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Examining Microscopic and Macroscopic Traffic Flow Parameters at Diverging Section on Multilane Urban Roads in India

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Abstract
The paper studies traffic flow parameters at diverging section on an urban multilane road in India. The diverging section on multi lane urban roads or national highways in India, is mostly supplemented with a flyover at its downstream. The purpose of providing flyover is that there is provision for vehicles to make U-turn and merge to traffic flowing in different direction. Therefore, for merging manoever, flyover is on upstream side. This study is targeted on studying microscopic and macroscopic traffic flow characteristics at diverging section. For that purpose, videographic survey of traffic flow was done using two cameras on urban multilane road in Delhi. Spot speed data were also collected at upstream and downstream of diverging section using speed radar gun, simultaneously. From the extracted traffic video, flow, headway and speed data were analyzed. It was found that shoulder side lanes have significant proportion of vehicles from all categories because of diverging operation. Speed data was found to be normally distributed across all lanes. Moreover, spot-speed study was conducted at the upstream of diverging (100 m upstream) as well as at the location of diverging section. It showed significant reduction in speeds of different vehicle categories over the section due to presence of diverging operation. Based on fitting of various distribution patterns on headway, it was also found that headway data is either following log-normal or GEV distribution. But, log-normal distribution could not fit for observed headway data for all four lanes in one direction (for eight-lane divided carriageway). Therefore, it was decided to opt for GEV distribution and comparison of observed vs theoretical pattern was plotted on same set of axes. It was found that the difference in shape, scale and location parameters of GEV for Lane 1 (lane closure to median) was minimum and Lane 3 (adjacent to shoulde side lane) was maximum, which shows vehicles from Lane 1 are least affected due to diverging operation, whereas vehicles from Lane-3 are most affected due to diverging manoever. Further, to monitor the change in boundary condition, especially capacity value, speed-flow relationships are compared for with-diverging and withoiut-diverging sections on same roadway. The comparison of speed-flow plots on same set of axes reflects that diverging maneuver of vehicles shows reduction in capacity of about 12%. The findings from this study could be useful for operational analysis and development of simulation model at diverging sections of similar type on multilane urban roads in India.

Keywords:Heterogeneous traffic, diverging section, time headway distribution, speed distribution, speed-flow relationship

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1. Introduction

An urban multi-lane road is one of the highest category of roads in India connecting urban areas with divided carriageway for high speed travel having partial control of access at frequent locations via basic, weaving, merge and diverge segments (at grade or grade separated). Unlike expressways, the movement of smaller vehicles such as motorized two wheelers and motorized three wheelers are normally permitted. For the purpose of capacity and level of service analysis on this type of facility, extended lengths of roadway composed of continuously connected basic, weaving, merge and diverge segments should be considered separately. Exit and entry ramps are essential components of such roadway facilities to provide access or egress at designated locations, where traffic merge or diverge. In order to evaluate the status of traffic flow and its consequent effect on capacity and safety of operation of facility, at the location of diverging. It is necessary to study variation in microscopic characteristics like flow, individual vehicle speed and time headway at the location of diverging section. Therefore, aim of the present study is to examine the traffic flow characteristics on an urban multi-lane road in Delhi, which is an eight-lane divided carriageway.

In view of this, few studies conducted at the location of diverging are reported here. Newell (1999) studied the delay occurring due to jam on the expressway off-ramp. Cassidy (2000) found that vehicles in queue which overflow from downstream intersection of off-ramp to the diverging area, can affect the operational status on expressway mainline severely. Further, relationship between the length of queue on off-ramp and the ratio of diverging vehicles was studied, and the principle of bottleneck formed was developed. Carlos et. al. (2002) studied the operational mechanism of jam on the off-ramp. Horowitz (2000) discussed some typical behavior with longitudinal and transverse control in the car-flow, such as merging, diverging, lane-changing and so on. Tiezhu et al. (2001) analyzed the traffic characteristics, such as speed, acceleration, deceleration, the distribution of merging points, and merging gap of ramp vehicles in the diverging zones of acceleration (deceleration) lanes of expressway on the basis of investigation. Xiaocui et al. (2012) studied the characteristics of diverging area on expressway off-ramp using detector, and set up the headway distribution model in different flow.

Mostly, traffic flow parameters are studied at the location of midblock sections. Some of them are reviewed here. Speed data has been reported in the studies (Kadiyali et.al., 1981; Minh, 2005) to be following normal distribution at midblock section. Considering the importance of headway studies, few studies conducted in this direction follows. Luttinen (1996) conducted studies on two way two-lane roads in Finland to carry out statistical analysis of vehicle time headways. It was verified that different theoretical distributions namely negative exponential distributions, shifted exponential distributions, gamma distributions and log normal distributions can fit to headway data. Zang (2009) studied time-headway distribution on an expressway in Guangzhou, China, is characterized as a Weibull distribution. Xue et al. (2009), studied time-headway distributions on the expressways in Beijing, Shanghai, and Guangzhou, China, are investigated. It is reported that for traffic volume less than 250 vehicles per hour, the time headways follow an exponential distribution. For traffic volume between 250 and 750 vehicles per hour, time headways follow a displaced negative exponential distribution. Headway distribution on urban roads in Riyadh in Saudi Arabia was carried out by Ghamdi (2001) to understand the impact of urban congested traffic and found that gamma distribution model is most suitable. Zhang and Wang (2007) carried out study on headway distribution models using urban freeway loop event data. Using the Advanced Loop Event Data Analyzer (ALEDA) system, they generated large amount of accurate headway observations on interstate highway. The results of this study showed that the Double Displaced Negative Exponential Distribution model provided the best fit to our urban freeway headway data at wide ranging flow levels. The shifted lognormal distribution also fits the general-purpose-lane headways very well.Arasan and Koshy (2004) studied headway distribution on urban arterials. The result of the study has shown that, the headways of urban mixed-traffic dominated by smaller vehicles like motorized two-wheelers can be modelled using negative exponential distribution over a wide range of traffic flow levels.

