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# Analysis of Lateral Placement and Overtaking Behavior of Vehicles

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***Abstract***

*The present research work conducts a thorough analysis of the overtaking behavior and lateral placement of motorized vehicles operating under heterogeneous traffic conditions. To gather the necessary data for this study, extensive observations were carried out on two separate four-lane divided highway sections, selected for their representative characteristics of typical road usage patterns. Video recording techniques were employed to collect detailed lateral placement data, while the overtaking behavior of various vehicles was observed utilizing the moving car method, a well-established technique in traffic studies. The collected lateral placement data was subsequently analyzed in an attempt to fit it to a normal distribution model. However, the findings indicated that the data did not conform to normal distribution, suggesting that the lateral placement of vehicles under the studied conditions exhibits unique characteristics that deviate from standard statistical expectations. This aspect of the research highlights the complexity of traffic dynamics in heterogeneous environments. In addition to the lateral placement analysis, the research work also focused on estimating acceleration parameters across the study sections. The results from this analysis revealed a notable decreasing trend between the acceleration rate and overtaking speed. This finding suggests that as vehicles accelerate during overtaking maneuvers, there are diminishing returns in speed, which may have implications for traffic flow and safety. Overall, this research provides valuable insights into the intricate behaviors of motorized vehicles in mixed traffic scenarios, emphasizing the need for further studies to understand the underlying factors influencing these patterns.*

**Keywords:** Lateral placement, overtaking, normal distribution, acceleration, heterogeneous traffic conditions

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## INTRODUCTION

Lateral distribution characteristics of vehicles on divided highways refer to the distribution of traffic across the pavement width or lanes. It is an important operational measure of lateral traffic behavior which may be influenced by the vehicle dimensions, speed, traffic volume, traffic composition, roadway features, origin-destination, travel patterns, geometric conditions, weather, driver behavior, lane width, lane type, location of entry points, and other road characteristics. Its knowledge is essential in determining the most frequent position of outer wheels of the vehicles which is required to ascertain the load-carrying capacity and riding quality of pavements along with requirements of repairing and strengthen of pavements [1].

 

Lateral placement characteristics of vehicles also indicate the lane discipline on highways. Vehicles driving closely to the center line of the lane and strictly following the lane usage regulations constitute lane-discipline traffic, mostly found in developing countries [2]. However, in the case of developing countries, problem of lane discipline is very common where vehicles generally occupy two lanes while driving and do not strictly follow the traffic regulations [3–5].

Overtaking maneuvers are undesirable traffic movements with the potential to cause road accidents, due to an increase in number of conflicting points. Overtaking maneuvers influence the highway capacity. The aim of the present study is to analyze the overtaking behavior and lateral placement of the vehicles on highways for heterogeneous traffic conditions.

In the earlier research work, Kotagi et al. (2020) studied and modelled the vehicle lateral characteristics on two-lane undivided urban roads, in Banglore city, for both opposite and on-going vehicles. The study found that for both opposite vehicles and ongoing vehicles, freedom is less for lateral movement [6]. Asaithambi and Shravani (2017) studied the overtaking behavior of vehicles in heterogeneous traffic conditions. The speed, overtaking distance, overtaking time, acceleration characteristics, flow rate, and safe opposing gap were the data extracted and analyzed. These parameters were proved to be important for capacity estimation of two-lane highways [5–7]. Mahapatra and Maurya (2015) studied the effect of several lane positions for 8-lane, 6-lane, and 4-lane divided highways. The study revealed that the different road features, such as raised footpaths, driver, road edges, and electric poles will also affect the lateral placement [8]. Balaji et al. (2013) studied the speed and lateral placement of vehicles on two-lane road sections. The study proposed different models between speed and lateral placement for different types of vehicle categories. A linear relation is observed for three wheelers, heavy vehicles, nonmotorized and motorized bicycles, and auto rickshaws. Whereas, a second-degree polynomial relation was observed for cars [1].

