Development of Speed – Density Relationship for the Urban Area - A Case Study of Ahmedabad City

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Abstract— An expanding vehicular growth in urban area is fact, so the facility to transportation should be adequate for road users. Development of relationship between speed-density-flow is the fundamental for knowing the traffic condition. All vehicles are of different size, shape, power, load carrying capacity and speed. A traffic flow characteristic is effected by vehicle composition, width of road and other physical and traffic factors. To estimate the capacity of road, same factors are influencing to traffic flow. An urban road stretches of Ahmedabad city is taken for developing speed-density relationship. Classified volume and Space mean speed are collected from the field data. Indian road way condition is having heterogeneity and leads to many problems for estimating traffic flow parameters.

Key words: Classified volume, Space mean speed, Urban road

I. INTRODUCTION

Due to rapid growth in cities of the country and movement of the people from rural area to urban area in search of employment, the traffic is increased on the urban roads. As per the United Nations projection, the urban area will be raised from the current urbanization of 32% to 52% in year 2050. The projected urbanization is 75% in 2070. The availability of the space in the urban area is decreasing and vehicular growth increases. The urban roads of India generally carry the heterogeneous traffic. All vehicles are of different speeds, size, load carrying capacities or passenger capacities etc. which affect the performance of the road facility.

The rise in the population of urban cities and increasing traffic on transport corridors, it is necessary to improve the existing urban arterial road capacity. Prediction of capacity is fundamental in planning, operation and layout of road network sections. IRC has suggested capacity of various roads of the urban area. The suggested capacity of urban road is not updated considering the latest technological development. Roadway factors that influence capacity of a two-lane road include lane width, gradient, lateral clearance, width and type of shoulder. Lane and shoulder width can have a significant impact on traffic flow.

II. OBJECTIVE

Followings are the objectives of the research

- To collect the traffic flow parameters from the study area
- To establish the relationship between flow parameters of an urban heterogeneous traffic and various roadway characteristics

III. LITERATURE REFERRED

Following literatures are referred for the research.

Chandra S. (2003) considered the effect of lane width on capacity under mixed traffic condition in India, speed of vehicle get reduced due to narrow lanes as we have the 3 to 4 meter general range of lane width. Arasan V.T. et al (2010) explained the methodology to determine of concentration of heterogeneous traffic on a bridge near saidpet, Chennai in India, by using the area occupancy method to determine the density and based on that they find the concentration. Ahmed munawar (2011) showed up with his experiment to find the speed and capacity of urban road by following the Indonesian highway capacity manual (1997) for Yogyakarta city. Side friction is also one of the capacity reduction factors but any manual is not considering it in terms of factor. It was good attempts to take account of that. Abdel-wahed talaat ali et al (2012) shared experience on capacity loss on horizontal alignment as a effect of highway geometric. As study showed that at curve due to reduction of speed or increase in longitudinal spacing flow is going to reduce. India as the developing county and as well as Indonesia which have similar kind of traffic heterogeneity. Patel Chirag et al (2013) determined the capacity and Level of Service for urban arterial road in Indian mixed traffic condition for access controlled six lane divided road. They carried out the traffic volume study for 16 hour and concluded that capacity for the six lane roads observed is 7450 vehicle and 2480 vehicles per lane

IV. DATA COLLECTION

The analysis for the estimation of capacity is carried out for the mid block section of Manav mandir to Gurukul road. The study area is one of the busiest roads in western part of Ahmedabad. Inventory data are collected from the study area. Traffic data are collected on the corridor through videography. The traffic volume survey is carried out for 6 (six) hours in morning peak hours, evening peak hours and off peak hours on working day.

V. DATA ANALYSIS AND DEVELOPMENT OF RELATIONSHIP BETWEEN TRAFFIC FLOW PARAMETERS

The traffic volume and space mean speed are found out from the extracting the videography. Traffic volume is measured from the 4 hour survey in the peak hours.

A. Traffic Volume

Traffic data are collected for the morning peak hours and evening peak hours only. Traffic composition is calculated and presented in the form of pie chart in fig 2.