From the review of literatures, it is found that there are very less number of studies pertaining to study of traffic flow parameters at the location of diverging in India as well as abroad. Further, time headway is an important parameter of traffic flow that affects the safety, level of service, driver behavior and capacity of a transportation system. Therefore, at the location of diverging, importance of time headway is highly important. This is because at same point of time, two different vehicles may be moving in different direction. One may be diverging and another vehicle may be following its straight path, which basically affects the headway at diverging. Also, there are very less number of studies pertaining to diverging section on multilane urban roads in India. Therefore, the objectives of this study is formulated as:

- To study the variation in traffic flow at diverging section on a multilane urban road.
- To fit suitable distribution for speeds of the vehicle categories over the diverging section for all the lanes separately.
- To check the effect on speed reduction of vehicle categories due to presence of diverging section.
- To fit suitable distribution for time headway data at the upstream and at diverging at disaggregate level for all lanes separately.
- To evaluate the effect of providing diverging section on speed-flow relationship on an eight-lane divided multi-lane urban road.

In order to accomplish these objectives, the remainder of this paper is organized in total eight-sections, including this section. Data collection, extraction procedure is explained in the section-two. Section three presents traffic flow characteristics such as traffic flow, composition and lane wise traffic proportion distribution. Section four describes the speed study on the study section. It includes lane wise speed distribution plot, spot speed study at upstream of diverging and at diverging during heavy flow conditions. Headway studies at the upsteam and at the location of diverging are reported in section-five. Speed-flow comparison and reduction in capacity due to presence of diverging section is shown in section seven. Finally, section eight reports the discussions findings from this study.

2. Data Collection and Extraction

For the purpose of field data collection, a diverging section was selected on multilane urban road in Delhi. This kind of roadway characteristics at diverging location is quite common over the entire roadway length. Several such diverging section were visited before making the final decision. The location was selected in such a manner that camera can be fixed at a vantage point in order to capture the traffic operation taking place at the location diverging. The google map of the study location is shown in Figure 1(a). The roadway section is eight-lane divided urban road having a carriageway width of 14-meter (3.5 m*4 lanes) on each side. Traffic video was captured by placing two cameras, one at upstream of diverging section and another just at the diverging. Figure 1(b) shows snapshot taken from video camera (Camera 1) installed at upstream of diverging section and at just downstream of diverging section (Camera 2). Traffic video was collected for the duration of 8 hours from 10 am to 6 pm using two coordinated cameras. The overall length visible using both the video camera was 150 meters and from visible length, a trap-length of 100 meters was considered as shown in Figure 1(c). Also, Figure 1(c) shows the way most of the traffic diverging occurs from shoulder side lane (Lane 4) and adjacent to shoulder side lane (Lane 3). The location selected can be clearly explained with the help of this drawing. The trap-length selected for the study purpose is 100 m. From Figure 1(c), it is quite clear that upstream of the diverging section at 100 before diverging location.


Figure 1 (a): Google Map View of diverging Section on Delhi Multilane Urban Road

Figure 1 (b): Snapshot at upstream and downstream of study location with camera 1 and Camera

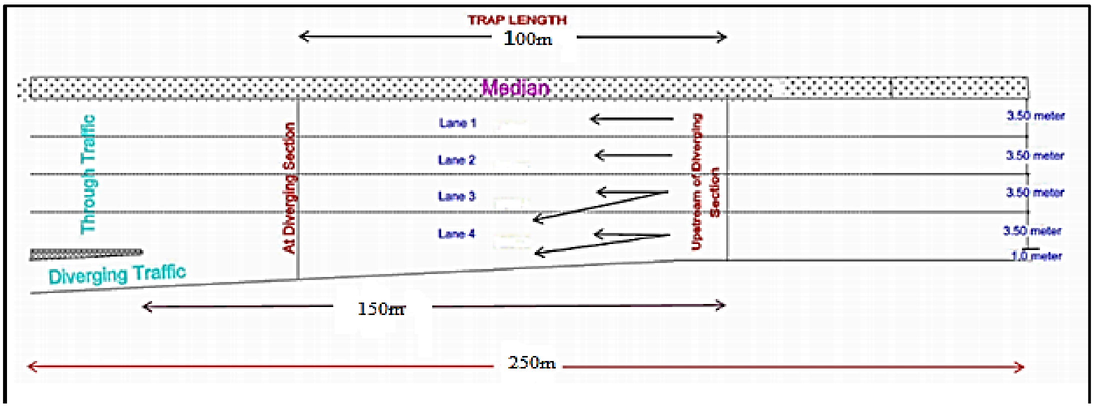


Figure 1 (c): Representation of the Diverging Section

Figure 1: Study Section Details

Data Extraction

The recorded traffic video was played on computer screen using Avidemux software. Using the field geometric details, grid lines were prepared in AutoCAD software for the study stretch and the same was overlaid on the recorded video which was played in Avidemux in order to make data extraction procedure convenient. To start the extraction work, traffic volume count for 1-minute interval was done by manual counting the vehicles passing through the section. Manually counted volume was simultaneously entered in Microsoft excel sheet in vehicle category-wise which was subjected to further analysis. Moreover, time stamp at entry and exit of vehicle through the upstream and downstream of the section was also noted to get time headway and speed data for further analysis process. The total duration of 3 hours and 40 minutes (2:00 pm to 5:40 pm) of traffic flow data was extracted from the traffic video of 8 hours (10:00 am to 6:00 pm). The duration was selected because during this duration the traffic flow was maximum based on visual inspection.

3. Observations on Traffic Flow

3.2 Traffic Composition

It can be seen that the study section has highest proportion of car (79%) from Figure 2. It is followed by motorized two-wheeler composition (2W), which is around 14% in the traffic stream and lower proportion of heavy vehicle in the traffic stream (1%-Bus, 1 % -Truck) was observed. Motorized Three-Wheeler (3W) was around 4% during the observation period.

