overall travel time consumed in travelling over a section of roadway.
2. Traffic interruptions or restrictions, with due consideration to the number of stops per mile, delay involved and the speed changes necessary to maintain pace in the traffic stream.
3. Freedom to maneuver to maintain the desired operating speeds.
4. Driving comfort and convenience reflect the roadway and traffic condition in –as-far as they affect driving comfort and convenience of the driver.
5. Economy, with due consideration operating cost of the vehicle.

Even though it is desirable to consider all the above factors in identifying a particular level of service, it is difficult to incorporate all these in absence of accurate data. The HCM, therefore, utilizes (i) travel speed and (ii) the ratio of the service volume to capacity, depending upon the particular problem. The latter is often referred to as "v/c ratio" in the manual. As regard the travel speed, Manual recommends the use of operating speed on that type of highway carrying generally uninterrupted flow, such as in rural

areas. For urban locations, the Manual recommends the use of average overall travel speed.

The operating condition of six level of service selected by the manual is given below, level a representing highest and level F representing lowest:

Level of service A. free flow, with low volume and high speeds. Traffic density is low, with speed controlled by driver's desired speed limits and physical roadway conditions. Little or no restriction in maneuverability due to presence of other vehicles and driver can maintain their desired speeds with little or no delay.

Level of service B.zone of stable flow, with operating speeds beginning to be restricted somewhat by traffic conditions.Drivers still have reasonable freedom to select their speed and lane of operation. Reductions in speed are not unreasonable. The lower limit of this level of service has been associated with service volumes used in the design of rural highways.

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

Level of service D. Approaches unstable flow, with tolerable operating speeds being maintained through considerably affected by changes in operating conditions. Fluctuations in volume and temporary restrictions to flow may cause substantial drops in operation speeds. Drivers have little freedom to maneuver:comfort and convenience are low, but conditions can be tolerated for short periods of time.

Level of service E. cannot be described by speed alone, but represents operations at even lower operating speeds than in level D, with volumes at or near the capacity of the highway. At capacity, speeds are typically but not always in the neighborhood of 50 K.P.H flow is unstable, and there may be stoppages of momentary duration.

Level of service F. forced flow operations at low speeds, where volumes are below capacity. Conditions result from queues of vehicles backing up from a restriction downstream. The section under study will be serving as a storage area during parts or all of the peak hour. Speeds are reduced substantially and stoppages may occur for short or long periods of time, because of downstream congestion. In the extreme, both speed and volume can drop to zero.

CHAPTER: 3 METHODOLOGY

3.1General

After studying the literature review in the previous chapter, the methodology adopted in present study and formulation of Work is described in this Chapter. Types of survey, methods used for survey are described in this chapter. The methodology is Show in the form of flow chart.

In this study speed-Flow Relationship is used to find out Congestion effect of parking and pedestrians. For getting the speed-Flow relationship, the space mean speed of the traffic stream is considered. After the collection of data, the volume is converted into PCU.

Capacity of SH-41 is quantified by developing speed-Flow relationship. Based on which alternatives for improvements can be suggested.

3.2Methodology

The methodology adopted for the study is presented as a flow chart in Fig.3.1.

The methodology involves the following tasks:

1. Review of study reports by Indian and foreign researchers.
2. Conduct of surveys.
3. Collection and analysis of data.
4. Develop speed-Flow relationship.
5. Comparison of Capacity of SH-41 with IRC.

To obtain speed-Flow relationship speed, density and volume data are collected at selected section. Classified volume count and spot speed surveys are used to collect volume and speed data respectively.

Flow (Q) is obtained by speed-flow-density relationship, $V_s = \frac{Q}{K}$ where, Vs speed of vehicle, Q flow and K density.