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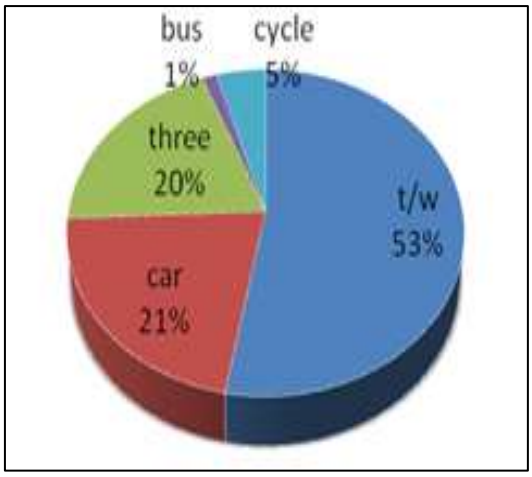

Fig. 1: Traffic composition at midblock of manavmandir to gurukul road

The two wheelers are 53% of total traffic in the study area. The proportion of cars is 21% of total traffic. Auto consists of 20% of total traffic in the study area.

Volume is found by extracting of Videography. The numbers of vehicles are multiplied by the passenger car units (PCUs). As pee the IRC 106-1990 suggested the following PCU factors for urban roads.

Sr. Num.	Vehicle Type	Equivalent PCU Factors	
		Percentage Composition Of Vehicle Type In Traffic Stream	
		5%	10% And Above
Fast Vehicles			
1	Two Wheeler Motor Cycle Or Scooter	0.5	0.75
2	Passenger Car, Pick-Up Van	1	1
3	Auto Rickshaw	1.2	2
4	Light Commercial Vehicle	1.4	2
5	Truck Or Bus	2.2	3.7
6	Agricultural Tractor Trailer	4	5
Slow Vehicles			
7	Cycle	0.4	0.5
8	Cycle Rickshaw	1.5	2

Table 1: Recommended PCU factors for various types of vehicles for urban roads in India

The maximum volume of the vehicles passing through stretch is considered as capacity of the road. The traffic volume is calculated considering the PCU factors given in IRC : 106-1990. The traffic volume is shown in the Appendix A.

B. Speed Interpretation

The spot speed is measured from the extraction of Videography. The spot speed, space mean speed are measured for every 5 minutes interval. The space mean speed is shown in the Appendix A.

C. Speed- density Relationship

Ideal speed flow relationship is parabola according to HCM (2010) which is having following segments.

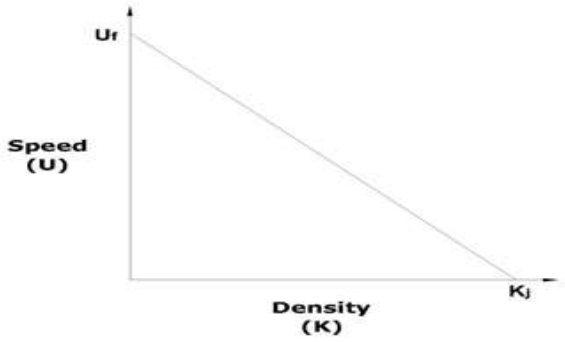

Fig. 2 (a): Graphical representation of ideal speed density relationship

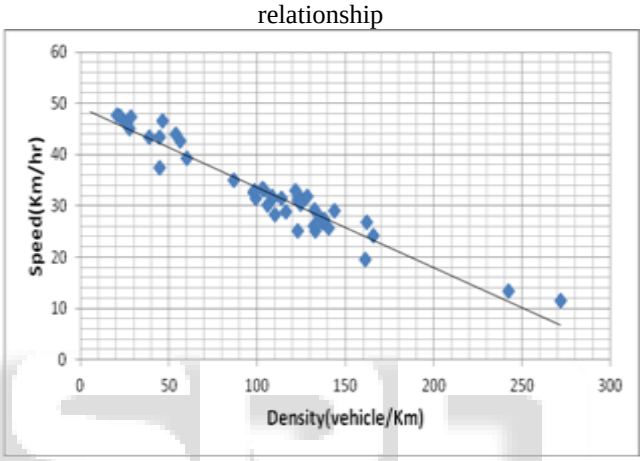

Fig. 2: (b) Speed flow relationship for Manavmandir-Gurukul road under prevailing conditions