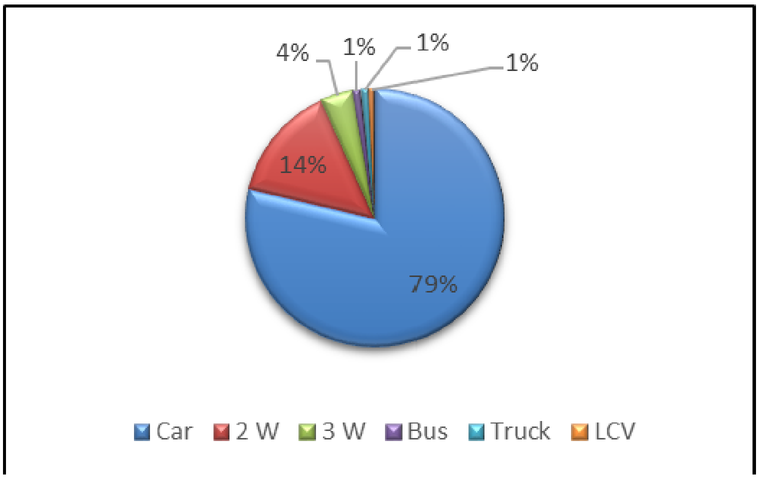
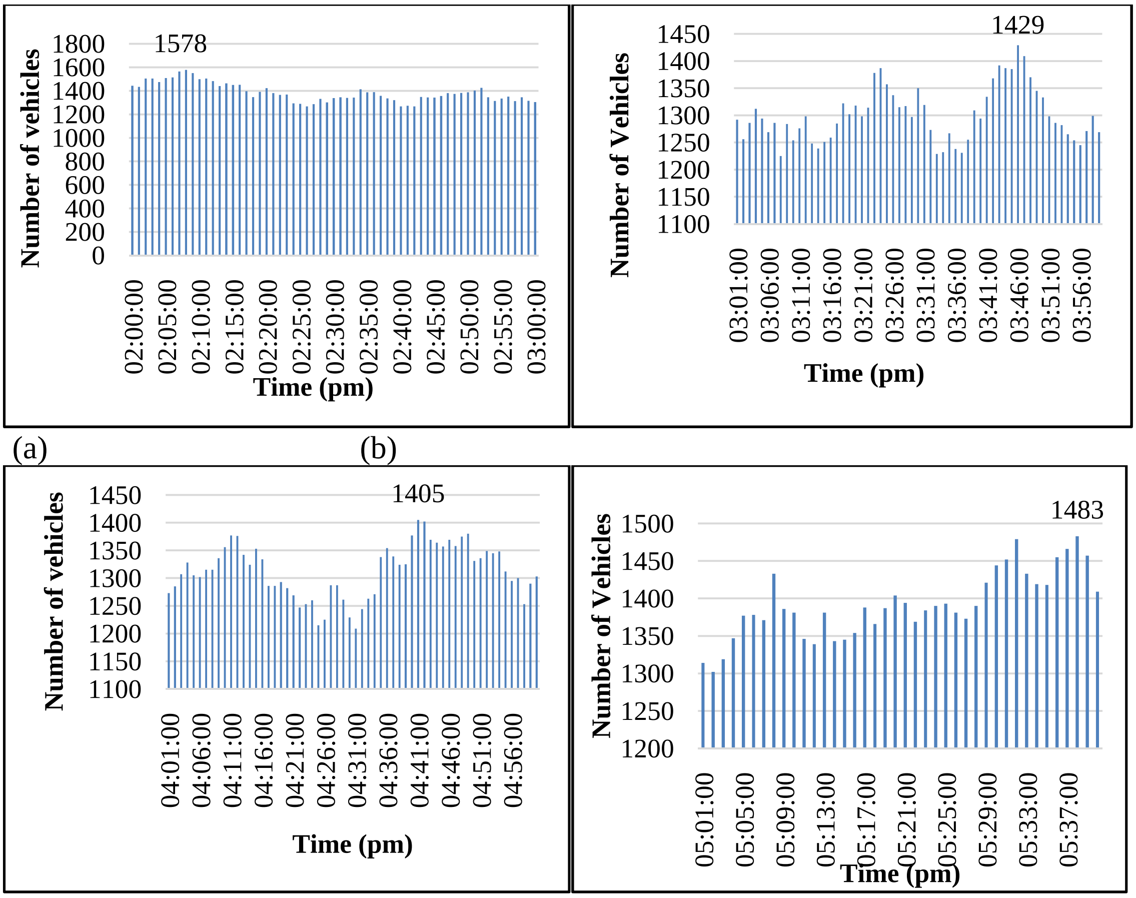


Figure 2: Traffic Composition on Study Section

3.3 Flow Variation at Study Location

It was found that traffic volume was observed around 9000 vehicles/ hour/direction for each one hour from 2:00 PM to 5:40 PM. The reason for the high observed traffic volume in terms of vehicles/hour on the study section is because of: (i) the traffic data was extacted during heavy flow duration (ii) significant proportion of motorized two-wheelers in the traffic stream. During the observed duration, 8-12% of the total vehicles were found to be diverging to the side road. For analysis on traffic flow, from each one-hour volume count data, a representative flow sample of ten minutes was taken for futher traffic composition analysis. The base of deciding the representative ten-minute interval sample was the duration with maximum flow. In order to find out the representative sample, cumulative ten-minute volume starting from zero to ten minute as first representation, one minute to eleven minute as second, two to twelve minute as third and so on were calculated with the help of Microsoft excel. Out of the 60 sets of cumulative flow of each ten-minute interval, highest one is selected for further analysis. Figure 3(a) through 3(d) shows the cumulative ten minutes for each one-hour duration starting from 2:00PM to 5:40PM.



(c) (d)

Figure 3: Cumulative flow variation observed on Delhi multi-lane urban road

3.4 Lane Wise Vehicular Proportion

Under Indian multilane urban roads, it is a common observation that the fast-moving vehicles like Car are found to be moving in the lane closer to the median side whereas slow moving vehicles are mostly restricted towards shoulder side lanes. However, this behaviour is somewhat different in case of diverging section because due to diverging maneuver, lanes which are closer to shoulder side also have significant proportion of vehicles from all classes. In order to study this behaviour in details, an investigation was conducted to report the traffic composition for all the four lanes in the study section and has been presented in Table 1. The analysis was done for the selected 10-minute intervals in the previous section with maximum flow. The lane numbering pattern in this study can be clearly understood from Figure 1(c).

It may be noted from Table 1 that Cars mainly chooses first two lanes from median-side. It can be considered as a special case of homogeneous traffic on urban multilane roads on Indian conditions for Lane 1 (median side lane) and Lane 2 (adjacent to median side lane). The last two lanes Lane 3 (adjacent to shoulder side lane) and Lane 4 (shoulder side lane) have significant contribution from all categories of vehicles including Cars, motorized two wheelers, motorized three wheelers and other heavy vehicles (bus and truck), since the section is located at the verge of diverging.

