Heavy Vehicle’s Impact on Traffic Flow at Urban Roads

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Abstract

The operational ability and acceleration capabilities of heavy vehicle are different as that of other smaller size vehicles and passenger car. Heavy vehicle, thus affects other vehicular traffic in a dissimilar manners than passenger car or other smaller sized vehicles, which causes dissimilar levels of traffic volatility. Increasing quantity and amount of heavy vehicle in the urban traffic may results in relatively different traffic flow characteristics. This research examines how heavy vehicle affect different traffic parameter in congested heterogeneous traffic situations. It especially concentrates on the heavy vehicle existence in common traffic and their interaction with other vehicles. Numerous factors that are considered as determinants of this impact were keep in mind in this research. This exploration illustrates the existence of heavy vehicles in the urban traffic stream disturb several factors of traffic parameter (Speed, travel time), capacity, lane changing manœuvre and congestion that are contemplation of as determinants of this impact were well thought-out in this research. In this study, a methodology for lane changing decision shedding light on such impact is proposed by vehicle conversion model in this converting the subjected vehicles to heavy vehicle and detecting driving decisions of following car drivers, the proportion of changed driving decisions under heterogeneous traffic condition with the different heavy vehicles percentage, and numbers of increased lane changes caused by these heavy vehicles is quantitatively provided, as well. The speed, travel time and capacity are found out by manual method and for finding LOS highway capacity software (2000) is used.

Keywords: Heavy vehicle, Traffic flow parameter, Capacity of lane, Traffic, Vehicle conversion model, Lane changing decision

I. INTRODUCTION

Heavy vehicle have substantial impact on traffic safety, despite accounting for only a small proportion of all vehicular traffic (Al-kaisy et al. 2005, Moridpour et al. 2010, Stuster 1999). The number of heavy vehicles has noticeably increased more than past few decades and the trend is likely to continue. Therefore, more and more researchers have paying attention on the heavy vehicles impact on urban traffic stream. Larger size vehicles or Heavy vehicles are well-known for their considerable effect on traffic because of their bigger size and average functioning capability compared to passenger cars or other smaller size vehicles. These heavy vehicles comprise recreational vehicles, buses and trucks, with different class having extensive different verity. These heavy vehicles have different physical (e.g., size) and functional characteristics (e.g., deceleration / acceleration capability) than passenger cars. Larger size vehicles or heavy vehicles acquire larger surface on the road, and because of their bigger size, these heavy vehicles are not as much flexible as compared to that of cars or other smaller size vehicles and as a result of this these heavy vehicle travels with slowly as compared to the other smaller dimension vehicle. When these heavy vehicles go through the urban traffic, it affects the several parameter of traffic in the traffic flow. Heavy vehicle’s influence on traffic stream is generally attributed to two important factors. First is, the average space taken by heavy vehicle is extra than that occupied by a normal passenger car. (Hesha Rekha et al, 2005) observed that the size of heavy vehicle are generally bigger than those of passenger car and average gaps behind and in front of these heavy vehicles are more than those associated with passenger cars. And second is the functional characteristics (i.e. deceleration, acceleration maneuverability, etc.) of heavy vehicles are contradictory from those of other smaller size vehicles. There are two major traffic related problems associated with heavy vehicle in urban regions, namely: safety related issues and delays that they may reasons to different smaller size vehicles. In urban regions, as accident relating heavy vehicles give rise to delays, while the congestion affect the chances of accident. The application of heavy vehicle that are able of carrying maximum loads has continued increasing swiftly. Such vehicles, includes Trucks, Buses, and other larger size vehicles. Four important factors contributes the heavy vehicles influence on road traffic: the operating abilities of trucks/heavy vehicle that are poor as compared to cars; the large dimension of trucks; the physical influence on close by cars and the psychological of drivers of other smaller dimension vehicles. It has been suggested by several researchers that the trucks existence in front of smaller size
vehicles may result in the drivers of these smaller dimension vehicles being more precautious due to the average sight distance and the big size of heavy vehicles (Mare Lake et. al, 2002). Thus, the congestion, delays and capacity of lane are affected by the headway of the larger dimension vehicles in heterogeneous traffic condition.

II. OBJECTIVES AND STUDY SCOPE

The objective of current research is to investigate the heavy vehicles impacts on traffic flow during peak hour on urban road. The impacts of heavy vehicle on different traffic parameter (i.e. speed, travel time), effect of heavy vehicles on capacity of lane and the influence of heavy vehicle on lane- changing decisions of passenger cars. This investigation is mainly concerned with urban highway segments where presence of heavy vehicles at peak hour typically has serious impacts on traffic maneuvers. Some factors that are consideration of as essential determinants of this effect are investigated in this study.