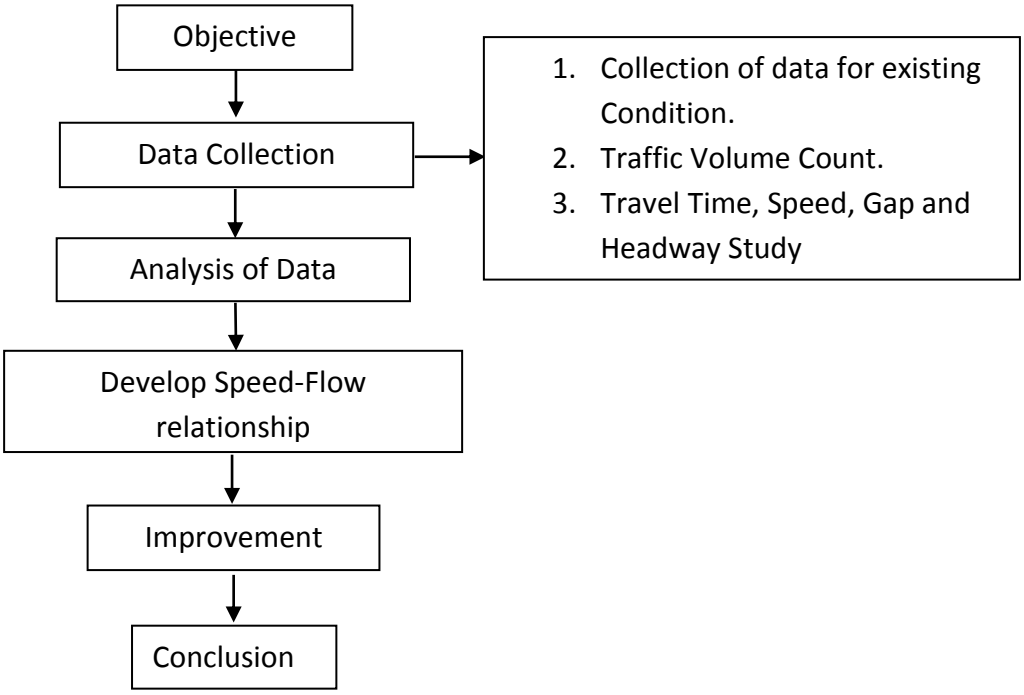


Fig 3.1 Flow Chart of Methodology

3.3 Various surveys

1) Traffic volume count
2) O-D survey
3) Speed survey

3.3.1 Traffic volume count

Traffic volume is a variable. It is of great significance to the traffic engineer. Traffic volume study is essentially a counting process involving quantity of movement per unite time at a specified location. The counting process generally includes composite group of different type vehicles (both slow and fast). The selected time periods in hours, days, weeks, months, or year depend upon purpose of the study and the required degree of accuracy.

A traffic volume study may cover entire highway system in the area, all roads intersecting a cordon line encircling a particular area (cordon volume counts), all road intersecting a screen line which divides city into two or more parts (screen line counts) or a specific location. The information required may include traffic volume and direction of flow, volume of turning traffic at intersections, hourly, daily, or seasonal variation of traffic or traffic counts classification wise based on type of traffic (car, bus, truck, trailers etc.) pedestrian volumes also become part of the study at certain locations.

Hourly traffic volumes and average daily volumes are those commonly used in planning, design, and operation of highway facilities. Traffic demand in vehicle per hour per lane is of great significance in dealing with practical traffic problems.

Methods of traffic volume counts are manual counting, mechanical methods (electric contact device, photo electric device, radar device, ultrasonic device, magnetic device, infra-red device, and pneumatic detector), photographic method, moving observer methods.

Traffic volume counting periods at specific locations depend upon the purpose and method used to obtain data. The periods should avoid special events conditions such as holidays, exhibitions, strikes etc. normally counts are made in good weather, on the working days, to cover 24 hours, 18 hours, 12 hours, 8 hours, or hourly volumes. Usually 12-hour count is most suited for all purpose (day traffic). Where volume is heavy day and night, 18 hours will serve the purpose.

Table 3.1 Traffic volume count

Hours of count	Normal period of study
12 hrs.	7 a.m. to 7 p.m.
18 hrs.	7 a.m. to 1 a.m.
8 hrs. (peak hour)	7-11 a.m. to 2-6 p.m.
4 hrs. (peak hour)	7-9 a.m. to 4-6 p.m.

3.3.2 Road side interview method

Road-side interview survey is one of the methods of carrying out a screen-line or cordon survey. The road side interview survey can be done either by directly interviewing drivers of the vehicles at selected survey points or by issuing prepaid post cards containing the questionnaire to all or a sample of the drivers.