Vlahogianni (2013) studied the overtaking behavior of male and female drivers using a driving simulator. The study found that gender, opposing vehicle, speed difference from the lead vehicle are the factors identified to affect overtaking behavior [9]. Chandra and Shukla (2012) studied the overtaking characteristics and acceleration characteristics of different vehicle types on four-lane highways. The study investigated that, the acceleration behavior of vehicles while overtaking, was influenced by the condition of the shoulder whether it is unpaved or paved [2]. Knoop et al. (2012) studied the variation of number of lane changes with density. The study presented a new approach for macroscopic and microscopic lane change models [7]. Dey et al. (2009) found that the lateral placement data follow a unimodal or a bimodal distribution reckoning on the traffic characteristics and composition [4]. Dey et al. (2006) investigated the priority of outer wheel path location in improving its riding quality. The study results showed that, the skewness range and placement factor are the two important factors which influences the riding quality [3].

## FIELD DATA COLLECTION

The required data from the field, for the present study was collected from two four-lane highway locations. The location of highways where data was collected are parts of National Highway (NH) exists on plain terrain with straight alignment, some sections are access control and some are partially access controlled in both the directions of travel. Section-I is located on NH 163 near Bibinagar village, Telangana. Section-II is located on NH 163 near Madikonda village, Telangana. Table 1 shows the details of study sections. The traffic flow was observed to be heterogeneous in terms of physical size and operating characteristics of vehicles. Even within the same category of car, several new models are observed on Indian roads. To make the data more amenable, vehicles with similar physical dimensions and operating characteristics were grouped together. The lateral position of vehicles across the whole carriageway width was noted by videography technique. The width of the pavement was divided into 25 cm width sections with the help of tape. The positions of vehicle types were recorded by noting down the strip number over which vehicles placed its left wheel while traversing the highway section.

 

Overtaking data was collected using moving car method. The data were collected on typical weekdays with normal weather conditions. The overtaking operation was splitted into five events and the time for each event is recorded (Chandra & Shukla (2012) [2].

**Table 1.** Details of study locations.

| Sections | Highway No. | Location | Type of Highway | Type of Shoulder | Properties (m) | Data Collected |
|---|---|---|---|---|---|---|
| I | NH 163 | Near Bibinagar (Telangana). | Four lane divided. | Paved. | CW: 7.0 SW: 1.5 | Lateral placement data. |
| II | NH 163 | Near Madikonda (Telangana). | Four lane divided. | Paved. | CW: 7.0 SW: 1.5 | Lateral placement, overtaking data. |

## RESULTS AND DISCUSSION

### Lateral Distribution Analysis

Placement data for lateral distribution characteristics of vehicles was collected in Section-I and Section-II. Video-graphic method was used to collect the data. The placement data from the recorded videos were extracted by playing the videos on a large screen monitor in the Transportation Engineering Lab. The placements of vehicles were recorded by noting down the strip number over which vehicle placed its left wheel while traversing the highway section. The vehicles category was also recorded along with the strip number. The lateral position of the left wheel of cars and two wheelers from the median edge along the width of the pavement at Section-I as shown in Figure 1, it was found that more proportion of cars is travelling in median lane, whereas higher percentage of two wheelers is travelling in shoulder lane.