Table 1: Vehicular Proportion for Lane1, Lane 2, Lane 3 and Lane 4

Vehicle Category	*2w*	*3w*	*Car*	*Bus*	*LCV*	*Truck*
Set 1(02:08 pm to 02:18 pm)						
Lane 1	1	-	99	-	-	-
Lane 2	-	-	96	1	3	-
Lane 3	38	1	56	-	3	1
Lane 4	48	2	45	1	2	2
Set 2(03:46 pm to 03:56 pm)						
Lane 1	-	-	100	-	-	-
Lane 2	1	-	98	-	1	-
Lane 3	21	1	75	3	-	-
Lane 4	40	3	46	2	5	4
Set 3(04:41 pm to 04:51 pm)						
Lane 1	-	-	100	-	-	-
Lane 2	5	-	91	1	3	-
Lane 3	28	1	66	2	3	-
Lane 4	36	1	54	2	5	2
Set 4(05:38 to 05:48 pm)						
Lane 1	2	-	98	-	-	-
Lane 2	3	-	94	1	1	1
Lane 3	26	-	69	2	3	-
Lane 4	33	1	61	1	2	2

The subsequent section presents the distribution fitting of speed data for different lanes for the study section. Moreover, spot speed survey conducted at 100 m upstream of the diverging section and at the diverging section is also presented to probe into the effect of diverging section on individual speed of different vehicle categories.

4. SPEED STUDIES

4.2 Speed Characteristics

Speed is a fundamental measurement of performance of a given roadway facility. The free-flow speed measured at any section is a function of number of factors such as road geometry, road surface conditions, vehicular characteristics, individual driver behaviour and other factors such as road-side environment, weather and time of the day. An understanding regarding the speed characteristics is of great importance in traffic engineering. It indicates the quality of service experienced by the road users. Moreover, it helps in further studies related to geometric design, traffic regulation and level of service. A statistical analysis of speed data is required for justifying that the sample data collected which comes from a population that is having similar traffic characteristics. Moreover, this analysis will serve as basis for stimulation based modelling of traffic stream characteristics. Speed data collected for different lanes must represent the actual field condition prevailing in Delhi multilane urban road. To satisfy this condition, normality check was done on speed data of each lane.

It may be observed from Figure 4 that there is a gradual reduction in speed as well as gradual increment in standard deviation as we move from median side lane to shoulder side lane. This is attributed to the fact that median side lane has major composition of Cars and also vehicle moving in shoulder side lane is affected by diverging behaviour.

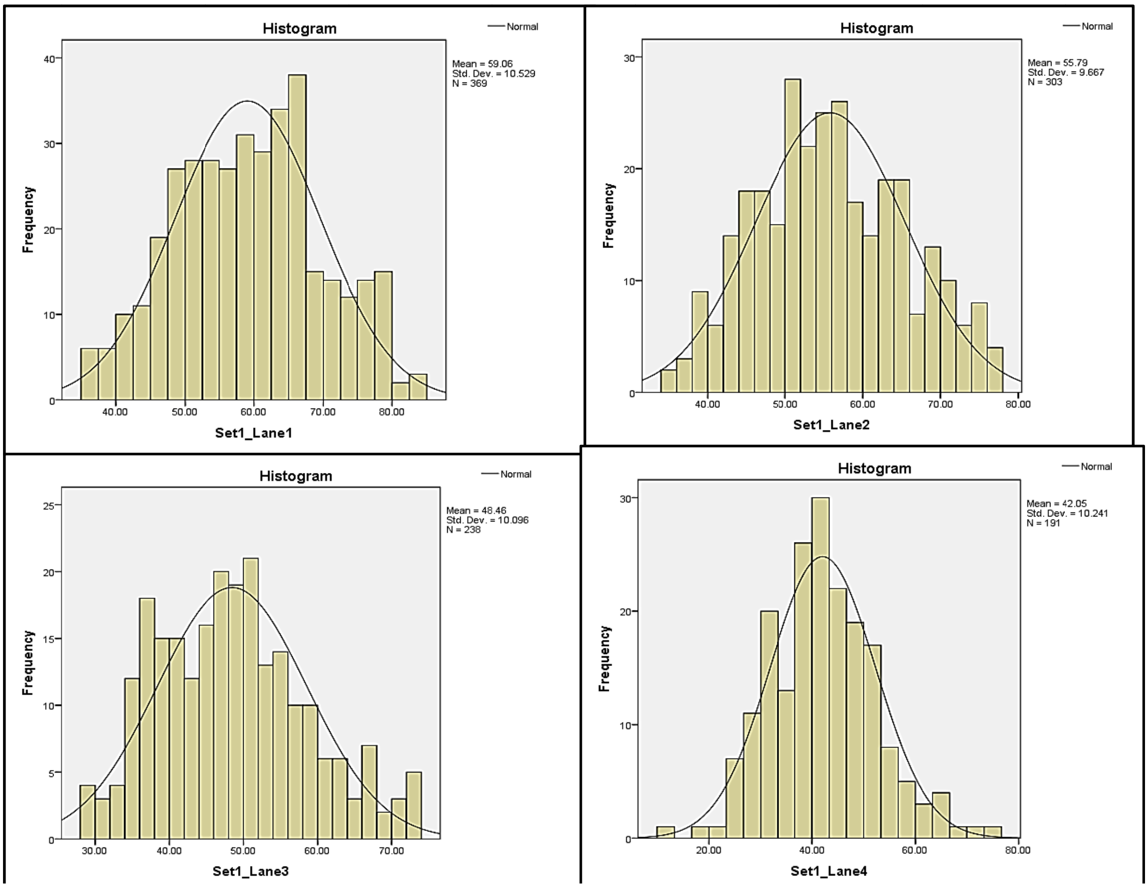


Figure 4: Speed Distribution Fitting for Different Lanes

Table 2 shows the results of normal distribution fitting for all four data sets for all the lanes. Chi-square goodness of fit test was conducted for the normal distribution fitting to the field observed data. It is found that the normal distribution fits speed data for all the four lanes. Chi-square test was conducted at 5% level of significance with a null hypothesis of no significant difference in the observed and theoretical distribution and alternate hypothesis being there is significant difference. The null hypothesis was accepted at the 95 % confidence interval and the speed dataset shows the normal distribution pattern.

