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A Review of Speed Flow Density Study of Two Different Road Indian Road and Their Comparison

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***Abstract* – In this work speed -flow-density study of an Indian road has been conducted. Data has been collected using video camera and later decoded in computer. This data is very essential to estimate capacity of an Indian road. Since the collected data is of a narrow density domain, capacity prediction from this data is not promising. One of the data is collected in mhow pithampur and another data is from indore mhow .Both the data's were compared statistically. For both the data's Z-value is calculated and it is compared with Z-critical to define whether both the data's are same or different.**

***Keywords* – Speed Flow Density, vehicles, flow rate.**

I. INTRODUCTION

raffic Flow depends upon the driver's movement and the interactions done by the vehicles in between two points. We cannot predict the traffic flow only by the driver's movement which is more difficult to analyze. The basic parameters of traffic flow are speed, density and flow which are most essential to know before to understand the vehicle flow. With the above three parameters we can design, plan and operate the roadway facility [1].

1. Speed

In traffic engineering speed is defined as the distance travelled by a vehicle over a certain period of time. It's quite impossible to calculate the speed of every individual vehicle and due to this the average speed is taken in to account. Average speed can be calculated in two ways. They are time mean speed and space mean speed. Time mean speed is defined as the average of speed of vehicles crossing a particular section. Space mean speed is defined in the following manners. First of all the time taken by a vehicle to cross a particular section is calculated and later on it is averaged for all the vehicles which cross the section in a particular time. Now space mean speed is defined as the ratio of distance (length) of particular section and the average time of vehicles crossing that particular section. Units: S.I unit is m/sec and C.G.S unit is cm/sec.

2. Flow

It is defined as the ratio of number of vehicles crossing a particular section and the time taken by the vehicle to cross that particular section. Units: vehicles/time.

3. Density

After a particular time the number of vehicles which occupy the particular region is defined as density. The density is generally averaged over certain duration of time. Units: vehicles/distance.

II. LITERATURE REVIEW

J Roux [1] tested the relevance of overseas models to South African conditions, a number of models have been investigated with data obtained from South African freeways. Models obtained from three separate freeway sections were compared to overseas models as well as models obtained from local studies. P. Balaji [2] in his paper vehicle class-wise speed volume model for three-lane undivided urban road found that multi-class speed flow equations are more relevant to these types of facilities rather than single class flow speed models. D. Ashish [3] developed speed density relations for different vehicle type on urban arterial roads under mix traffic conditions in Chandigarh, Jaipur and Delhi using a set of simultaneous equations and established speed prediction models. R.S. Dhapudkar [4] reviews the status of heterogeneous mixes worldwide, and what factors need to be considered in such mixes. He developed a macroscopic stochastic model of traffic movements at signalized intersection, to study macroscopic traffic parameters (flow, speed and density) and to establish new models for the Indian highway. XU Cheng [5] developed fundamental diagrams of traffic flow. 10 typical speed-density relation models are summarized and analyzed by parameter calibrations and fitting errors using Beijing Expressway data. Saurav B. [6] study among vehicular density measured from moving observer method in field and density predicted from theoretical speed-density models. Moving observer data were collected from nine test vehicle runs in a weekday. Vehicle counts with and against test vehicle, vehicle passing and over taking the test vehicles, journey time and travel distance were recorded. Parameters of traffic stream such as volume, speed and density were calculated from the collected data. Then Greenshield's model, Greenberg's model and Underwood's model were fitted in the graphical representation of speeddensity relationship and corresponding parameters were determined using SPSS.

Hashim and Wahidah [8-15] based on the functional relationships between flow, density and speed for the three major highways in Malaysia. The translogarithm function of density-speed model was compared to the classical models of Greenshield's, Greenberg's, Underwood and Drake et al.

