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ANALYSIS OF SPEED-DENSITY RELATIONSHIP WITH EFFECT OF ROAD SIDE FRICTIONS AT MODASA

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Abstract:** In light of urbanization, there is frequently a lot of action on and close by these streets, which influences the manner by which they work. This obstruction to the smooth stream of traffic is known as "side frictions". Traffic flow parameters on urban roadway are impacted by different components like sorts of vehicles out and about, width of street, structure of the street, development take a shot at streets, different land utilizes that pull in mechanized/person on foot traffic bound to medical clinics, business region, shoulder and roadway width, passages, territory and so forth. Anyway for urban streets, the effect of side frictions for example transport stops, infringements, on-road stopping, passages and ways out from real streets and so forth are additionally much noteworthy. Side friction occasions causing an effect on traffic execution out and about portion usually depicted as side friction. **In this study, Modasa city of Indian state of Gujarat is selected and traffic behavior on the arterials was studied. In this regard classified traffic volume count survey, spot-speed study was conducted on the selected arterial. Traffic flow parameters speed and density on the selected arterial is analyzed with and without road side friction conditions. Free flow speed and jam density on the arterial is determined with and without friction condition.

Keywords — Density, Free flow speed, Jam density, Side friction, Speed, Spot-speed study

I. INTRODUCTION

In India, Due to rapid urbanization, most of the towns of India are developing at very fast rate and emerging as a city area. The traffic in these developing towns is heterogeneous and has various static and dynamic characteristics. It needs to be converted into homogeneous traffic, so that the traffic flow parameters can be evaluated. One of the growing town of Indian state of Gujarat is Modasa. Traffic in this town is highly heterogeneous and cause traffic congestion. Main reason of traffic congestion is road side frictions. Due to this situation Capacity and level of service can be decrease which is dependent on traffic flow parameters like; speed, flow and density. For find out effect of road side frictions on capacity and level of service on any road way, first of all we have to find out speed, flow and density parameters with effect of road side frictions. In this study speed-density relationship is analyzed using classified volume count survey and spot speed survey with and without road side friction condition. In speed-density relationship X-axis shows density in PCU/km and Y-axis shows speed in Kmph. Maximum number on X-axis shows the jam density for that section and maximum value on Y-axis shows the free flow speed of that section. Figure 1 shows speed-density relationship. In figure 1 U_f shows speed in kmph at zero density and K_j shows jam density at zero kmph speed. Various studies has been carried out for find out effect of road side frictions on traffic flow parameters.

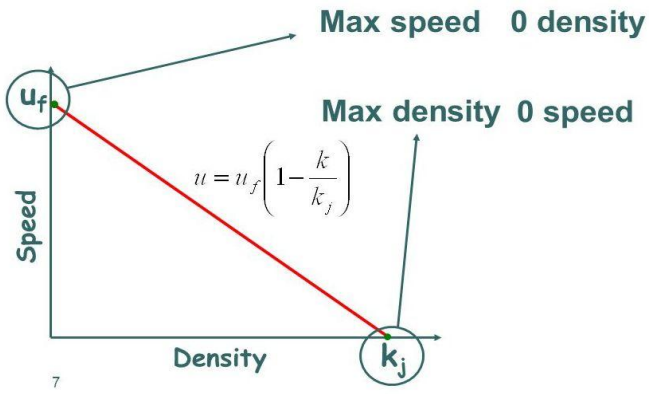

Figure 1: Speed-density relationship

II. LITERATURE REVIEW

Rao et al. (2016) have concluded that road side friction caused capacity reduction because of temporary bottlenecks created by on-street parking, entering exiting bus from bus bay and bus present at kerb side bus stop. Percentage reduction in capacity because of bus bay is more than kerb side bus stops as number of buses operating in later case are less and more over building entry at exit of bus bay exaggerated the capacity reduction. Using both types of PCUs