Table 2: Results of chi-squared goodness of fit test for normal distribution

Set	Lane 1			Lane 2			Lane 3			Lane 4		
	p	χ2	Result	p	χ2	Result	p	χ2	Result	p	χ2	Result
1	0.12	11.2	Accept	0.06	11.96	Accept	0.17	5.01	Accept	0.33	2.2	Accept
2	0.2	14.6	Accept	0.09	10.72	Accept	0.61	3.58	Accept	0.41	10.3	Accept
3	0.3	4.62	Accept	0.07	11.32	Accept	0.28	7.39	Accept	0.12	8.5	Accept
4	0.2	3.03	Accept	0.38	4.19	Accept	0.34	8.96	Accept	0.06	14.6	Accept

4.3 Comparison of Speeds at upstream and at location of diverging

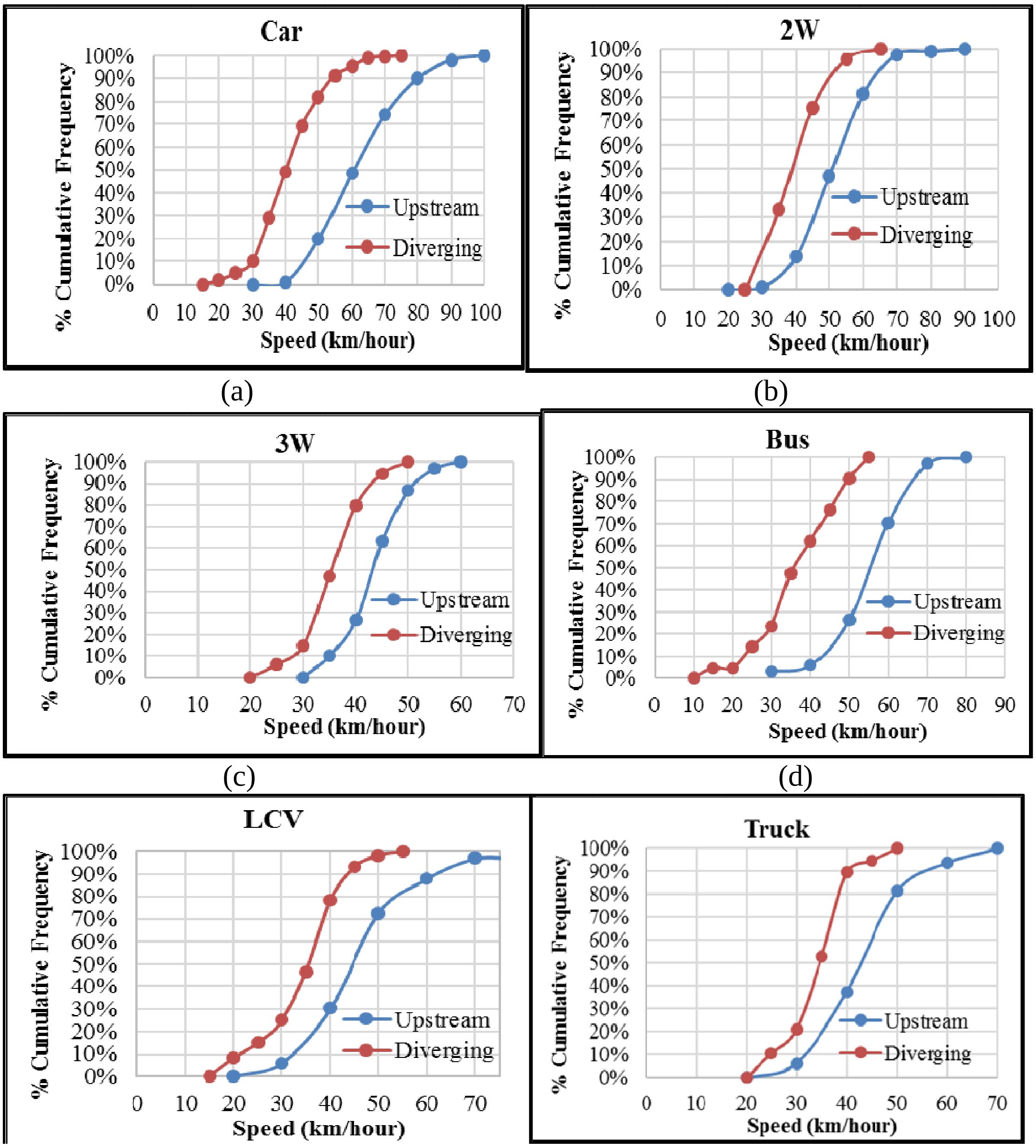
Since, there was no variation observed during free-flowing condition due to the presence of diverging section, therefore spot speed survey was conducted during relatively heavy flow. The flow during the spot speed study was observed between 6000-8000 vehicles/hour/direction. To study the effect of presence of diverging on speeds, spot speed study is carried out at two locations over the study stretch. First location is at upstream of the diverging (at 100 meters before diverging), second is at the location of diverging. The percentile speed of different vehicle categories at upstream and at the location of diverging is shown in Table 3 below.

Table 3: Percentile Speed at merging and upstream of merging section on study section

Vehicle Category	*Locations*	*Percentile Speeds*			
		15th	*50th*	*85th*	*98th*
2W	At merging	29	39	48	63
	Up-Stream	41	51	62	72
3W	At merging	31	36	41	47
	Up-Stream	38	43	56	57
Car	At merging	32	41	51	63
	Up-Stream	49	61	77	90
Bus	At merging	26	37	46	54
	Up-Stream	48	54	65	76
LCV	At merging	26	36	41	48
	Up-Stream	37	44	56	84
Truck	At merging	27	35	39	46
	Up-Stream	33	42	54	63

Further, comparison of cumulative frequency distribution of speed for different vehicle categories at upstream and at diverging section is shown in Figure 5(a) through 5(f). From the Figures 5(a) through 5(f), it is clear that there is a significant reduction in the peed of the vehicles due to the presence of diverging section on Delhi-Gurgaon

Expressway. Based on the speed data at different percentile speed as shown in Table 2, t-test was conducted for each vehicle category at upstream of diverging and at the location of diverging. It was found that there is significant difference in the speed at upstream of the diverging section (100 m before) and at diverging section at 5% level of significance. The percentage reduction in speed for different vehicle categories are in the range of 23 to 33 % based on mean of the observed speed data. Among different vehicle categories, the reduction in speed for car is maximum. Speed reduction for different vehicle categories has been shown in the Table 4 below.