In the first approach for developing traffic stream models, Single regime two variable models, only two traffic variables, e.g. flow and speed or flow and density, are considered in the calibration process. In addition, only a single function is developed for the complete range of flow conditions including freeflow and congested-flow situations. From these models Greenshields' model [1], Song Rui and Xue Xingjian model [3], El Adawi's model [4] outside Egypt.

Example of this type of models in Egypt is presented by the Development Research and Technological Planning Center (DRTPC) at Cairo University [5]. In this research, data were collected for most intercity roads of Egypt. However, the introduced models were a single regime models for each road type with low value of coefficient of determination. Therefore, these models cannot be used in various traffic studies because it is not statistically justified.

Another example of single regime models in Egypt is the one developed by El-Adawi [3]. El-Adawi developed two models that describe the relationships between speed, density, and flow rate parameters of uninterrupted urban flow on elevated roads in Cairo based on field data collected from the 6th of October Elevated Road. Data on traffic characteristics such as flow rate, speed, density, and headway were collected using video camera on 60 m long section. However, these models are developed in urban area and need to be updated.

Traffic congestion is the percentage loss in freedom of movement under prevailing roadway, traffic and control conditions. It is defined as the travel time or delay in excess of that normally incurred under free flow travel conditions. With growing concern about congestion, efforts have been made to express the severity of the problem in a quantitative manner. Knowledge about traffic characteristics like flow, speed and density on the urban roads and establishment of speed-flow relationship is essential for that.

Lot of studies have been carried out for establishing speed-flow relationship, headway distribution and quantification of congestion. In this chapter a review ofthe published works is done and the proposed method for modelling of heterogeneous traffic congestion is explained.

Dawson et al (1968) suggested that time headway between vehicles is an important flow characteristic that affects the Level of Service and capacity of a transportation system. The capacity of the system is governed primarily by the minimum time headway distribution under capacity flow conditions. Although the headways are seemingly a simple aspect of traffic flow, they can be used collectively as an index of available stream capacity, or as an index of the level of stream congestion.

Patrick Athol (1956) analyzed time headway between vehicles and emphasised that headway measurements are necessary to understand the behaviour of traffic in terms of its component parts. Detailed studies of headways show a significant difference between traffic flow under congested and non-congested conditions at the same volume level.

May (1990) has reported that the shape of headway distributions varies as the traffic flow rate increases. Under low flow conditions there is very little interaction between the vehicles and the time headway is random. As the traffic flow increases there is increasing interaction between vehicles. As the traffic flow level approaches capacity, almost all vehicles are interacting and are in a car following process.

Dawson et al (1968) established that hyperlang model is found suitable for describing headways in single-lane flows on two-lane roads. Hyperlang is a linear combination of a translated exponential function and translated erlang function. The exponential component describes the free headways and the erlang component describes the constrained headways in the traffic stream.

Satish Chandra et al (2001) and Ravindra Kumar (1997) have established that exponential and lognormal models are not able to describe headway distribution under mixed traffic conditions. Hyperlang model is a versatile model for describing the headways in single-laned flows under mixed traffic condition.

Level of traffic service index was another empirical measure proposed by Greenshields (1965) and it was directly measured using a "drivometer" considering driver annoyance due to delay.

Lakshmana Rao et al (1995), Srinivasan et al (1991), Lindley (1987), Lomax (1988), Lindley (1989) and Parbat (1996) have used volume characteristics viz. v'c ratio and traffic volume per lane to quantify congestion. The v/c ratio is the mostly used congestion measure by transportation agencies in India also. Theoretically a v/c ratio value greater than one and the designated capacity norms raise many doubts regarding the use ofit.

