STUDY OF SPEED CHARACTERISTICS ON MULTILANE HIGHWAY

Umank Mishra1, Koudagani Venkatesh2, Animesh Anshu3,
1 Associate Professor, 2 Assistant Professor
1,2 Dept. of Civil Engineering,
Vaageswari College of Engineering,
Karimnagar, Telangana India.
1 umank17@gmail.com,
2 koudagani.venky@gmail.com
3 B.Tech Student, Dept. of Civil Engineering,
Galgotia College of Engineering and technology
greater noida- 201306, UP, India.
3 animeshsngh90@gmail.com

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Abstract

Speed is one of the basic traffic flow parameter and useful in understanding of vehicular interactions for calculating highway traffic capacity and formulation of effective traffic regulation and control measures. In this paper an appropriate method was adopted to study the speed characteristics on urban multilane highway. The traffic flow data was collected at certain location on Delhi-Gurgaon expressway (NH-8) using videography technique. The probability distribution function and descriptive statistics of traffic stream speed was investigated. It was found that the speed follows the
The versatile behaviour of Indian traffic has brought opportunities and challenges to the planning and management of Indian transport system. If we compare with other developed countries, traffic characteristics in India is characterized by poor roadway infrastructure and limited operation and management experience. In developed countries, there exists homogeneous traffic conditions but in case of developing countries like India, traffic condition is highly heterogeneous in nature and vehicles do not follow traffic discipline which makes it difficult to study, extract and analyse traffic flow characteristics.

Speed is the fundamental measurement of the traffic performance on the highway system. It is the rate of movement of traffic usually expressed in Kilometre per hour and is one of the most important factors directly influencing mobility. Speed of vehicles is affected by traffic density, driver’s behaviour, behaviour and type of vehicles, weather condition, physical characteristics of the road etc. In heterogeneous traffic, the road space being used by different types of vehicles. Also, lanes play an important role in study of traffic characteristics and performance. Estimation of traffic capacity is highly concerned with the lane position and their number. Most of the previous analysts assumed that average capacity per lane on different highways is equal, however by further research and studies showed that average capacity per lane decreases with increase in number of lanes (Yang & Zang, 2005). Therefore more specifically, the analysis was carried out for the following objectives:

• To examine the traffic composition on the highway.
• To examine the average speed of traffic and various factors affecting the traffic speed.

2 Literature Review

In this section previous studies on the analysis of traffic characteristics at Multi-lane highways are reviewed.

Ali et al. (2007) examined various relationships between traffic characteristics along 35 four lane urban roads in Virginia. According to the results obtained it showed that there had an impact of posted speed, width of median and segment length on free flow speed on urban streets.

Figueroa and Tarko (2005) examined the relationship between various roadway designs and operating speeds on four lane roadway in Indiana. The results obtained using a regression model showed that increasing the posted speed limit resulted in higher operating speed. It also showed that speeds are comparatively higher in rural areas.

Yang and Zhang (2005) performed field survey of traffic flow on multi-lane highways in Beijing and found that the average roadway capacities per hour per lane on four-lane highway is 2104 PSU, on six lane is 1973 PSU and on eight lane highway is 1848 PSU. This implies a marginal decrease of average capacity per lane with increasing number of lanes on highway.

In various Indian multi-lane highways the speed-flow characteristics as well as capacity estimation had been studied based on traditional and microscopic simulation models by Velmurugan et al. (2010).

Arsan and Akhtar (2011) also conducted a study in India to investigate the effect of variation of traffic composition, road width, magnitude of upgrade and its length on highway capacity. They found that the highway capacity significantly changes with the change in traffic volume, traffic composition, width of roadway, magnitude of upgrade and its length.

Recently in Egypt, Semedia (2013) carried out a study to investigate the relationship between the roadway factors and operating speed at multi-lane highways. It was found that pavement width followed by median width and existences of side
access along the road section are the most influencing variables on operating speed. In another study by Semedia (2013a) aimed at investigating the impact of road geometric characteristics and heavy vehicles on level of service and capacity in rural multi-lane highway in Egypt.

3 Study Stretch

The stretch selected for study was Delhi-Gurgaon expressway. As a commercial hub of Northern India, it is already on one of the busiest traffic arteries in the National Highways network. This expressway is one of the busiest inter-city route and handles more than 180,000 PCUs daily. The various specification of the highway includes following:

- Starts at DhaulaKuan in Delhi and terminates on the outskirts of Gurgaon (Manesar).
- The road has 11 flyover and overpasses.
- Four toll plazas including the 32-lanes toll plaza at Delhi Haryana border, which is the biggest toll plaza in south Asia and the second biggest in Asia.
- Elevated sections of the expressway are open only for vehicles capable of attaining of 80-100 km/h.