III. DATASETS

The data used in this research were collected from 2 lanes 2 way highway patch of Hingna road and 3 lanes 2 way highway patch of Wardha road, Nagpur, by using video cameras that are mounted on the building. The study site is 100-meter long. Detailed information about observed vehicles (speed, acceleration, vehicle size and type) was extracted from the video data. Data reflected congested traffic conditions are collected for Hingna road in morning peak and evening peak periods were collected between 8:30 am to 10:30 am and between 5:00 pm to 7:00 pm on January 1, 2016 and data collected for Wardha road at evening peak periods from 5:30 pm to 7:00 pm on April 8, 2016.

IV. IMPACT OF HEAVY VEHICLES ON LANE-CHANGING DECISIONS OF PASSENGER CAR

The data for lane changing decision collected from Wardha road. The methodology used for determining the influence of heavy vehicle on lane changing decision carried out by the vehicle conversion model and the lane changing model. First, according to the predetermined proportion of heavy vehicles, the vehicle conversion model is applied and then, under the assumed traffic conditions, the lane changing model is employed. In order to guaranty accuracy of conversion model and lane changing model of the vehicle, in this study we try to consider all possible factor that influence driving behavior.

A. Methodology

As mentioned in the introduction, the capacity and flow are find out by manual method and for the detection of LOS highway capacity software (2000) is used. For the evaluation of heavy vehicle’s impact on lane-changing behavior of car drivers the methodology used in this study is to figure out responses of car drivers when the subjected vehicles in the same lane adjusted to heavy vehicles and other surrounding traffic conditions keep the same. The methodology for finding the influence of heavy vehicle on lane changing decision of passenger car is done by ‘vehicle conversion model and lane changing model’.

1) Vehicle Conversion Model

In order to realistically reflect the movements of heavy vehicles under the assumed traffic conditions, a vehicle conversion model convert the subjected vehicles to heavy vehicles is developed. The vehicle type of subjected vehicles can be easily set to the heavy vehicle type. In what fallows, we just need to adjust the speed of subjected vehicle to the speed of heavy vehicle and other surrounding traffic conditions keep the same.

![Image](image1)

Fig. 1: illustrates the subject vehicle and its surrounding traffic.
As the subject vehicle’s speed is set to 20-25 km/hr and drive it through the center lane the model can realistically reflect the movements of heavy vehicles.

Figure 2 represents the actual speed profile of the car and the solid line shows the speed profile after conversion, that is, the speed of assumed heavy vehicle. On the whole, the speed after conversion is lower than the actual speed and the changing tendency of actual and converted speed is consistent, which demonstrates responsibility of vehicle conversion model.

![Fig. 2: Represents the actual speed of car vs. Speed after conversion](image)

**B. Lane Changing Model:**

After applying vehicle conversion model by converting all factors of subjected vehicle as a heavy vehicle by keeping the surrounding traffic condition same in peak hours of three lane two way road then, under the available traffic conditions, the lane-changing model is employed to evaluate the lane changing decisions of following passenger car drivers. From this, we can figure out how many drivers change their driving decisions under the impact of heavy vehicles.

<table>
<thead>
<tr>
<th>Traffic composition and traffic flow characteristic of Wardha road.</th>
<th>Number of motorcycles</th>
<th>Number of passenger cars</th>
<th>Number of heavy vehicles</th>
<th>Level of service</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow (veh/hr)</td>
<td>3024</td>
<td>913</td>
<td>98</td>
<td>LOS: D</td>
</tr>
<tr>
<td>Speed (km/hr)</td>
<td>2017</td>
<td>42</td>
<td>48</td>
<td></td>
</tr>
</tbody>
</table>

Traffic composition and traffic flow characteristics data of Wardha road are listed in table 1 which illustrates the data reflecting traffic conditions in evening peak periods of Wardha road which are collected at peak hour between 5:30 pm to 7:00 pm on April 8, 2016.

The lane changing model for non-lane-changing, lane-changing samples and total samples are listed in Table 2. We can see that, out of total samples how much number of samples changes their lane.

<table>
<thead>
<tr>
<th>Number of lane changing samples</th>
<th>Right-lane changing samples</th>
<th>Non-lane-changing samples</th>
<th>Left-lane-changing samples</th>
<th>Total samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of samples</td>
<td>371</td>
<td>183</td>
<td>78</td>
<td>632</td>
</tr>
</tbody>
</table>

**C. Impact Evaluation:**

Previously, we see that the vehicle conversion model and lane changing model both perform well. The performance of model largely depends on the numbers of parameter adopted. We use the proposed methodology to evaluate the heavy vehicles influence on lane-changing decisions of car following the subject vehicle.