Lomax (1997) reported K-factor as an indicator of congestion, where the Kfactor is the percentage of average annual daily traffic occurring in the peak hour. Kfactor was developed to measure the percentage of daily traffic during peak hour of travel. As congestion increases, the peak hour begins to spread into a peak period. Therefore, the percentage of daily traffic that occurs in the peak hour or K- Factor reduces. Decreasing K-Factor values are thus indicative of the rising off-peak traffic volumes and lengthening of the peak period. As traffic congestion levels rise, the Kfactor decreases. A system wide freeway K-factor less than 9.2 has been suggested to indicate undesirable levels of congestion. Both of these occurrences are associated with increasing congestion. Using of K-Factor as a measure of the severity of congestion is complicated because ofthe availability of data.

Rothrock (1957) suggested lane occupancy as a spot measurement of density and as a measure of congestion. Rothrock defined congestion index as the ratio of actual time-of-occupancy to the optimum time-of-occupancy. The percent occupancy is equal to the vehicles per mile times the average length of the vehicle divided by 5280. The method needs detector stations at regular intervals for measurements. In their definition, the optimum time-of-occupancy was based on local conditions like speed limits and time ofday.

Pignataro (1973) has suggested several speed measures besides average travel speed, which are given below. The average travel rate is the reciprocal of average travel speed. Peak period nominal speeds are a weighted average of speeds on free ways and principal arterial streets, which allow comparison of the free way and principal arterial street network between urban areas. The ratio of peak period speed to off peak period speed, and the average travel time per trip, are also suggested as direct measures of congestion. Variance of speed or ‘acceleration noise’ provides a measure of dispersion or change of speeds.

III. INFERENCE FROM THE EARLIER STUDIES

It can be seen that there is no unified and universally acceptable relationship between the traffic stream parameters due to the heterogeneity and varying composition of different classes of vehicles under mixed traffic flow. The speed-flow relationship established has been mostly for freeways where there is no restriction to flow of traffic. On an urban road, the composition of traffic changes rapidly over time. Due to wide variation in composition of traffic and in vehicle sizes and their differential speed criteria, the speed-flow data are normally reported to be scattered in the speed-flow domain. The traffic on urban roads is interrupted due to the presence of signals. So if observation is made at mid-blocks on urban roads, the traffic is found to move as a constrained group of vehicles and as vehicles at free speed. Even during peak hour flow certain percentages of vehicles travel at free speed. So aggregating the flow lor fixed time intervals such as 1 minute, 5 minutes or 15 minutes and building relationship on the data will be similar to building the relationship with partial data. The actual time taken by constrained or partially constrained group of vehicles is to be taken to establish speed-flow relationship in urban areas. The net green time, which allows the traffic to flow into the road stretches, varies from intersection to intersection. Therefore it becomes essential to identify the constrained group and free flowing vehicles to compute the flow rate and the corresponding stream speed to establish speed-flow relationship accounting the traffic composition.

IV. NEED FOR TRAFFIC DENSITY ESTIMATION

ITS face a range of challenges, including system interdependency, network effect, scale, funding, political, institutional and other challenges [4]. Some challenges are inherent to intelligent transportation systems across all countries; others specific challenges faced with regard to deploying intelligent transportation systems in the India. The Indian roads traffic scenario is quite different from that of the developed world.

The road conditions are more varied, the traffic is unstructured, and there is lack of lane discipline and numerous types of vehicles. This scenario is challenging for current techniques of traffic estimation that mostly work on freeways or assume structured traffic.

Traffic monitoring systems generally try to count, classify or estimate speed of vehicles moving on the road. Traffic scenario in India is mostly characterized by poor quality of roads, highly chaotic and disorderly traffic and heavy congestion. Several assumptions like a) presence of freeways b) uniformity of vehicle speed c) lane based motion of vehicles; made by conventional ITS techniques in developed regions, do not hold here. These factors render ITS techniques devised in context of traffic conditions in developed countries, inapplicable in Indian scenario.