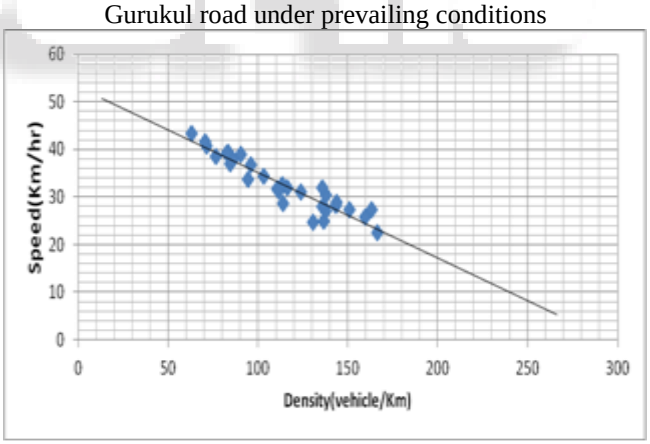

Fig. 2: (c) Graphical representation of Speed- Density relationship for Gurukul to Manavmandir

Speed-Density linear relationship is estimated and the relationship is developed using excel programme.

$y = -0.156x + 49.26$ $R^2 = 0.926$ for Manavmandir to Gurukul road. ---------- (1)

$y = -0.178x + 52.92$ $R^2 = 0.880$ for gurukul to manavmandir road. ---------- (2)

Where,

y= Speed in Km/hr

x= Density in vehicles/km

The R square value of model (1) is 0.926, which indicates good relationship between data of speed and density for the Gurukul to Manavmandir road. The R square

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value of model (2) is 0.880, which indicates good relationship between data of speed and density for the Manavmandir to Gurukul road.

VI. CONCLUSIONS

Traffic flow is heterogeneous in India. The lane discipline is not followed. In the present study, traffic flow parameter i.e. speed-density is developed. Followings are the major conclusions of the study

- The relationship is developed between the Speed-density for the present condition in the study area.
- The maximum density of the Manav-mandir to Gurukul road and either side of road are nearly 300 vehicle/ Km.
- The mathematical model is developed between speed and density for the study area.
- The R square value indicates the good relationship between observed speed and density.
- The developed model can be used for the traffic condition similar to Ahmedabad city.

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VII. APPENDIX A

PCU	**0.75**	**2**	**1**	**2.2**	**0.4**						
Time (min)	**T/W**	**Three wheeler**	**Car**	**Bus**	**Cycle**	**vehicle /5 min**	**vehicle/hour**	**PCU/5min**	**PCU/Hr**	**Speed**	**Density**
5	160	41	95	0	2	298	3576	297	3564	31.47	113.6
10	136	36	104	2	5	283	3396	282.4	3388.8	31.31	108.46
15	167	48	107	2	3	327	3924	332.65	3991.8	31.47	124.69
20	183	41	93	1	0	318	3816	314.45	3773.4	31.05	122.89
25	158	38	87	1	4	288	3456	283.7	3404.4	31.84	108.54
30	171	49	94	1	12	327	3924	322.45	3869.4	31.83	123.27
35	191	51	82	1	15	340	4080	329.45	3953.4	31.79	128.34
40	166	38	105	1	4	314	3768	307.7	3692.4	27.88	135.15
45	177	32	100	1	4	314	3768	298.95	3587.4	27.3	138.0
50	182	58	112	1	8	361	4332	366.7	4400.4	26.74	162.00
55	162	60	103	0	9	334	4008	344.5	4134	32.98	121.52
60	186	28	117	1	15	347	4164	314.7	3776.4	28.96	143.78
Total	2039	520	1199	12	81	3851	46212	3794.65	45535.8		

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