Analysis of Speed Parameters of Mixed Traffic Flow on the Sections of Arterial Streets (Jalandhar and Chandigarh Cities)

Peerzada Mosir Shah¹ and Niharika Gupta²

Department of Civil Engineering, Lovely Professional University, Phagwara - 144411, Punjab, India;
rpeerzada@rediffmail.com, niharika.18545@lpu.co.in

Abstract

Objectives: Traffic Flow and Speed data analysis is now days very crucial for forecasting and operational implementation of traffic system as there is rapid boost in the road users. Speed is a significant transportation constraint as it is directly linked to safety, time, comfort, convenience, and financial side for any type of road. This study aims at providing an analytical approach to speeds of heterogeneous system of traffic of the various sections. Analysis of flow and speed is required for better management of the stream. Methodology: The data collected from the spot speed studies are used to determine vehicle speed percentiles, which in turn are useful in making many speed-related decisions. Traffic volume and speed data was collected for various sections of six lanes and four lane roads in Jalandhar and Chandigarh roads respectively. Speed data gathered from different sections were analyzed and observations were made that the speed data of individual vehicle usually follows a normal distribution curve but whenever we combine the speed data of all vehicles at a section on the given road, it may or may not follow the normal distribution graph depending upon the composition of the traffic along that section. Findings: In our study of the various sections it may be noted that speed data follows a normal distribution only when SSR is in the range 0.89-1.16. The peaks in the data vary according to the proportioning of slow moving vehicles in the section. Applications: The SSR value can be utilized in the determination of speed related decisions of limits on the road sections and distribution of traffic based on the spread pattern obtained. It is also necessary for determining the characteristic designing of slow moving vehicles.

Keywords: Normal Distribution, Percentile Speed, Speed Spread Ratio (SSR), Traffic Volume

1. Introduction

Speed is considered to be crucial part of traffic engineering as it is directly or indirectly related with the geometric speed, traffic operations, congestion and capacity. Speed by definition can be termed as the rate of movement of vehicles in distance per unit time. Speed data of a traffic stream usually follows the normal distribution when the traffic is homogeneous, but in case of heterogeneous it may or may not follow the normal distribution. In case of heterogeneous it deviates from the normal curve. The mathematical study of the observed data makes it possible to understand the speed characteristics. In many developing countries such as India, Bangladesh, Pakistan the traffic is heterogeneous. In all these developing countries within same group of...
vehicle such as Buses we have 4-6 different sizes of buses on roads with different characteristics. In this paper we have introduced a term known as SSR (Speed Spread Ratio). SSR = \(\frac{V_{85} - V_{50}}{V_{50} - V_{15}}\), from this term we can calculate the range of SSR for different sections which follows the normal distribution curve. In our paper we have carried the study on the arterial roads of Jalandhar and Chandigarh cities and have taken the assumption that speed data does not follow the normal distribution because of the heterogeneous traffic present on the roads of Jalandhar and Chandigarh. We have also calculated the traffic composition for each section of the road and have correlated it with the normality of speed distribution. Our main aim is to study the speed distribution of heterogeneous traffic on different sections of roads and its variation with traffic composition.