The survey points are selected along the junction of the cordon-line or screen-line with the roads. The cordons may be in the form of circular rings, radial lines of rectangular grids. For small towns, say with a population less than 5000, single circular cordon at the periphery of the town should suffice. The internal travel being light, the external cordon survey in that case will give the origin-destination data. In this case of medium sized cities say with a population in the range 5,000 to 75,000 two cordon lines are necessary, the external cordon at the edge of the urban development and the internal cordon line at the limits of the central business district. Road side interview at the intersection of roads with these two cordon lines should be able to fairly assess the patterns of travel in such cities. For large cities, the cordon lines are screen lines may be more complicated, and the home interview technique cannot be dispensed with. Cordon line and screen line surveys by the road side interview technique serve to check the accuracy of the home interview survey data.

For dual carriage ways or roads with very little traffic the traffic in the both the directions is dealt with simultaneously. In other cases the traffic in two directions will be interviewed at different times. If the survey covers most of the day it may be sufficient to interview traffic in one direction are the same as in the direction interviewed.

It is impractical to stop and interview all the vehicles. Sampling is, therefore, necessary. The number of samples depends on the number of interviews and the traffic using the road. It may become necessary 0 vary the sampling rate at the traffic flow changes during the different parts of the day. Sampling methods should eliminate any element of bias. A convenient method is to sample one in a fixed number of vehicles. Viz. every tenth, fifteen or twentieth vehicle etc. another simple method is to select the next vehicle as soon as each interview is completed.

Since interviews may last for several minutes, vehicles must be stopped in an interview bay so that traffic flow is not obstructed. Suitable advance warning signs should be erected.

The period and duration of the survey are important matters that need careful prior thought. A 24 hours count will not normally be needed, and the survey is often restricted to 16 hours in a day. For the remainder of the day, vehicular counts are, however, made. In order to eliminate bias due to unusual conditions on any particular day, it is the practice to obtain data for each week day.

For complete and reliable data to be obtained by the survey, it is necessary to frame and design the questions with care. The enumerators must also be given adequate and instructions to avoid ambiguity in the answers and to ensure uniform pattern of data from different enumerators. Pre-printed forms are used to record the answers.

It will be seen from the sample form in table that coding of data will be an advantage.

The analysis of the data by computers will be easy. Since the interviews are done by sampling basis, expansion factors are needed to calculate the total number of trips. These expansion factors will be calculated separately for each class of vehicle and for different time periods. Thus if z_c represents the number of cars interviewed in a particular time period, and if Zc is the total number of cars counted during this time period, then the expansion factor is Zc/z_c.

Road side interview is an economic method of survey and yields accurate and reliable data. The disadvantage with the method is that vehicles are delayed when being interviewed.

3.3.3Spot Speed Studies

Speed of vehicle fluctuates from time along the road and its value as show on the speedometer at a particular spot is called the “spot speed”. The traffic police is interested in these speed-checks at problematic locations (spot), while a trip maker is more interested in the total journey time involved in the complete journey on the “journey speed”. It is on the part of the traffic engineer that desirable journey speed is maintained on the highway system. For maintaining good journey speeds, the delay or involuntary stop due to road congestion should be minimum and vehicle should be running smoothly. This involves the concept of running time and running speed of vehicle.