(e) **(f)**

Figure 5: Speed Distribution plot at Upstream and at Diverging Section for different vehicle types

Table 4: Percentage Reduction in Speed of different vehicle categories due to diverging

Vehicle Categories	*Car*	*Bus*	*Truck*	*LCV*	*2W*	*3W*
Speed Reduction	33%	29%	28%	27%	23%	27%

5. Headway Studies

Statistical analysis of time headway is of great importance for microscopic traffic parameter modelling. It describes an inherent pattern of the traffic flow. Such a statistical model is essential for empirical traffic modelling as well as in calibration of simulation model. From the theoretical perspective, such a model will guide the researchers to build up an analytical framework in order to describe traffic flow characteristics. For the simulation models, these models will serve as the input based on its mathematical distribution. More specifically, a statistical distribution of time headways is required in generating a random temporal space between vehicles in a simulation.

Considering the importance of headway study, distribution plot for headway is done at upstream of diverging section and at the location of diverging. At entry and exit of trap length considered for study section, time headway data of different lanes data were analysed. Different distribution types were analysed such asGamma, Exponential, Negative Exponential, Shifted Negative Exponential, Log-normal and Generalized Extreme Value (GEV) distribution. Among them, log-normal and GEV are better fitted to field data. It is found from the distribution fitting that the log normal distribution fits well for most of the data in the upstream of diverging section as well at diverging section, except for Lane 2. It was due to large number of data points having small value of time headways. However, the results of the distribution fitting to the field data at upstream and at diverging are shown in Table 5(a) and Table 5(b). The mathematical fitting of GEV distribution for different lanes are presented in Figure 6(a) and 6(b) for upstream of diverging and at the location of diverging.

Table 5(a): Headway distribution fitting at upstream of diverging section

Lane number	*Mean Headway (sec)*	*Parameters of log-normal distribution*				*Parameters of GEV distribution*		
		DF	*Observed*	*Table value*	*Result*	*Statistics*	*Critical value*	*Result*
lane 1	1.4	6	9.63	12.59	accept	0.04	0.06	accept
lane 2	1.63	7	27.25	14.06	reject	0.06	0.07	accept
lane 3	2.41	2	3.41	5.99	accept	0.04	0.08	accept
lane 4	1.95	4	5.17	9.48	accept	0.05	0.07	accept

Table 5(b): Headway distribution fitting at diverging section

Lane	*Mean Headway (sec)*	*Parameters of log-normal distribution*				*Parameters of GEV distribution*		
		DF	*Observed*	*Table value*	*Result*	*Statistics*	*Critical value*	*Result*
1	1.47	6	5.65	12.59	accept	0.055	0.0755	accept
2	1.64	8	16.43	15.50	reject	0.0522	0.0713	accept
3	2.9	3	7.04	7.81	accept	0.0544	0.0655	accept

4	1.61	7	12.814	14.07	accept	0.0544	0.0706	accept

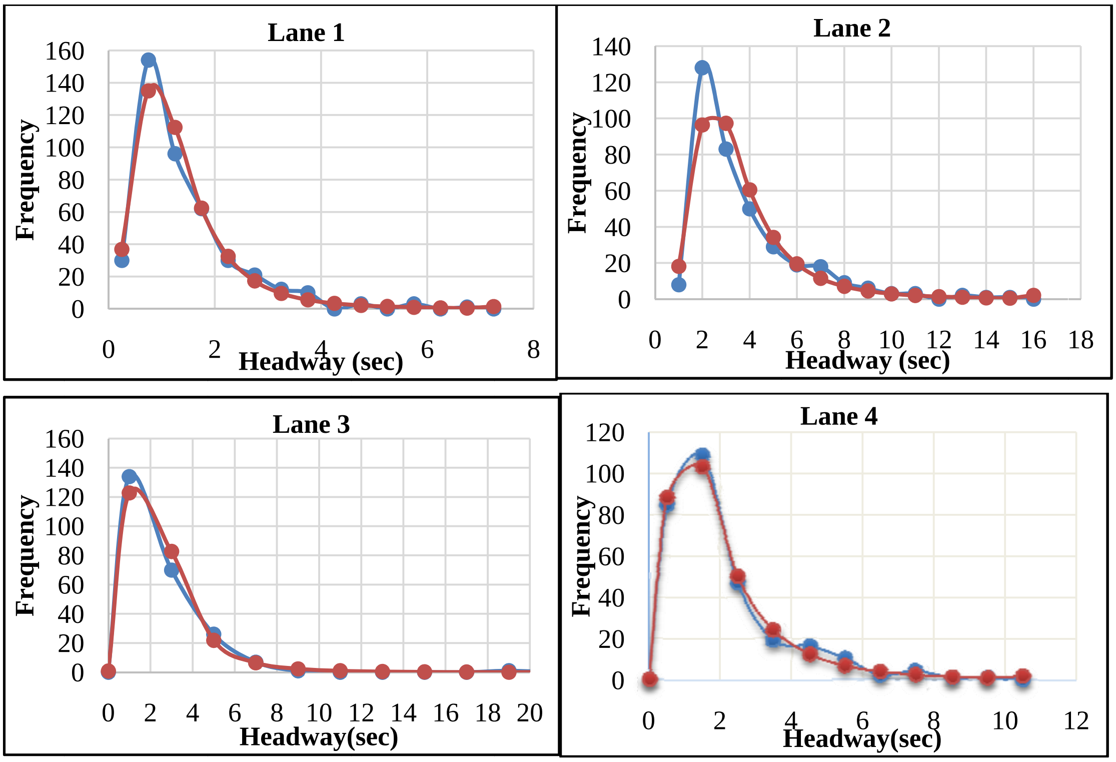
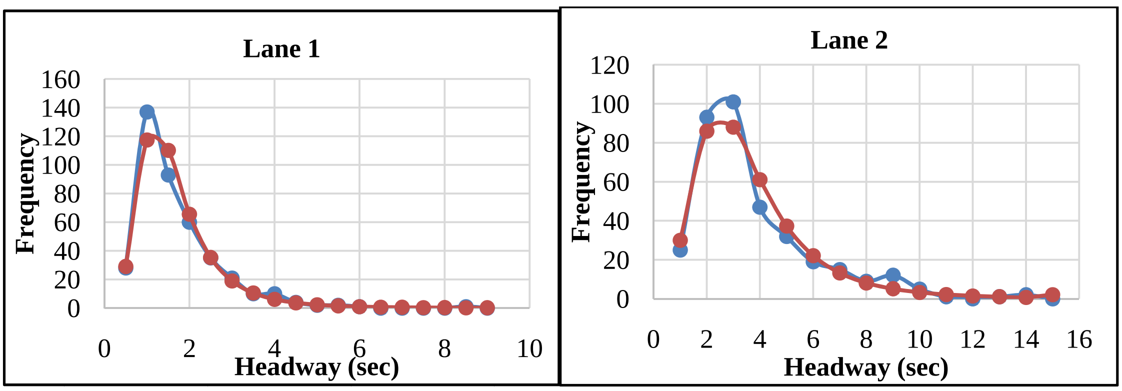