In\(^5\) calculated speeds and capacity at 31 sites on rural highways in New South Wales between period of 1963 and 1973. The data was analyzed using multiple regressions. It examined that the light vehicles on a two lane roads, the car speeds which are calculated are approximately normally distributed with the co-efficient of variation ranging from about 0.11 to 0.18. In\(^6\) studied free speed performance of vehicles on a four lane divided highway. The speed distribution of vehicles was observed to the normal distribution with co-efficient of variation for car, buses and two wheelers being 0.11, 0.13 and 0.16 respectively. In\(^7\) analyzed the effect of traffic volume on speeds of 2 lane rural highways in Ontario Canada. The 10\(^{th}\), 50\(^{th}\) and 90\(^{th}\) percentile speed were calculated. In\(^8\) studied the effect of traffic composition on normality of speed distribution curve. The data for the study was collected at 17 different urban arterial roads in three cities of India namely New Delhi, Jaipur and Chandigarh. In\(^9\) established a unique relationship between the road characteristics and the \(V_{85}\) i.e. 85\(^{th}\) Percentile speed on the highway of Kansas, this was developed using speed models. In\(^10\) obtained the speed data on the various roads of Riyadh and it comes with an output that the data which we obtain through 85\(^{th}\) percentile speed by regression modeling gives much effective estimate than that which we get from the normal approximation model. While on the other hand max number of two wheeler vehicles were exceeding the speed limits which in turn suggests that more stress was to be given on speed limit enforcement. In\(^11\) studied the traffic flow characteristics around various roads in Chandigarh city and calculated Traffic volume, speed and capacity for various roads around the city and also provides various recommendations to overcome the traffic problems in Chandigarh city. In\(^12\) this paper represents the traffic condition on the Malaysia Federal Route 5 – Skudai Pontian Highway. In this paper Arash has determined the speed percentile of various vehicles which helped in making speed-related decision. In\(^13\) examined that the light vehicles on a two lane roads, the car speed which are calculated are approximately normally distributed with the co-efficient of variation ranging from about 0.11 to 0.18. In\(^14\) calculated the Traffic characteristics around Phagwara district and gave various recommendations to overcome the traffic problems in the area. In\(^15\) obtained that the speed of the vehicles conform to the normal distribution with a mean of 42-45 km/hr and standard deviation of 19-13 km/hr on various inter-city roads around India. In\(^16\) developed a mathematical equation for predicting speed of different vehicles categories under different condition of roads, traffic volume and composition. In\(^17\) found that we can also symbolize the mean speed with a word gamma. In\(^18\) developed speed models based on traffic data collected on sub-urban section of three cities in India. The average speed of fast vehicles varied from 37.8 kmph to 51.5 kmph and for slow vehicles the variation was observed from 10.75 kmph to 15.83 kmph. In\(^19\) indicated that distribution of speed follows a unimodal or bimodal curve depending on the categories of vehicles moving on that road. Speed spread ratio correlates with the shape of the curve. In\(^20\) suggests Percent Free-Flow Speed (PFFS) as performance measure to define Level of Service (LOS). Larger speeds differential under the conditions of heterogeneous traffic causes more error in estimating Free-Flow Speed (FFS) and thus affects PFFS.

2. Field Data Collection

Data was collected on different sections of arterial roads of Jalandhar and Chandigarh cities. This study was carried on six and four lane roads. The consideration in taking the section was that it should be free from any intersection, flyover, bus-stand, parked vehicles and majorly being a mid-block section. Traffic study was carried in order to determine the composition of traffic on the roads and speeds of different vehicles at the given road section. Traffic Volume data was calculated using video camera
technique during the peak hours of the day as shown in Table 1. For the calculation of speed, we have taken a direct timing procedure method with a road stretch of 60m on the mid-block section of given road and the spot speed study was conducted. Two observers were stationed at both ends of the stretch with each observer equipped with a stop watch. The time taken by each mode of vehicle to travel as known stretch of road was observed and noted in seconds. The data collected for the various modes of heterogeneous traffic was analyzed using the spreadsheet software and the spot speeds for each vehicle were calculated in kilometers per hour. Cumulative frequency curves were plotted to determine the percentile speeds.

3. Analysis of the Speed Data

The speed data was collected for all categories of vehicles at the given section. An attempt was made to fit the normal distribution to the speed data of all vehicles combined at section 1 as shown in Table 2. The speed distribution curve for all vehicles at section 1 is shown below in Figure 1. This represents the shape of the normal distribution curve.

| Section Number | Type of Road | Traffic Volume (veh/hr) | Car, Vans (%) | Buses (%) | Trucks, Mini Trucks (%) | 3 Wheelers (%) | 2 Wheelers (%) | Cycles |
|----------------|--------------|-------------------------|--------------|----------|------------------------|---------------|----------------|--------|
| 1              | Six Lane     | 2668                    | 53.6         | 3.82     | 1.57                   | 13.29         | 28.18          | 0      |
| 2              | Six Lane     | 3500                    | 48           | 5.4      | 2.9                    | 9.8           | 33.5           | 0.8    |
| 3              | Six Lane     | 3350                    | 38.8         | 4.8      | 4.3                    | 17.1          | 35             | 0      |
| 4              | Six Lane     | 2400                    | 45           | 7.2      | 2.8                    | 15.8          | 28.6           | 0.6    |
| 5              | Six Lane     | 5500                    | 55           | 4.1      | 1.5                    | 12.4          | 27             | 0      |
| 6              | Six Lane     | 2206                    | 52.08        | 4.3      | 2.4                    | 11.43         | 28.33          | 1.45   |
| 7              | Six Lane     | 3289                    | 42.17        | 6.7      | 0.8                    | 6.7           | 37.39          | 6.14   |
| 8              | Six Lane     | 2339                    | 40.8         | 3.6      | 0.7                    | 10.94         | 36.43          | 7.52   |
| 9              | Four Lane    | 1720                    | 43.17        | 5.4      | 1.22                   | 11.68         | 36.74          | 1.744  |
| 10             | Four Lane    | 2080                    | 39.5         | 3        | 0.5                    | 17.5          | 34             | 5.5    |
| 11             | Four Lane    | 2016                    | 44.5         | 2.3      | 0.4                    | 14            | 36             | 2.8    |
| 12             | Four Lane    | 1816                    | 46.1         | 1.6      | 1.1                    | 15.5          | 35.3           | 0.4    |