The impact of vehicle on non-lane-changing and lane changing decisions is displayed in figure 3.
From the figure 3, it is clear that, with the increment of the numbers of heavy vehicle in the center lane, among non-lane-changing samples the drivers deciding to change the lanes gradually increase. Compared with non-lane-changing and left-lane-changing samples, right lane-changing samples are more susceptible to the heavy vehicles existence.

The heavy vehicles influence on non-lane-changing and lane-changing decisions is displayed in Figure 4. From the figure, it is clear that, with the increment of heavy vehicles number in the middle lane, among non-lane-changing samples the drivers deciding to change lanes gradually increase. Hence, heavy vehicle in middle lane force the following drivers to change their lane.

V. EFFECT OF HEAVY VEHICLE ON DIFFERENT TRAFFIC PARAMETERS

Heavy vehicles cause’s plenty of inconvenience and because of their poor operating capabilities (deceleration and acceleration rate) and larger dimension they are less flexible and travel with the slower speed as compared to the smaller dimension vehicles. When these heavy vehicles enter into urban traffic stream it affects different traffic parameters of smaller dimension vehicle. A research is done at Hingna road for finding which traffic parameters are affected if heavy vehicle enters the traffic stream.

A. Methodology:

For determining the impact of heavy vehicle on traffic flow, 100-meter patch of Hingna road is selected and the data is extracted of peak hour of five working days. As mentioned in the introduction, the objective is completed by manual method. In this study
we find speed, travel time and flow of affected and unaffected vehicles. For this, we consider two different cases. In which, case I: evaluation of speed and time of unaffected vehicles (in this we consider 300 passenger cars which flow freely in the absence of heavy vehicles). And case II: evaluation of speed and time of affected vehicles (in this case we consider 300 passenger cars which flow behind the heavy vehicles in the presence of heavy vehicles). In which we consider 100-meter patch of Hingna road which is two lane two way urban highway roads.

1) Case II: Evaluation of speed and time of unaffected vehicles.
In this case, the speed and time of unaffected passenger car samples are calculated for the 100-meter of selected patch. From the calculated data it should be found out that, if there is no heavy vehicle available in the traffic stream at peak hour, the time required to cover the distance is less. And as there is absence of poor operating vehicle (heavy vehicle) in the traffic before these smaller dimension vehicles the actual speed of these smaller dimension is more. The evaluated speed and travel time of unaffected vehicles are illustrated in Figure 5.

![Figure 5: Illustrate the speed and travel time of unaffected vehicles.](image)

2) Case II: Evaluation of speed and time of affected vehicles.
In this case, the speed and travel time of 300 affected passenger car samples are calculated for the 100-meter of selected patch. From the calculated data it should be found out that, if heavy vehicle enters in the traffic flow at peak hour, the time taken up by the smaller dimension vehicles to cover the distance is more. And as there is presence of poor operating vehicles (heavy vehicle) in the traffic behind these smaller dimension vehicles the actual speed of these smaller dimension vehicle is affected. The evaluated speed and travel time affected vehicles are demonstrate in figure 6.

![Figure 6: Illustrate the speed and travel time of affected vehicles.](image)
$B$. Impact Evaluation:

From case I we should observe that, in free flow condition, where passenger car or smaller dimension vehicle are not affected by heavy vehicle the time required to travel or cover the distance is less and speed of the unaffected vehicles are more as compared to affected vehicles (vehicles which travel behind the heavy vehicles) i.e. of case II. The performance of smaller dimension vehicles is directly or indirectly depends on how much the flow of lane and amount of heavy vehicles flowing through that traffic stream.

VI. CONCLUSION

According to the common driving experiences, most car drivers usually carry out lane changes to mitigate speed and visibility obstruction from heavy vehicles, but the influence of heavy vehicles on lane-changing decisions has rarely been investigated in literature. In this study, different methodology for evaluating the influences of heavy vehicles on lane-changing decisions of cars drivers are proposed for this, the methodology used are – the vehicle conversion model and lane-changing model. Evaluation results show that: the heavy vehicles proportion in the corresponding lane is 10%, when the heavy vehicles percentage is raised from 1% to 2%; the quantity of increased lane changes raises from 9 to 18 on the 100-meter long multilane urban freeway section. Such result is consistent with the result in the observed datasets where the proportion of heavy vehicles is 1% and the number of lane changes causes by heavy vehicles is 9. In this section the lane changing decision of passenger car under the impacts of heavy vehicles are examined. From the research work, it was found that heavy vehicles are responsible for lane changing decision of smaller dimensions’ vehicles.

In this paper, we make a minor effort to put together some strategies and ideas which relates to the urban traffic impacts. The impact of heavy vehicle on the passenger car and other small dimension vehicle is a critical issue in urban roads. From the examination effort, it was found that heavy vehicles are responsible for affecting the traffic characteristic of smaller dimensions’ vehicles and other complication on urban roads.

REFERENCES