SPEED, FLOW AND HEADWAY MODELING OF URBAN MIXED TRAFFIC CONDITION

MD. MOHTHASHIM MOINUDDIN[1], MIR IQBAL FAHEEM[2]&MOHD.MINHAJUDDIN AQUIL[3]

[1]PG Scholar, [2]Professor & Head & Vice Principal, [3]Asst. Prof., Dept of Civil Engineering

Deccan College of Engineering and Technology,

Aghapura, Hyderabad-500001 Telangana, India

Abstract

The problems associated with mixed traffic conditions on urban streets of developing countries are unique. Pedestrians, bicycles, buses, cars, motorcycles/scooters, auto rickshaws, cycle rickshaws and various other kinds of travel modes share the same street space creating inefficient mobility conditions that are robbing the economic potential of the cities in developing countries. Due to various reasons these problems are yet to be resolved. The inability to resolve these problems is making them more and more complex. Increasing motor vehicle ownership in the developing countries is further aggravating the situation. Hence knowledge of fundamental traffic flow characteristics and associated analytical techniques is an essential requirement in the planning, design and operation of transportation systems. The theory of traffic flow enables traffic engineers to describe the relationship between flow, density and speed for all conditions of traffic flow on roadways. Many researchers have proposed models to describe the relationships between traffic flow characteristics on roadways. The main Objective of this study is developing mathematical models of speed, flow and headway for mixed traffic conditions, finding suitable headway distribution for different type of flow conditions and estimating capacity from speed and flow relationship for various study sections are considered in this study.

Keywords: flow, headway, speed, mixed traffic conditions, SPSS software

1. INTRODUCTION

Urban Transport is one of the most important components of urban infrastructure. A good network of roads and an efficient Mass Urban Transport System make a substantial contribution to the "working efficiency" of a large city. A poor urban transport system may slow down economic growth of the city and also lead to its decay. It has been estimated that the poor Traffic and Transportation scenario in the urban areas of the country currently result in an annual loss of the order of Rs. 20,000 crores in vehicles operating and travel time costs alone. In view of the rapidly growing urban population pressure on urban transport system is bound to increase much more in the coming years. Urgent measures are therefore needed to tackle this problem.

2. LITERATURE REVIEW

Traffic stream in India and many other developing countries consists of both fast moving vehicles such as the car, bus, auto rickshaw, motorized two wheeler and slow moving vehicles such as the pedal cycle, animal drawn vehicle, rickshaw and man driven tricycle. The large variation in speeds of fast moving (motorized) and slow moving (nonmotorized) vehicles cause the speed distribution curve to deviate from generally accepted unimodal normal distribution to a bimodal or a multimodal distribution.The traffic in mixed flow can be classified as fast-moving and slow-moving vehicles or motorized and non motorized vehicles. The differences that characterize mixed traffic systems otherwise known as heterogeneous traffic systems are mainly due to the wide variation in the operating and performance characteristics of vehicles. The vehicles also vary in size, manoeuvrability, control, static and dynamic characteristics. In urban areas substantial pedestrian movement, encroachment at intersections, street parking, business demand of abutting properties and narrow roads also accompanies mixed traffic flow. Many researchers have proposed models to describe the relationships between traffic flow characteristics on roadways. Speed - flow relationships can be studied by using various equations such as Bureau of Public Roads curve, Akcelik equation and updated Bureau of Public Roads curve improve the accuracy of speed estimates used in transportation demand models. While developing speed - flow relationship it is observed that cubic equations performed reasonably well when compared to linear functions.Mostly the frequency distribution of speed data is normally distributed.

Parameters were evaluated for unimodal and bimodal speed distribution curves by using different mathematical equations. A new parameter spread ratio is introduced to predict the bimodality in the speed data. The correct description of speed distribution will be extremely useful in congestion studies and traffic simulation on a section of highway having a mixed nature of traffic.