3.4 Study area map from Unjha to Mehsana SH-41

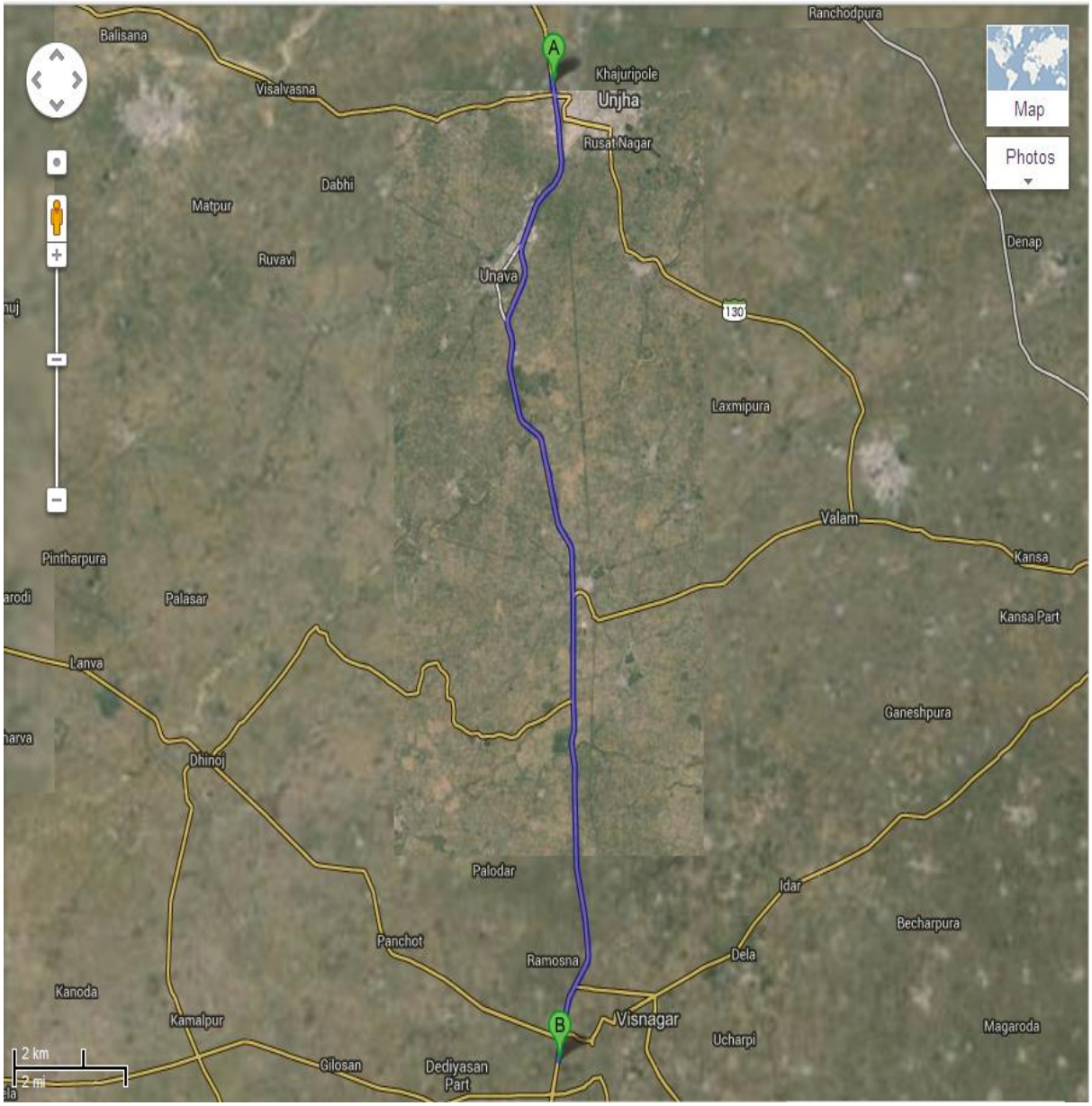


Fig. 3.2 Study area map

SH-41 is a main highway which connects Ahmedabad to Palanpur and between this two cities there is a two major city one is Mehsana and other is Unjha.Out of this mehsana is famous for GIDC and Fabrication work and unjha is most popular for spice market due to this reason traffic over this route, that's why we select our study area between mehsana to unjha.

CHAPTER: 4 RESULTS

4.1 Volume Count Survey Sheet (Unjha-Mehsana)

Volume Count Survey Sheet					
S. R. PATEL ENGINEERING COLLEGE, UNJHA.					
Location: Unjha-Mehsana			**Time interval: 1 hour**		
Survey: Volume Count			**Survey time: 9:00 A.M. to 7:00 P.M.**		
Time	**Type of Vehicle**				
	2W	**3W**	**4W**	**Bus**	**Trailor**
09:00 to 10:00	186	47	403	14	107
10:00 to 11:00	200	58	428	18	119
11:00 to 12:00	223	73	434	23	133
12:00 to 01:00	237	88	451	39	157
01:00 to 02:00	224	77	437	28	132
02:00 to 03:00	202	57	422	16	114
03:00 to 04:00	213	70	433	25	127
04:00 to 05:00	227	76	449	38	146
05:00 to 06:00	234	81	453	41	152
06:00 to 07:00	240	86	459	44	156
Total	2186	713	4369	286	1343