because of bus bays and bus stops 10-53% capacity reduction is observed. On-street parking caused 28-63% capacity reduction affecting the functionality of urban roads. Also dwell time of buses showed considerable effect on the capacity. With increase in duration of dwelling time of bus it is found that capacity is reduced as more the time bus stops on road more the disturbance it causes to traffic on the section [1]. **Chandra and Kumar** (2003) have collected data at ten sections of two-lane roads in different parts of India. The width of carriageway this term is commonly used in India for the total width of the paved surface of a road excluding its shoulders ranged from 5.5 to 8.8 m. All vehicles were divided into nine different categories and their PCU's were estimated at each road section. It was found that the PCU for a vehicle type increases linearly with the width of carriageway. This is attributed to the greater freedom of movement on wider roads and therefore a greater speed differential between a car and a vehicle type. The capacity of a two-lane road also increases with total width of the carriageway and the relationship between the two follows a second-degree curve. This relationship is used to derive the adjustment factors for substandard lane widths and the results are compared with literature. They reasoned that the impact of path width is progressively unmistakable under blended traffic conditions when vehicles don't tail each other and will in general move side by side. This examination has demonstrated the impact of path width on the PCU for various classes of vehicles and along these lines on the limit of a two-path street. It is discovered that the PCU for a vehicle type increments with expanding path width. The impact of path width on the PCU is obviously direct; the slant of linearity relies upon kind of vehicle. The capacity of a 7.2 m wide road is estimated to be 2818 PCU/h which is slightly larger than the value specified in HCM 1994 but much lower than the value of 3,200 PCU/h suggested in HCM 2000. This is attributed to the nature of mixed traffic and the regulatory system on Indian roads [2]. **Chandra et al.** (2014) carried out study at six-lane urban roads in New Delhi. Three sections of six-lane were chosen where there is no bus stop or any other kind of side friction and these sections were termed as the base sections. The capacity of these sections was estimated by plotting the speed-flow curves and average of these capacity values was found to be 6314 PCU/hr which is termed as base capacity. The capacity values of other sections which are under the influence of bus stop were also determined from speed-flow plots and these capacities were compared with the base capacity. The reduction in capacity due to a bus stop was found to be in the range of 8 to 13 percent [3].

III. METHODOLOGY

In this study videography technique was used for data collection. Videography is done for two conditions first when friction is not available on selected stretch and second when friction is available on selected stretch. For first condition when no friction is available on stretch video camera position is at zero friction point. For second condition where friction is available on stretch video camera position is at maximum friction point. After data collection in video camera videos are transferred to the computer for data extraction. Data extraction was done in five minutes interval for both classified traffic volume count and spot-speed study. For spot-speed study 12 meters length is considered for space mean speed (SMS) calculation in kmph. After getting flow (PCU/hr) and speed (kmph) data density is find out based on fundamental relationship of traffic flow parameters.

$$\textbf{Space mean speed} = \frac{\textbf{Distance between two spots} * 3.6}{\textbf{Average of vehicle crossing time in sec}}$$

$$\textbf{Density} = \textbf{Flow}/\textbf{Speed}$$

IV. STUDY AREA

Traffic circle (near SBI) to Bus Station (4 lane two way divided) having length 442 m situated in Modasa town. It is a state highway number 59 which connects the Nadiad to Raigath passing through Modasa town. CBD area of Modasa town is spread across the selected stretch and all important locations of Modasa town are situated on this stretch, due to this heavy traffic congestion problem observed during morning and evening peak hours.

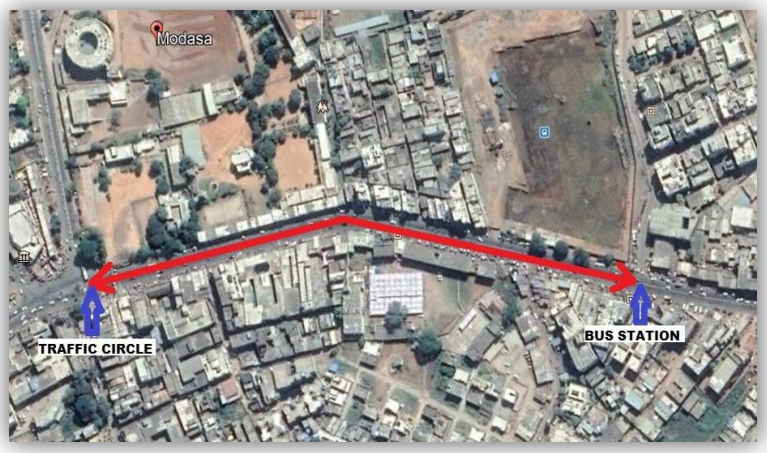

Figure 2: Google earth image of study area

V. DATA ANALYSIS

After videography, collected data have been analyzed on desktop/laptop or projector with windows 7 professional version operating system and updated VLC media player. The operating system and media player enabled to play all required videos simultaneously for particular parameter extraction. The data entered in Microsoft Excel sheet and generated different pie charts for both friction and without friction condition and scatter graphs and developed equation using best fitting curve from scatter Speed-density graph.

Table 1: PCU values for four lane divided Road as per Indo-HCM

Four lane divided road		
Motorized Traffic		
Vehicle Type	**Range**	**Median**
Two Wheeler	0.11 - 0.33	0.20
Three Wheeler	0.39 - 1.66	0.80
Car	1	1.00
Bus	1.62 - 5.90	4.58
Mini Bus	1.08 - 3.94	2.10
LCV	2.10 - 3.60	2.30
TAT	2.70 - 5.68	3.80
MAT	3.61 - 7.91	5.10
Tractor with Trailer	3.78 - 7.43	5.38
Non-Motorized Traffic		
Bicycle	0.34 - 0.50	0.39
Cycle Rickshaw	1.39 - 3.16	2.04

Total vehicle composition is found out and pie charts are prepared for both with friction and without friction conditions. Figure 3 to figure 6 shows the pie charts for different condition and different directions. PCU values are taken from Indo-HCM 2018 for four lane divided roadway condition.