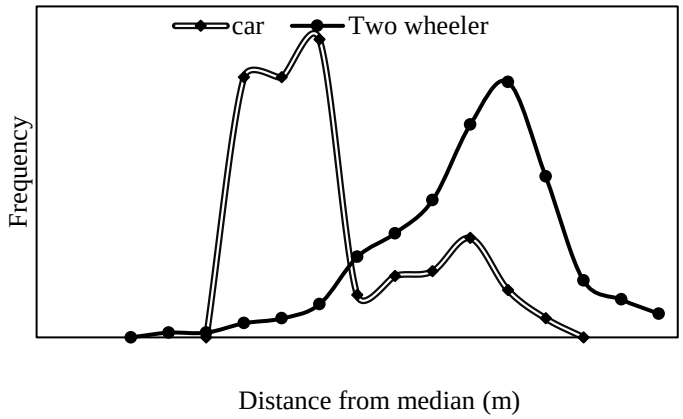


**Figure 1.** Lateral placement of cars and two wheelers at Section-I.

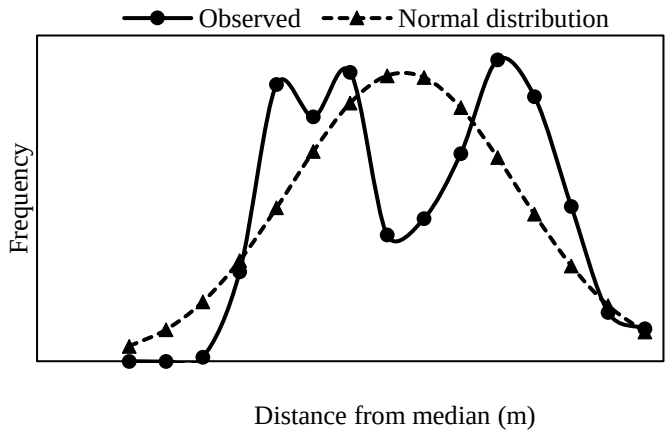


**Figure 2.** Lateral placement of mixed traffic at Section-I fitted to normal distribution.

 

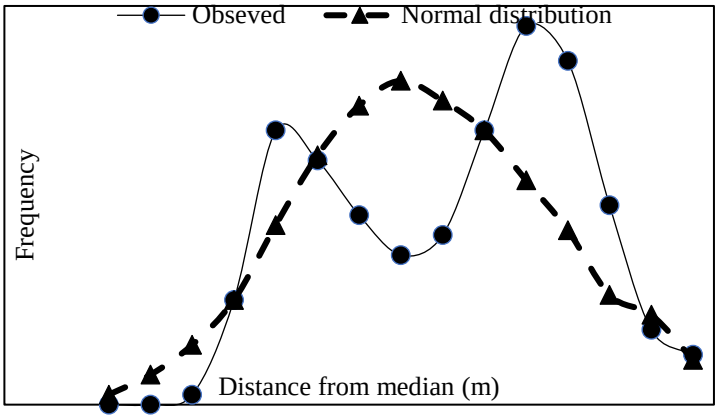


**Figure 3.** Lateral placement of mixed traffic at Section-II fitted to normal distribution.

Literature review indicates that the frequency distribution of lane-wise lateral placement data of vehicles generally follows a normal distribution. Therefore, a normal distribution was tried to fit the observed data. The frequency distribution of vehicles observed for total traffic at Section-I and Section-II are shown in Figures 2 and 3. The calculated Chi-square value at Section-I and Section-II were obtained as 136.30 and 141.23 respectively against the tabulated value as 21.02 at 12 degrees of freedom, at 5% level of significance. The observed distribution shows many fluctuations in the data throughout the pavement width, along with fluctuations existing within each lane. Thus, a normal distribution is failed to explain the observed lateral distribution of vehicles across the carriageway width.

Further, Beta4 distribution was also tried to fit the field observed lateral placement data. The frequency distribution of both field and Beta4 distribution in Section-I was shown in Figure 4. The calculated chi-square value at Section-I was 90.04 against a tabulated chi-square value of 16.91 at degree of freedom 9. It can be inferred that though Beta4 distribution is not fitting the field observed data. From Figure 4, it can also be inferred that Beta4 distribution is giving a better fit when compared to normal distribution.

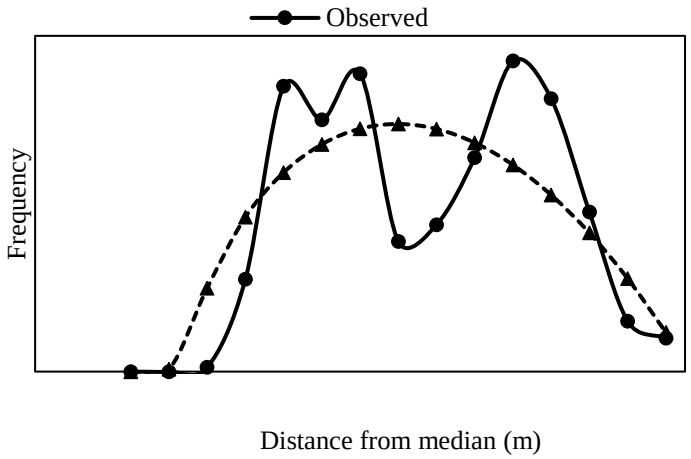


**Figure 4.** Lateral distribution of mixed traffic at Section-I fitted to Beta4 distribution.

**Analysis of Overtaking Data**

The data to analyze overtaking vehicles was collected by floating car (test vehicle) method on highway Section-II and determined the relevant parameters, such as acceleration rates, overtaking speed, overtaking distance and time of overtaking vehicles. The acceleration parameters for different

 

types of vehicles are shown in Table 2. Vehicle type CB has a higher acceleration rate than vehicle type CS and TW.