V. VEHICLE-BASED TRAFFIC SURVEILLANCE

Vehicle-based Traffic Surveillance illustrates the characteristic of using some kind of devices installed in vehicles to locate its position using different methods of realizing and identifying. The three popular applications are Global Positioning System (GPS), Transponders, and wireless phones [7]. Global Positioning Systems as shown in figure 4.1 use earth-orbiting satellites to obtain the global map, and locate position of all vehicles with GPS box installed. The second approach using Transponders which are some kinds of vehicle tags that left inside the car and using synchronous data signal between the vehicles and the controllers on the transport infrastructure to recognize the occupation of the vehicle on the roads.

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Similarly cellular phones are also used to identify the traffic density (figure 4.1). All these methods are proven to produce high accuracy and fast data speed, but they all require vehicle owner to invest an initial capital to install one of those devices in their vehicles that creates a barrier for drivers with low budget, and the privacy threats for those who do install one of those devices in their vehicles, since all the information is frequently and automatically sent to the database server

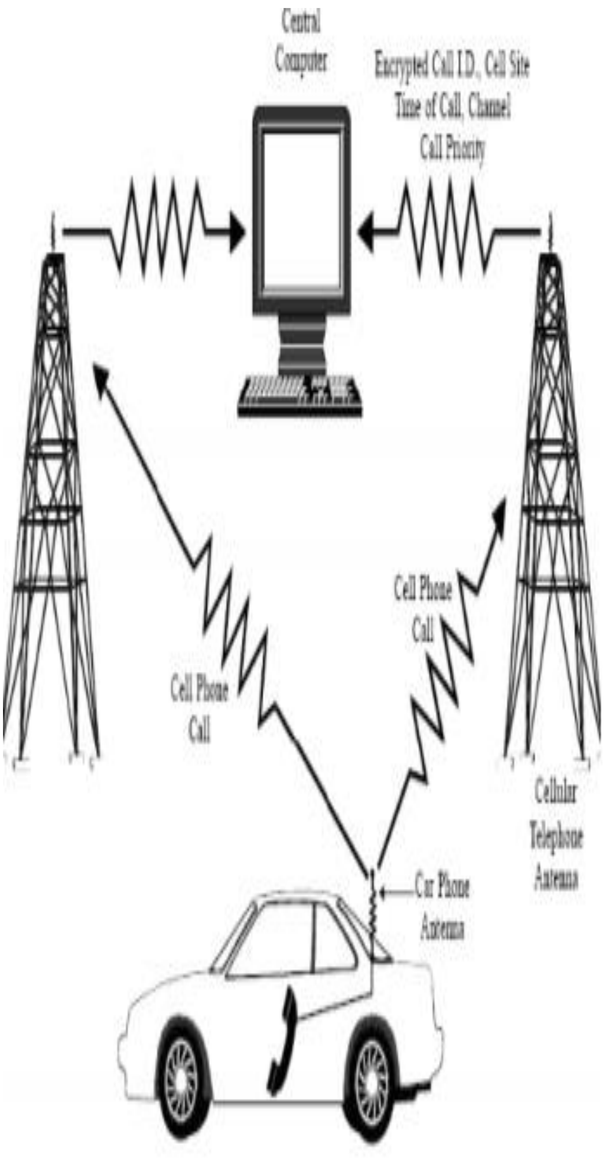

Fig. 1. Vehicle Tracking by Cellular Phones.

Interrupted flow is more complex than uninterrupted flow, because of the time dimension involved in allocating space to conflicting traffic streams. On an interrupted flow facility, flow is dominated by points of fixed operation, such as traffic signals and stop signs. These controls have different impacts on overall flow. The operational state of traffic at an interrupted traffic-flow facility is defined by the following measures:

- Volume and flow rate,
- Saturation flow and departure headways,
- Control variables (stop or signal control),
- Gaps available in the conflicting traffic streams, and

Delay. Volume—the total number of vehicles that pass over a given point or section of a lane or roadway, during a given time interval; volumes can be expressed in terms of annual, daily, hourly, or sub hourly periods.