Figure 1. Observed and expected frequency curves.

The calculated and critical values of Chi-square were obtained as 2.27 and 9.49 respectively, at 4 degree of freedom and 5 percent level of significance at Section 1 shown in Table 2. The calculated value is less than the tabulated value, therefore it follows the normal distribution curve and our assumption that speed data does not follow the normal distribution is rejected in case of section 1 shown in Table 2. Speed distribution curve for section 1 is also shown below in Figure 1 which clearly shows that all the speed data follows the normal distribution.
Analysis of Speed Parameters of Mixed Traffic Flow on the Sections of Arterial Streets (Jalandhar and Chandigarh Cities)

Figure 2 shows the Observed and Expected frequency curves and from the figure it can be illustrated that the speed data follows the normal distribution in case of Section 2. Similarly, the speed data follows the normal distribution in case of section 3, section 4, section 5 and section 12. While as on rest of the sections it was seen that the speed data does not always follows the curve of normality.

4. Speed Spread Ratio (SSR) for Determining Normality of Speed Distribution

A term known as SSR (Speed Spread Ratio) is defined as the ratio of difference in 85th and 50th percentile speed to the difference in 50th and 15th percentile on a section.

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

It can be clearly seen from the Table 3 that the vehicles having SSR range between 0.89-1.16 follows the normal distribution. Speed distribution also has a greatly influenced by slow moving vehicles, as lower the proportion of slow moving vehicles higher is the probability that speed data follows the normal distribution. From the Table 1 the percentage composition of cycles is between 0-0.8 for section 1,2,3,4,5,12 and all are following the normal distribution.

| S.No | Speed Interval (Kmph) | Observed Frequency (O) | Probability (p) | Expected Frequency (E) | \(\chi^2 = (O-E)^2/E\) |
|------|-----------------------|------------------------|-----------------|------------------------|-----------------|
| 1    | 25-34.99              | 7                      | 0.05393         | 5.824                  | 0.2374          |
| 2    | 35-44.99              | 18                     | 0.15748         | 17                     | 0.0588          |
| 3    | 45-54.99              | 24                     | 0.2299          | 24.82                  | 0.027           |
| 4    | 55-64.99              | 20                     | 0.2237          | 24.15                  | 0.7131          |
| 5    | 65-74.99              | 17                     | 0.1633          | 17.63                  | 0.0225          |
| 6    | 75-84.99              | 13                     | 0.0954          | 10.3                   | 0.7077          |
| 7    | 85-94.99              | 6                      | 0.04643         | 5.014                  | 0.5054          |
| 8    | 95-105                | 3                      | 0.019369        | 2.091                  |                 |
|      | TOTAL                 | 108                    | 1               | 108                    | 2.2719          |
distribution while as the rest of the sections have higher percentage of cycles therefore speed data in these sections does not following the normal distribution.

Table 3. Speed spread ratio

| Section Number | V85 | V50 | V15 | SSR Ratio | Normal Distribution |
|----------------|-----|-----|-----|-----------|---------------------|
| 1              | 44  | 34.65 | 25  | 0.96      | Yes                 |
| 2              | 68.65 | 56.45 | 46  | 1.16      | Yes                 |
| 3              | 49.65 | 42.15 | 33.75 | 0.89     | Yes                 |
| 4              | 46  | 39.5 | 33.5 | 1.083     | Yes                 |
| 5              | 54.75 | 46.75 | 38.45 | 0.96     | Yes                 |
| 6              | 57  | 52   | 43.25 | 0.5714   | No                  |
| 7              | 48.65 | 35.75 | 20.18 | 0.82     | No                  |
| 8              | 52  | 43.17 | 28.29 | 0.59     | No                  |
| 9              | 62.15 | 54   | 38   | 0.69      | No                  |
| 10             | 59.75 | 49.54 | 37.54 | 0.68     | No                  |
| 11             | 48.34 | 43.29 | 34.24 | 0.55      | No                  |
| 12             | 54.74 | 46.74 | 38.44 | 0.963     | Yes                 |