4.2 Volume Count Survey Sheet (Mehsana-Unjha)

Volume Count Survey Sheet					
S. R. PATEL ENGINEERING COLLEGE, UNJHA.					
Location: Mehsana-Unjha			**Time interval: 1 hour**		
Survey: Volume Count			**Survey time: 9:00 A.M. to 7:00 P.M.**		
Time	**Type of Vehicle**				
	2W	**3W**	**4W**	**Bus**	**Trailor**
09:00 to 10:00	161	41	320	19	138
10:00 to 11:00	176	48	364	23	150
11:00 to 12:00	192	63	388	26	162
12:00 to 01:00	189	59	369	21	147
01:00 to 02:00	171	47	351	18	136
02:00 to 03:00	152	39	327	15	122
03:00 to 04:00	159	41	340	19	137
04:00 to 05:00	171	52	357	22	144
05:00 to 06:00	184	59	363	26	147
06:00 to 07:00	190	67	373	30	152
Total	1745	516	3552	219	1435

4.3 PCU Value for vehicle

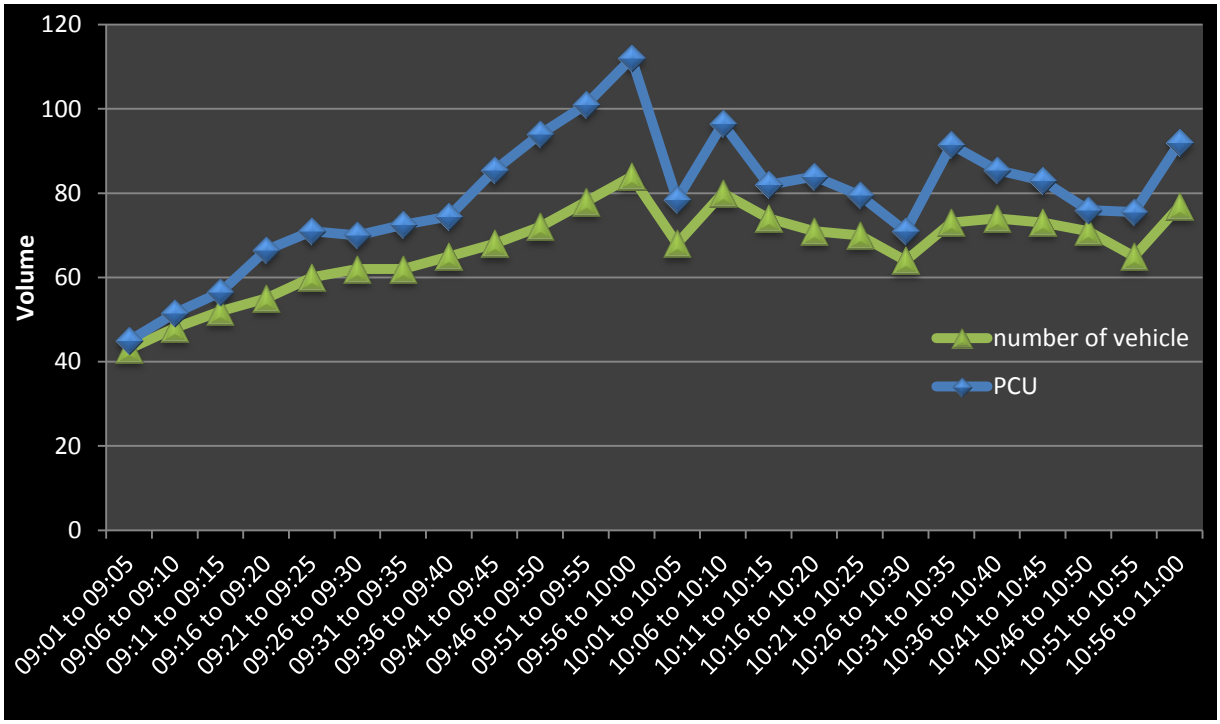
No.	2W	3W	4W	Bus	Trailor	Total pcu/hr
1	93	47	403	42	321	906
2	100	58	428	54	357	997
3	111.5	73	434	69	399	1086.5
4	118.5	88	451	117	471	1245.5
5	112	77	437	84	396	1106
6	101	57	422	48	342	970
7	106.5	70	433	75	381	1065.5
8	113.5	76	449	114	438	1190.5
9	117	81	453	123	456	1230
10	120	86	459	132	468	1265
Total	1093	713	4369	858	4029	11062