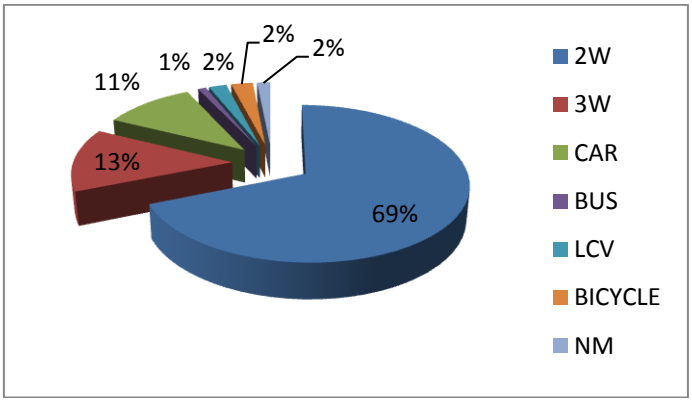

Figure 3: Vehicle category wise traffic flow at Traffic circle to Bus station without friction

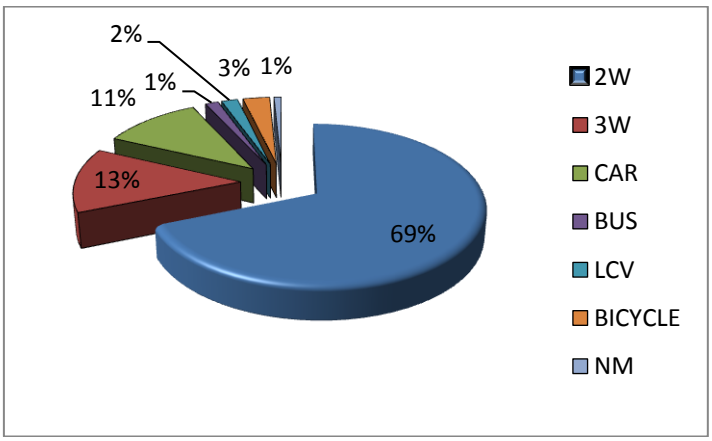

Figure 4: Vehicle category wise traffic flow at Traffic circle to Bus station with friction

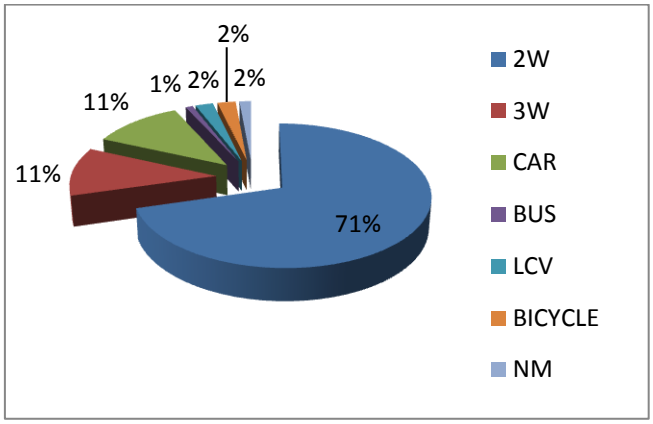

Figure 5: Vehicle category wise traffic flow at Bus station to Traffic circle without friction

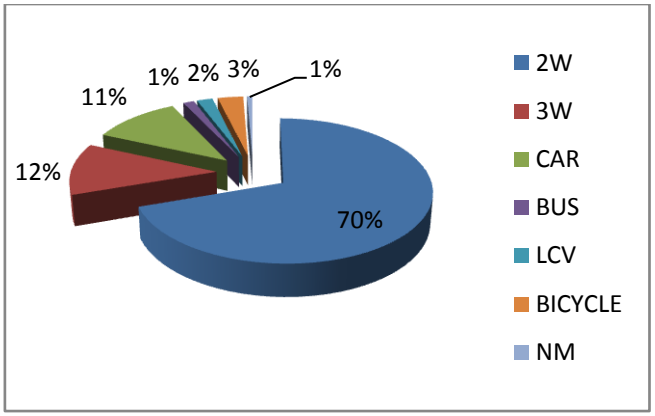

Figure 6: Vehicle category wise traffic flow at Bus station to Traffic circle with friction

VI. SPEED-DENSITY RELATIONSHIP

After traffic flow, space mean speed and density calculation the scatter graphs are generated in Microsoft Excel using trend line function linear relationship is developed. For all Stretches Speed-density graphs are shown below (figure 7 to figure 10). Results are shown in table 2.