4 Data Collection

The parameters evaluated in this study are the classified vehicle count and speed. The data was collected for one hour duration in the evening (4:30 to 5:30 PM). The video is recorded from the height as from middle of foot over bridge with the help of DSLR Nikon camera fixed. The classified vehicle count of traffic carried out by recording the video and counting the number by playing the recorded video in the laboratory.
5 Data Extraction

Initially by taking reference of two successive street light poles, a 65 metres stretch of road is selected. Grids are plotted using AUTOCAD software. With reference to the grids, two straight lines across the road showing entry line and exit line is plotted using screen marker software. The data extraction was done manually by converting video into images of 25 frames per second using video to jpg convertor software to obtain accuracy of time up to 0.04 seconds. Irfan view software was used for measuring the occupied time, frame by frame for every vehicle in detection zone. The travel time for the vehicles in detection zone was measured from the instant the front bumper touches the first reference line to the instant it touches the second reference line. The classified traffic flow count consisting of various vehicle categories such as car, bus, truck, two wheeler, three wheeler and light commercial vehicles (LCV) was determined considering all the four lanes together in one direction for every 60 seconds time interval. The traffic composition and lane usage is presented in figure 1. The entry frame as well as the exit frame is then noted for each vehicle mentioning their lane also. The data is then interpreted in MS Excel worksheet and frame difference is calculated.

**Speed:** The speed for each vehicle is calculated by dividing the distance of marked section which is 65m, by time taken by each vehicle which is calculated as

\[
\text{Speed}(m/s) = \frac{\text{distance}}{(\text{frames per second})} \times \frac{(\text{frames per second})}{(\text{frame difference})} \quad (1)
\]

In heterogeneous traffic stream vehicles of different dimension and characteristics uses the same road space, therefore weighted
space mean speed was used to represent the heterogeneous traffic stream speed. The weighted space mean speed given as

\[ V_m = \frac{\sum_{i=1}^{k} N_i V_i}{\sum_{i=1}^{k} N_i} \]  

(2)

where \( k \) = total number of vehicle categories present in traffic stream
\( N_i \) = Number of vehicles of category \( i \)
\( V_i \) = Speed of vehicle of category \( i \) in (km/h)
\( V_m \) = Weighted mean speed in (km/h)

The speed data obtained was fitted to normal distribution curve as depicted in figure 2. The cumulative speed distribution of various vehicle categories obtained from field data presented in figure 3. The spread ratio shown in table 1, clearly indicates that the speed is approximately normally distributes as it ranges between 0.69 to 1.35. Spread ratio is calculated as

\[ SR = \frac{V_{85} - V_{30}}{V_{50} - V_{15}} \]  

(3)

The lane wise comparison of weighted mean speed is presented in figure 4. The weighted mean speed of stream decreases from lane 1 to 4 because of the increase in degree of heterogeneity from lane 1 to 4.
Table 1: Speed statistics of different types of vehicles at Delhi Gurgaon Expressway

<table>
<thead>
<tr>
<th>Vehicle Category</th>
<th>SAMPLE</th>
<th>MEAN SPEED (km/h)</th>
<th>S.D</th>
<th>MAX SPEED (km/h)</th>
<th>V15 (km/h)</th>
<th>V45 (km/h)</th>
<th>V65 (km/h)</th>
<th>SR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car</td>
<td>4096</td>
<td>81.60</td>
<td>18.33</td>
<td>140</td>
<td>63</td>
<td>82</td>
<td>102</td>
<td>1.05</td>
</tr>
<tr>
<td>Truck</td>
<td>205</td>
<td>90.50</td>
<td>19.43</td>
<td>110</td>
<td>40</td>
<td>60</td>
<td>80</td>
<td>1.00</td>
</tr>
<tr>
<td>Bus</td>
<td>49</td>
<td>66.91</td>
<td>23.78</td>
<td>135</td>
<td>44</td>
<td>67</td>
<td>90</td>
<td>1.00</td>
</tr>
<tr>
<td>Two wheeler</td>
<td>379</td>
<td>65.58</td>
<td>16.49</td>
<td>110</td>
<td>49</td>
<td>67</td>
<td>84</td>
<td>0.94</td>
</tr>
<tr>
<td>Three wheeler</td>
<td>33</td>
<td>54.49</td>
<td>12.16</td>
<td>82</td>
<td>42</td>
<td>54</td>
<td>68</td>
<td>1.17</td>
</tr>
<tr>
<td>LCV</td>
<td>72</td>
<td>63.22</td>
<td>20.56</td>
<td>112</td>
<td>42</td>
<td>64</td>
<td>84</td>
<td>0.91</td>
</tr>
</tbody>
</table>
6 Discussion and Conclusions

In this paper, the data was collected from a eight lane divided Delhi-Gurgaon Expressway (NH-8) and extracted manually for one hour duration. From this data set, speeds of vehicles, traffic composition and lane usage were determined. Empirical observations showed that the speed follows the normal distribution and it varies along the different lanes. The weighted mean speed for the stream was observed to be 78.5 km per hour. It is noteworthy to be mention that, it decreases from lane 1 (median side) to lane 4 (shoulder side), due to increase in the degree of heterogeneity from lane 1 to 4. Further, lane 1 and 2 together compromises of nearly 78% of total traffic and only 22% of remaining traffic is carried by lane 3 and 4. The findings of this study has a great significance in development of microscopic simulation model, level of service and safety analysis.

References