Figure 6 (a): GEV distribution fitting for headway data (a) Lane 1 (b)Lane 2 (c)Lane 3 (d) Lane 4 at upstream of diverging section



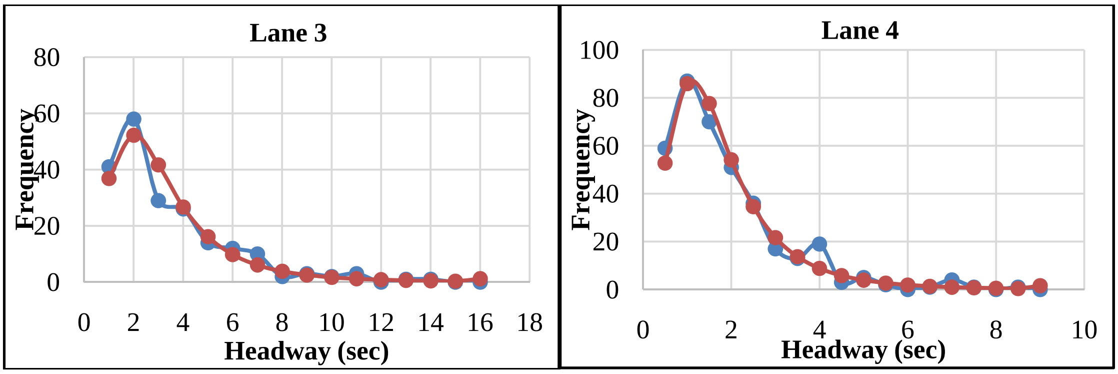


Figure 6(b): Lane-wise GEV distribution fitting for Lane 1, Lane 2, Lane 3, Lane 4 at diverging section

*Note: *Blue Line indicates Observed Frequency and Pink Line indicates Expected Frequency*

The results indicate the flexibility of GEV distribution over wide range of variation in time headway. To investigate further, the effect of change in location, scale and shape parameter at upstream of diverging section and downstream of diverging section, a comparison was done for all the four lanes using expected frequency. Lane 1 was found to have least change whereas Lane 3 was having maximum change in these parameters. Therefore, the comparisons have been given for Lane 1 and Lane 3 as shown in Figure 7 and this aforementioned observationalso becomes quite evident from these figures.

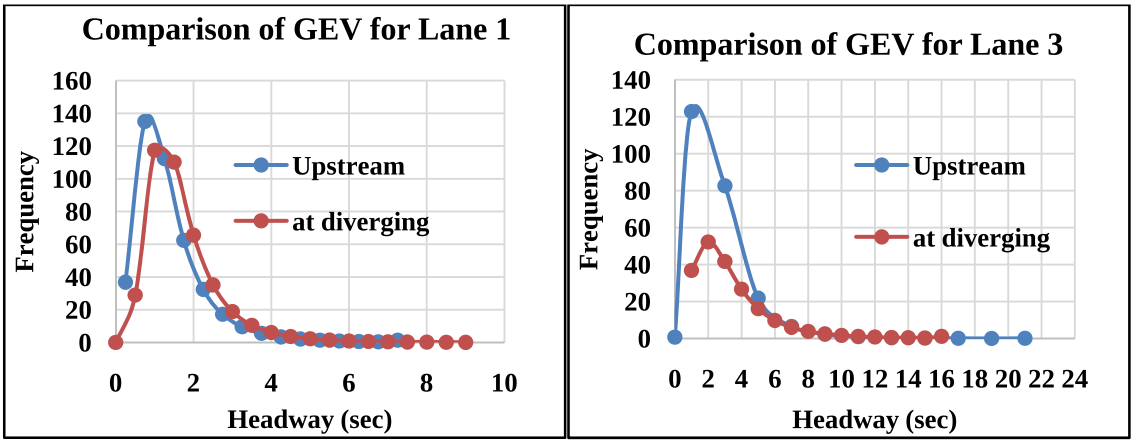


Figure 7: Comparison of GEV distribution fitted to headway data at upstream of diverging and at location of diverging for Lane 1 and Lane 3

Table 6 shows the value of shape, scale and location parameter for all the four lanes. It can be noted from table that; Lane 1 is having least deviation in all the parameters whereas Lane 3 is having maximum deviation in all these parameters. This is due to the fact that, there is not much variation in headway for traffic moving in Lane 1, since it comprises of mostly Small Cars and Big Cars, moving with very high speeds with least lane changing behaviour and having almost negligible effect of diverging section. However, Lane 3 is having maximum variation is headway. Since, at same point of time, some vehicles are moving straight and some vehicles are diverging. This might result in maximum effect on the flow of vehicles through Lane 3 and similar conclusion can be drawn based on visual observation of Figure 7.