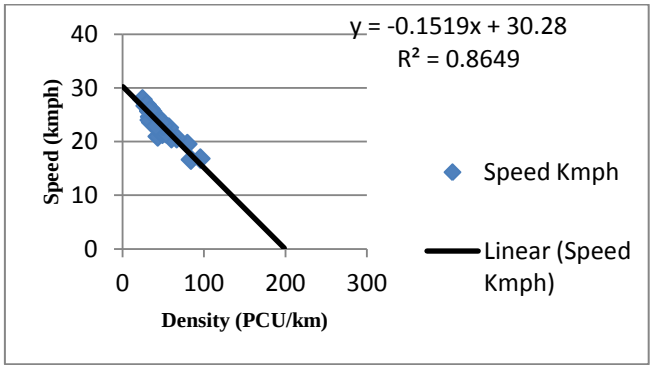

Figure 7: Speed density graph for Traffic circle to Bus station without friction

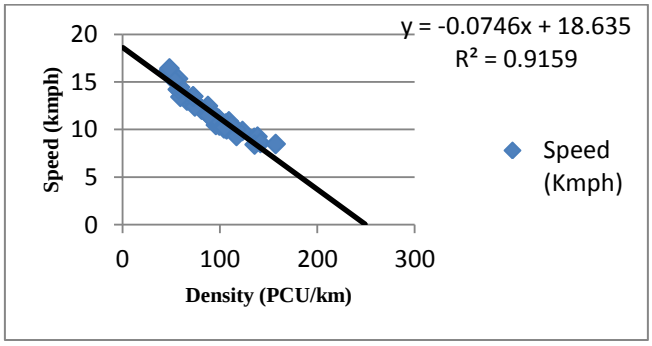

Figure 8: Speed density graph for Traffic circle to Bus station with friction

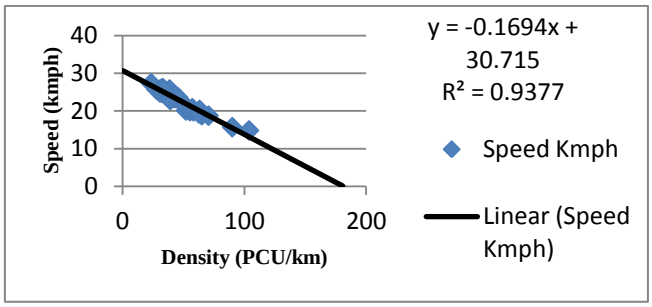

Figure 9: Speed density graph for Bus station to Traffic circle without friction

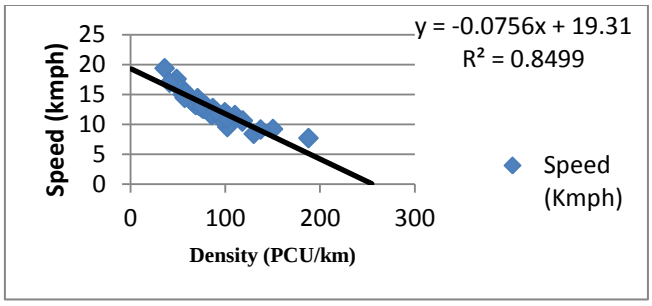

Figure 10: Speed density graph for Bus station to Traffic circle with friction

VII. CONCLUSION

After flow and space mean speed data collection speed-density scattered graphs are plotted in excel and in excel using trend line function linear relationship between speed and density was established and coefficient of determination (R^2) was obtained. Results are shown in table number 2 in which free flow speed and jam density is observed with and without friction condition.

- For Traffic circle to bus station direction free flow speed for with and without friction condition is 18.63 kmph and 30.28 kmph respectively.
- For Bus station to Traffic circle direction free flow speed for with and without friction condition is 19.31 kmph and 30.71 kmph respectively.
- For Traffic circle to bus station direction jam density (K_{jam}) for with and without friction condition is 249.79 PCU/km and 199.34 PCU/km respectively.
- For Bus station to Traffic circle direction jam density (K_{jam}) for with and without friction condition is 255.42 PCU/km and 181.31 PCU/km respectively.

Table 2: Speed-density relationship

Name of town	Name of stretch	Speed-density relationship							
		Without friction condition				With friction condition			
		Model	Coefficient of Determination (R^2)	Kjam (PCU/km)	Free flow speed (kmph)	Model	Coefficient of Determination (R^2)	Kjam (PCU/km)	Free flow speed (kmph)
Modasa	Traffic circle to Bus station	y = -0.1519x + 30.28	0.8649	199.34	30.28	y = -0.0746x + 18.635	0.9159	249.79	18.63
	Bus station to Traffic circle	y = -0.1694x + 30.715	0.9377	181.31	30.71	y = -0.0756x + 19.31	0.8499	255.42	19.31

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ACKNOWLEDGMENT

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