3.   SPEED - FLOW MODELING

M G Raichur (1996) studied speed – flow characteristics on NH – 8 between Baroda – Surat section. In this study the actual journey speeds of different types of vehicles at which they travel at particular condition of traffic volume were observed by adopting the Moving car observer method. By analyzing the data the stream speed and stream flow were calculated. The main conclusion that was drawn from this study is may be because of development of minor and major industries in the surrounding areas on both the sides of the National Highway the stream speed is reducing with increasing stream flow. Dowling (2004) recommended updated Bureau of Public Road speed-flow curves for freeways and signalized arterials to improve the accuracy of speed estimates used in transportation demand models: $T = Tf * [1 + a (v/c) b]$, Where, T - Predicted travel time over length of roadway, Tf - travel time at free-flow speed (defined as 115 percent of speed at capacity), v - Volume or demand , c - Practical capacity (defined as 80 percent of actual capacity) , a = 0.15 and b = 4.

Chu Cong MINH (2005) studied the comprehensive analysis of motorcycle behaviour and operation through videotaping of some roads that have significant motorcycle proportion.Due to large variation in speed of different types of vehicles the weighted mean speed is employed as stream speed is calculated by using the given in Equation 1:

$$V_m = \frac{\sum_{i=1}^{k} n_i V_i}{\sum_{i=1}^{k} n_i}$$

......................Equation (1)

Where k : Total number of vehicle types present in stream, Vm : Mean stream speed (Km/h), Vi : Mean speed for type i vehicle (Km/h), ni : Number of vehicles of type i,

4. HEADWAY MODELING

The time gap between successive vehicle arrivals namely time headway on a highway is an important microscopic traffic flow characteristic that affects the safety, level of service, driver behaviour and road capacity. Traffic planners and design engineers need to have a thorough knowledge of time headways and their distributions which will enable better planning for and management of traffic. Under very low flow conditions there is very little interaction between vehicles and the time headways will be random. When the traffic flow is near capacity (heavy flow or car-following condition) the time headways would be almost constant. The intermediate-headway state will prevail when some vehicles in a traffic stream are free to move while others are constrained due to interaction between vehicles. The subjects of time headways and related mathematical distributions have been studied at least since 1930s and most of the studies pertain to homogeneous traffic conditions. Partha Pratim Dey 2008) determined the capacity of a two-lane road for homogeneous type of traffic stream consisting of any one of the remaining categories of vehicles. These values were 5600, 1850, 780, and 580 vehicles per hour (vph) for two-wheeler, three-wheeler, heavy vehicles and tractor respectively is shown in Equation 2.

$$\frac{100}{C_m} = \frac{P_C}{2,860} + \frac{P_{HV}}{780} + \frac{P_{Tractor}}{580} + \frac{P_{2\text{-}W}}{5,600} + \frac{P_{3\text{-}W}}{1,850}$$ ....Equation (2)

Where PC, PHV, PTractor, P2W, and P3W = proportions of car, heavy vehicle, tractor, two-wheeler and three-wheeler respectively and Cm=capacity under mixed traffic condition in VPH.

5. METHODOLOGY

Step 1: Study area selection:

The selection of the study locations to carry the traffic volume, traffic composition, vehicular speeds and the arrival times is based on : The road sections are sufficiently straight, The influence of the intersection on the study stretch should be minimum, The road should not have any gradient.The influence of bus stops on either side of the site is minimum.The road sections have fairly uniform carriageway width.Pavement condition should be smooth and should be good.No parking or pedestrian facility should be there.The traffic stream and the

locations should be as such, which represent the mixed traffic in a better way generally prevailing on Indian urban roads.By considering the above criteria, the following stretches were selected for conducting the survey.1. Near BVK theatre, 2. Near Sagar ring road, 3. Near Kamineni Hospital road, 4. Near Uppal cross road

Step 2: Data Collection:

The second step is data collection on identified sections. Data regarding Volume counts, space mean speeds, free flow speeds, time headways were collected at selected stretches. Traffic Volume counts were collected by using Manual method. In this study the data was collected regarding volume of different types of vehicles for 6 hrs of duration with 15 minutes time intervals at a the reference point of stretch. Spot speeds were measured by using Pro Laser Infrared Radar gun. This works on the principle of sending out invisible laser beam pulses *(per second)* and recording the time taken to receive the pulses back from the object in motion. Registration method is adapted to measure space mean speeds. This is a conventional procedure used for determining the speeds by recording the registration number, entry and exit times of vehicles on a trap length of 500m with the help of two synchronized stop clocks. Time Headways were collected by manual method. In this method the time at which the vehicles pass the reference point was noted.

Step 3: Data Analysis:

After counting of Individual traffic volume, converted in to Total Number of PCUs by adopting PCU values for different types of vehicles as per IRC: 106 – 1990. By noting the registration number and time of arrival and departure of the vehicles at the entry and exit points, the travel time over the selected trap length was determined and thereby the travel speeds. The volume of traffic was later expanded into 15 min Traffic in PCUs/15 min. Then the graphs were plotted between speed Vs flow to develop the relation between speed and flow thus to find out the capacity of the road. The observed spot speeds of vehicles have been classified into suitable intervals of 5Kmph to determine the frequency distribution of vehicles as per speed. The time mean speed and standard deviation values have been calculated from the frequency distributions. Spot speeds were analyzed to obtain maximum and minimum observed speeds as per direction for flow as well as mean speeds, 85th percentile speeds further, an attempt has been made to check the validity of the data by

fitting the normal distribution curves on the observations using the mean and standard deviations for the speeds of different vehicles. The Chi-squared test was conducted to test the goodness-of fit of the observed data. The collected headway data is will be analyzed and the flow levels will be fixed according to the distributions fitted. The speed-flow curve and distribution of spot speed are presented in Figures 1 to 3.
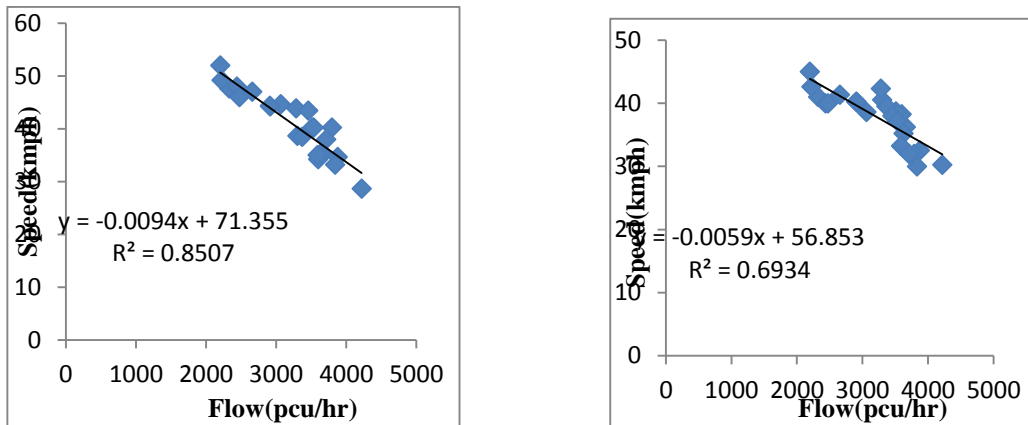