4.4 Volume and Traffic composition

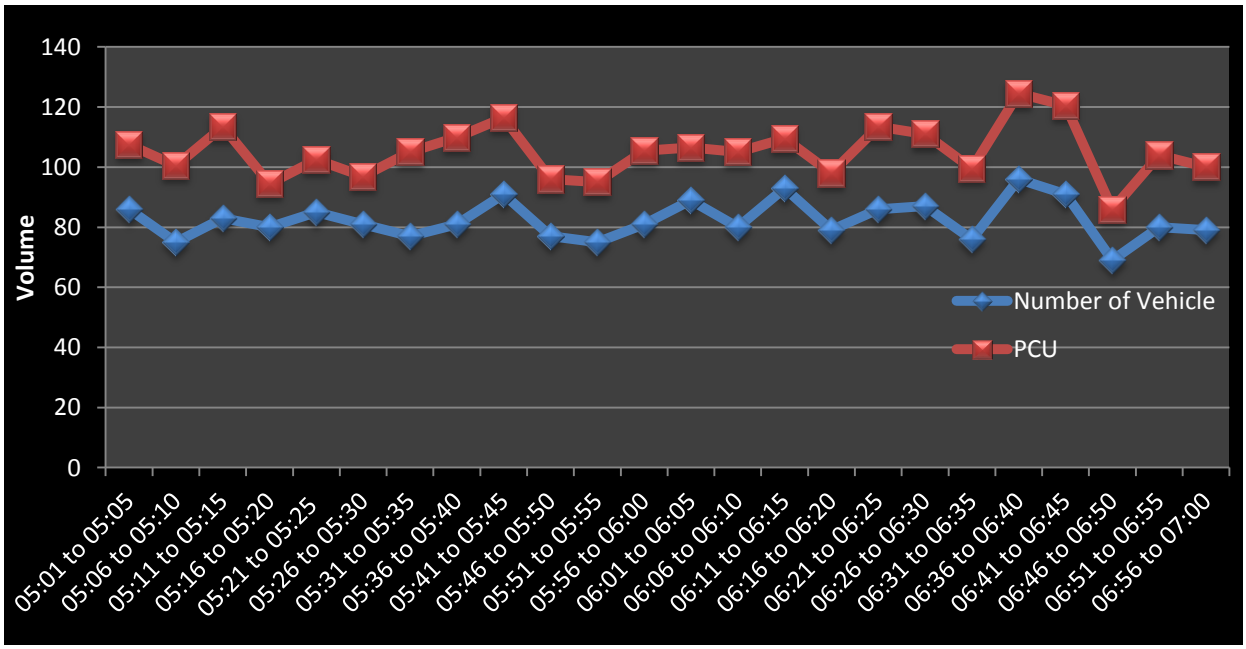
Name of Vehicle	Average Number of Vehicle (hour)	PCU for Vehicle	Total PCU	Average Speed(km/h)	Density(K) (Volume)	Traffic Composition
2 wheeler	219	0.5	109.5	53	2.066	24.55%
3 wheeler	72	1	72	42	1.714	8.07%
4 wheeler	437	1	437	97	4.876	48.99%
Bus	29	3	87	72	1.028	3.25%
Trailor	135	3	405	40	10.125	15.13%
Total	892	8.5	1110.5	304	19.809	100