Table 6: Values of Shape (k), Scale (σ) and Location parameters(μ)for Lane 1, Lane 2, Lane3 and Lane 4

Parameter	*Lane 1*		*Lane 2*		*Lane 3*		*Lane 4*	
	U/S	*D/S*	*U/S*	*D/S*	*U/S*	*D/S*	*U/S*	*D/S*
k	0.21	0.19	0.25	0.17	0.20	0.24	0.23	0.19
σ	0.54	0.57	0.60	0.70	1.04	1.41	0.85	0.7
μ	0.94	1.00	1.08	1.08	1.54	1.91	1.20	0.98

K=shape parameter;σ=scale parameter; μ =location parameter, U/S= Upstream; D/S=Downstream

6. Comparison of Speed-Flow Relationship at Mid-Block and Diverging Section

Based on the data available, speed and flow data was aggregated at 5-minute intervals. Then, fundamental relationship was developed between speed and flow at the diverging section on Delhi multilane urban roads. In order to find out the effect of diverging section on capacity of multilane urban road in Delhi, a comparison was made with midblock section on similar roadway taken from previous study (Arkatkar et al., 2014). Initially, traffic composition was compared for both mid-block sections and diverging section as shown in Table 7. Paired t-test was conducted to check for the difference in composition at midblock and diverging at 5% level of significance. It was found that, there is no significant difference in traffic composition for both midblock and diverging section. To find the effect of diverging on roadway capacity, speed-flow relationship developed by Arkatkar et al (2015) (15) for the same roadway was overlaid on the speed-flow relationship developed in this study as shown in Figure 8. The comparison between the relationships showed that there is not much effect on free-flow speed at diverging section when compared with mid-block section for the study stretches under consideration. Significant reduction in capacity of roadway was observed at the location of diverging section. The difference in capacity is observed around 12% in this study.

Table 7: Comparison of traffic composition at midblock and diverging section

Types of Vehicles	*Composition (in percentage)*	
	Midblock Section	*Diverging Section*
Car	76	79
Motorized Two-Wheeler	19	14
Motorized Three-Wheeler	2	4
Bus	1	1
Truck	1	1
Light Commercial Vehicle	1	1

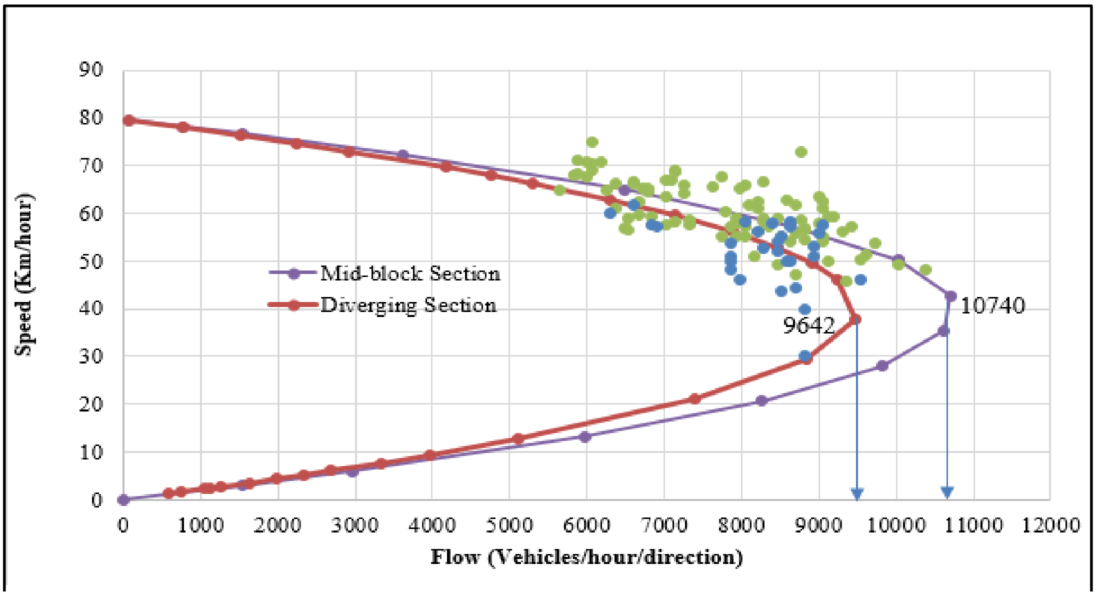


Figure 8: Comparison of Speed-Flow Relationship at Mid-block and Diverging Section on multilane urban road, Delhi

7. Discussions and Findings

The research evaluates traffic flow characteristics at the diverging section on multi-lane urban roads in Delhi. It may be considered as representative diverging section, since similar kind of roadway characteristics are observed at the location of diverging over the total length of 28 km of the roadway under consideration in this study. Also, on multilane highways in India, more or less similar pattern of roadway is provided at the location of diverging section. However, in general, there are very less studies attempted at diverging sections on multilane urban roads in India. Therefore, realizing this as a research gap, the present study was conducted with a motivation to study traffic flow characteristics at the location of diverging on a multilane urban road in Delhi, as a case study. Various traffic macroscopic as well as microscopic traffic flow parameters such as flow, speed and headway are studied in depth at the location of diverging to derive preliminary yet very significant findings. Some of the key findings from this study are given below:

- Median side lane (Lane 1) and adjacent to median side lane (Lane 2) has maximum percentage of vehicles as Small Cars and Big Cars. However, adjacent to shoulder side lane (Lane 3) and shoulder side lane (Lane 4) has composition from all vehicle categories.
- Speed data for individual lanes separately follows normal distribution at the location of diverging.
- Spot speed studies conducted at upstream and at diverging section describes that percentile speed also decreases when vehicle approach the diverging section. The reduction in speed of different vehicle categories ranges between 23 to 33 %.
- Based on various distribution tried to fit headway data, it is found that Generalised Extreme Value (GEV) distribution is found to be best-fitting the headway data at both upstream and at the location of diverging of the study section.

- Shape, location and scale parameters, when studied for all four lanes at upstream of diverging section and at diverging section, Lane 1 was found to be having the least deviation in headway distribution, whereas Lane 3 was having maximum deviation in headway distribution. Therefore, headway distribution for Lane 3 is most affected due to diverging manoeuvers as observed from real-traffic conditions, whereas Lane-1 being far away from diverging maneuvers laterally, is least affected. This may be attributed to the reason that Lane 3 has some vehicles following the straight path and many other vehicles intent to accept diverging path.
- Comparison of speed-flow relationship at mid-block and diverging section showed that a total reduction in capacity was observed to be about 12%.

The results obtained from this study could be useful in operational analysis of diverging section on multilane urban roads in India. Also, the authors foresee that, it would be helpful in development of simulation model for diverging section at given multilane road. This also may prompt researchers for studying the effect of variation in traffic flow parameters at the location of diverging, especially under mixed traffic conditions, prevailing in India or any other Asian countries of similar nature for that matter. Moreover, level of service and safety aspects at the location of diverging sections can also be studied with the developed simulation model, using some of the findings from the present study.

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