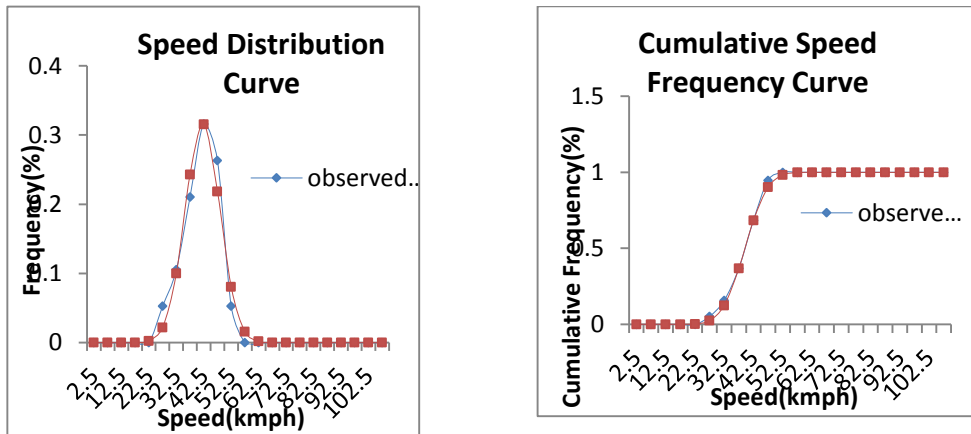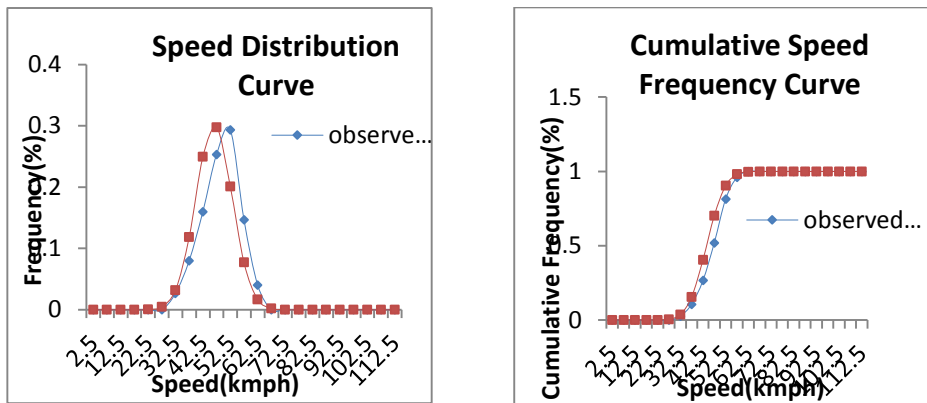**Figure 1 speed-flow curve for car and bus**

Figure 2 Distribution of spot speeds at BVK theatre: Bus

Figure 3 Distribution of spot speeds at BVK theatre: Car

CONCLUSIONS

The following conclusions were drawn from the present study Capacity of a two-lane road at Gemini Theatre is found to be 4007 PCUs/Hr, at University cross Road 1416 PCUs/Hr, arts and Science collage 2374 PCUs/Hr and at Nit Second gate it is 2451 PCus/Hr.The analysis has shown that the spot speed data for any particular vehicle follows a normal distribution with a specific mean and standard distribution.From the free speeds study at various stretches the standard deviation values for different type of vehicles are less which means that most of the vehicles are travelling almost around mean speed of that particular group of vehicles. The free speeds of vehicles on highways are lower than the expected for both individual type of vehicles and mixed traffic. Some of reasons are generally lower standards of driving discipline (lane Discipline) prompts the drivers to adopt safe speeds.From the analysis at Gemini Theatre it is observed that the capacity values are exceeding the standard values specified in IRC. It shows that existing capacity may not sufficient for accommodating exiting traffic. If proper measures are not taken then it will be problem to accommodate the future traffic.The equations developed for determining the influence of percentage of various vehicles lead to mixed results. The extensive study is needed to achieve accurate results. At various stretches the influence of percentage of different types of vehicles on average speeds of various vehicles are different. Analysis of headway data gave rise to normal distribution for the data collected at Gemini Theatre which is considered as

high flow condition and exponential distribution for data collected at remaining three study sections which can be considered as low flow condition.

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