4.5 Line Diagram

4.5.1 Line Chart (Diagram) of Time v/s Volume in peak hour



4.5.2 Line Chart (Diagram) of Time v/s Volume in peak hour



4.6 Chart of speed flow diagram

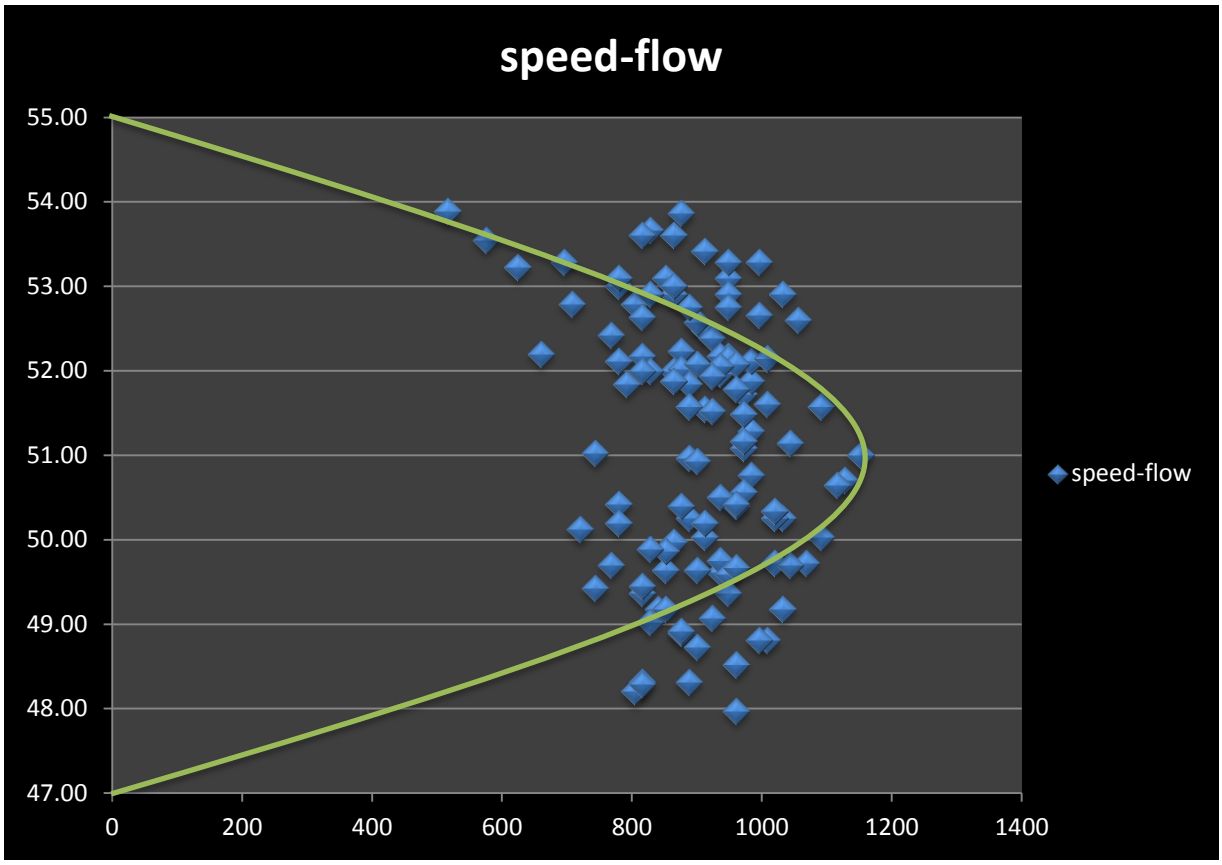


Fig. Chart of speed flow diagram

4.7 Traffic Composition

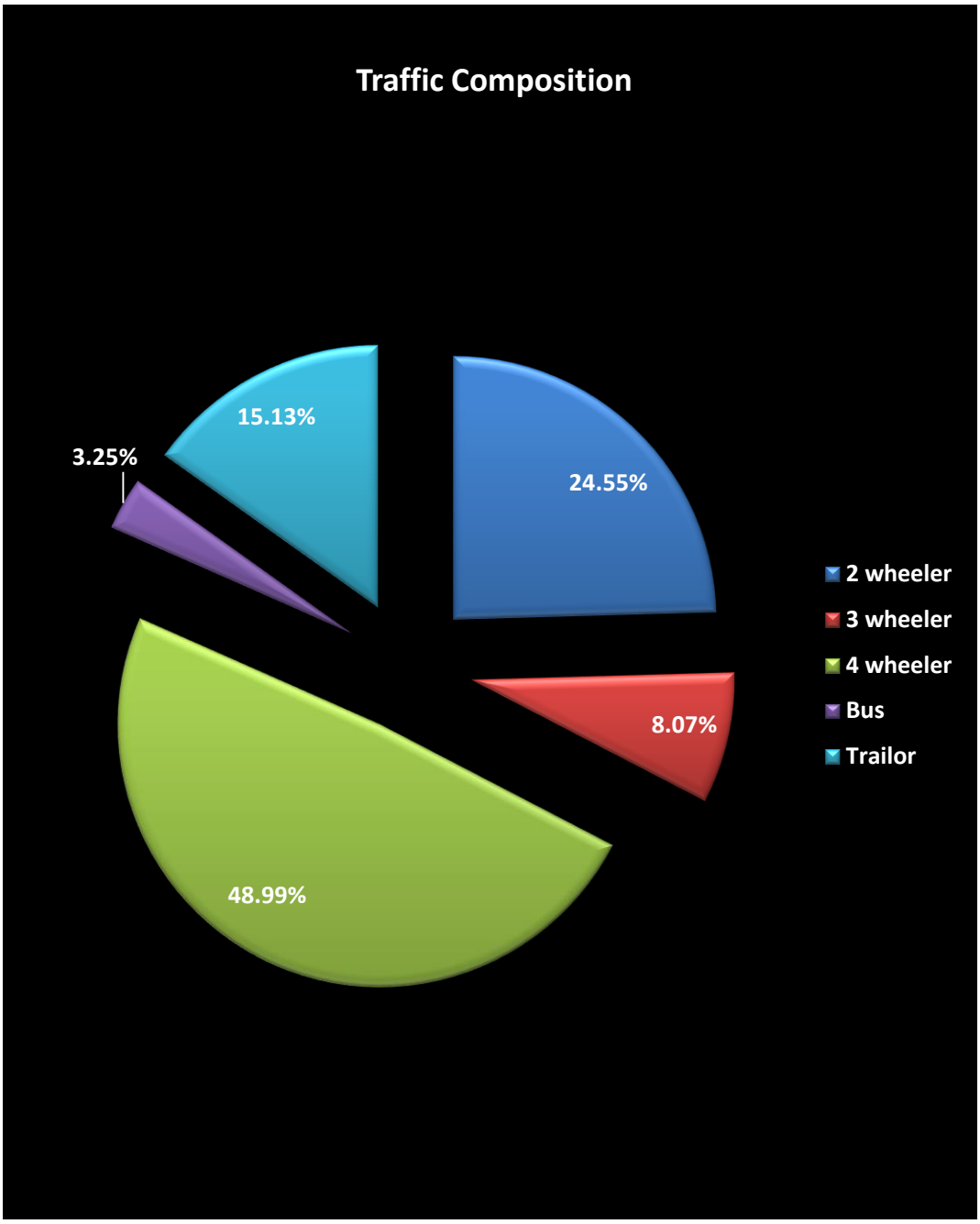


Fig.4.7 Traffic composition

CHAPTER: 5 CONCLUSION

Based on detail studies and analysis carried out on section of four lane two way divided road (Study area) of Unjha-Mehsana SH-41, following conclusions are drawn.

1) Speed-flow relations for with encroachment and without encroachments were developed, which clearly shows the influence of Encroachment on capacity and travel speed.
2) Capacity reduction as Compared to standard capacity was quantified and found to be 1170 PCU/hr, but In IRC it is 1400 PCU/hr.
3) The presence of state highway 41 makes the traffic system a complex one.This survey shows the PCU per hour is 1200.
4) During morning and evening peaks, the capacity of road exceed its limits and congestion occurs.

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- **Website**
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ANNEXURE-I

Volume Count Survey Sheet

Smt.S.R.Patel Engineering College,Dabhi-Unjha

Location: **Date:**

Survey: Volume Count **Survey time:**

Time interval:

Time	Type of Vehicle					
	Type 1	Type 2	Type 3	Type 4	Type 5	Type 6