**Table 2.** Acceleration rates on study Section-II.

| Type of Overtaking Vehicle | Minimum (km/hr/sec) | Maximum (km/hr/sec) | Average (km/hr/sec) | Standard Deviation (km/hr/sec) |
|---|---|---|---|---|
| CS | 0.03 | 2.80 | 1.12 | 0.97 |
| CB | 0.04 | 3.75 | 1.22 | 1.18 |
| TW | 0.18 | 1.71 | 1.05 | 0.55 |

The acceleration rates of overtaking vehicles were analysed with varying overtaking speeds. Figure 5 shows the relation between rate of acceleration and overtaking speed for vehicle types. The two considered parameters showed a decreasing trend.

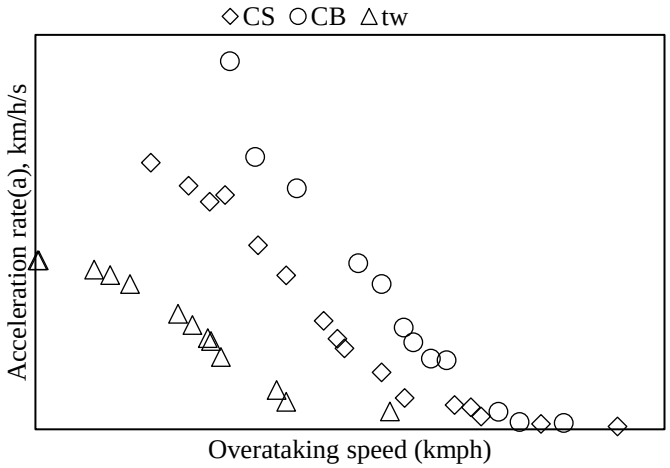


**Figure 5.** Relation between rate of acceleration and overtaking speed.

When plotted a graph (Figure 6) between total overtaking time and speed difference of overtaken vehicle, a negative correlation was observed between the two parameters.

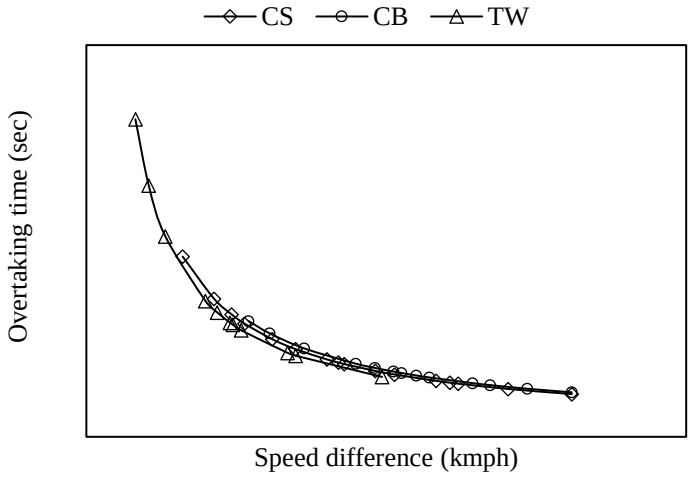


**Figure 6.** Overtaking time versus speed difference.

 

## CONCLUSIONS

The present paper analysed the overtaking behavior and lateral distribution of vehicles on 4-lane divided highways. From the results, it is observed that higher percentage of cars is travelling in median lane where as higher percentage of two wheelers is travelling in shoulder lane. The observed lateral placement data does not fit for normal distribution, further Beta4 distribution (4 parameters) was also tried to fit, but Beta4 distribution is also failed to describe the data though its giving better fit than normal distribution. Whenever the acceleration parameters of vehicles are estimated on study sections, a decreasing trend was observed between acceleration rate and overtaking speed. A negative correlation was found between overtaking time and speed difference of overtaken vehicle.

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