Flow rate—the equivalent hourly rate at which vehicles pass over a given point or section of a lane or roadway, during a given time interval of less than Ihour, usually 15 min. Volume and flow are variables, that quantify demand, i.e. the number of vehicle occupants or drivers (usually expressed as the number of vehicles), who desire to use a given facility during a specific time period. Congestion can influence demand, and observed volumes sometimes reflect capacity constraints rather than true demand. The distinction between volume and flow rate is important. Consideration of peak flow rates is important in capacity analysis. The average vehicle spacing in a traffic stream is directly related to the density of the traffic stream, as determined by. Density (veh/km) = 1000/ [Spacing (m/veh)] An important additional point is the screen line at which the traffic volume or flow rate is surveyed. Traditional intersection traffic counts, yield only the number of vehicles that have departed the intersection. The maximum flow is therefore limited to the capacity of the facility. When demand exceeds capacity and a queue is growing, it is advisable to survey traffic upstream, before the congestion.

VI. CONCLUSION

The collected data is from a limited domain of density, so unable to predict capacity properly. Both the density and flow data follow normal distribution, i.e., as per the natural phenomena of density and flow. If the data is up to the mark then there is a possibility of predicting the relation in between traffic parameters as shown in fundamental diagrams. Both the data's are compared to one another and it was found that they are different to each other.

- **Summary and Conclusions**

This article summarizes the studies on various mixed traffic characteristics in developing economies. However, the studies addressing the problems of any particular country but not relevant in others are not included. It can be seen that the ideas and concepts of homogeneous traffic studies have been used in the studies of many mixed traffic studies. Only a brief overview of the former's studies is given here, with directions to the relevant publications for the interested readers.
The objective of this article is three-fold: to provide a comprehensive review of the studies on mixed traffic in

developing economies, to identify the limitations and gaps in the current understanding of the traffic characteristics and to provide a background and guidelines for the researchers in planning their future studies. All the reviewed studies have been organized in six sections, namely vehicle characteristics, passenger car equivalents, lateral characteristics, capacity and level of service, saturation flow and delay studies at the signalized intersections and modeling. Except the final section on 'modeling', each of the sections presents a review of the previous studies on that topic, under a few subsections, as needed. It is generally observed that the concepts of homogeneous traffic have formed the basis for many of these studies. The shortcomings of those concepts in mixed traffic conditions have been emphasized, along with other gaps in the knowledge of those traffic characteristics and thus, identifying the possibilities of the future research. Finally, a general outline of a micro-simulation model for mixed traffic is described, along with a review of the previous models. A comparison of various micro-simulation models is presented and a lack of attention given to the lateral vehicle maneuvers is identified in the review. Also, a brief review of the macroscopic modeling, which is still in its nascent stages for mixed traffic, is provided.

Despite the initial adoption of the ideas from homogeneous traffic studies, the modifications in the later studies have given satisfactory results in some of the reviewed areas. However, this evolution has been inadequate in the other areas, resulting in the gaps/limitations in their understanding. With the understanding of these limitations, the authors identified the following as high-priority areas for the future research.

Firstly, a lack of empirical knowledge, particularly of the vehicle specific characteristics like lateral clearance and acceleration, has been observed, at various points in this review. An understanding of these characteristics is essential in the formulation of a simulation model that can reproduce the realistic vehicle maneuvers. Further research in this direction is needed to provide the necessary foundation for the modeling studies.

Secondly, future research on micro-simulation models, particularly those based on car-following models, must focus on developing more realistic models/logics for the lateral movement. The lack of empirical research pointed out above is partly responsible for the inadequacy of the current models. However, the shift from car-following to gap-filling behavior can be brought into the simulation model only with further improvements in these logics.

And finally, given its history and development in developed economies, it is surprising that the studies on macroscopic modeling have been virtually non-existent, until recently. No significant advancements have been made in this topic, other than the replacement of density with area occupancy, pointing out the need for research at a fundamental level.

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