5. Conclusion

The present study demonstrates the effect of traffic composition on the speed distribution curve on a section of multiline divided urban highway under mixed traffic conditions. It depicts that the speed data may or may not follow the normal distribution curve as there is dependence of the variation and proportion of slower vehicles like 3-wheelers, cycles and cycle rickshaws in the traffic stream. Greater the percentage of slow moving vehicles such as auto rickshaw and cycles, lower is the possibility that speed data follows the normal distribution curve. Due to the higher percentage of slow moving vehicles in the traffic stream, a second peak in the speed distribution curve is observed. Second thing which we concluded from this study is that the sections having SSR range from 0.89-1.16 follows the normal distribution curve. The Speed Spread Ratio (SSR) defined in this paper is able to provide good information on the normality in the speed data. It is analysed in this study that speed data on an urban road would follow the normal distribution as long as SSR is within the range of 0.89-1.16. Two peaks are observed in the speed data when SSR is either less than 0.89 or more than 1.16. The second peak occurs when proportion of slow moving vehicles is more or pedal cycles are present in the traffic stream.

6. Acknowledgement

For getting success in any field of life one only needs guidance and inspiration, both being very important as they help at each and every step in achieving the goal. I feel highly thankful to Lovely Professional University to avail me facility during this project. It’s an honor to express thankfulness to Ms. Niharika Gupta (Assistant Professor) to avail best guidance during this project. Also I am very thankful to my parents for their best guidance, inspiration and financial help for completing the project.

7. References

1. Leong HJ. The distribution and trend of free speeds on two-lane-two-way rural highway in New South Wales. Proceeding of 4th Australian Road Research Board Conference; 1968. p. 791–814.
2. Kadiyali LR, Lal NB, Sathyanarayana M, Swaminathana AK. Speed-flow characteristics on Indian highways. Journal of Indian Roads Congress; 1981 Oct. p. 233–62.
3. Van Aerde M, Yagar S. Volume effects on speeds of two lane highways in Ontario. Transportation Research Records. 1983 July; 17(4):301–13.
4. Ashish D, Satish C. Speed characteristics of mixed traffic flow on urban arterials. International Journal of Civil, Environmental, Structural, Construction and Architectural Engineering. 2013 Dec; 104:342–51.
5. Najjar YM, Stokes RW, Russell ER. Setting speed limits on Kansas two-lane highways. Transportation Research Record 1708, Transportation Research Board, Washington D.C; 2000 Sep. p. 20–7.
6. Al-Ghamdi. Spot speed analysis on urban roads in Riyadh. Transportation Research Record 1635, Transportation Research Board; 1998 Nov. p. 162–70.
7. Sampathkumar V, Vanjinathan J, Pemmaraju VR. Intersection improvement at Moolkadai along Grand Northern Trunk Road in Chennai. Indian Journal of Science and Technology. 2015 Oct; 8(28):1–5.
8. Singh B, Tripta G. Study of traffic volume and level of service of Panjab University, Chandigarh. International Journal of Engineering Research and Applications. 2015 Jul; 5(7):9–14.
9. Maradkhani A. Evaluation of traffic characteristics. International Journal of Recent Trends in Engineering. 2009 May; 1(6):62–8.

10. Parthasarathi V, Surya M, Akshay B, Siva KM, Shriram KV. Smart control of traffic signal system using image processing. Indian Journal of Science and Technology. 2015 Jul; 16(8):1–5.

11. Mclean JR. Observed speed distribution and rural road traffic operations. Proceeding of 9th Australian Road Research Board Conference, Australian Road Research Board, Vermont South, Victoria; 1978 Aug. p. 235–44.

12. Shah PM, Niharika G. Study of traffic flow characteristics on the National Highway (NH-1) connecting Jalandhar Phagwara. International Journal of Latest trends in Engineering and Technology. 2016 Mar; 6(4):1–12.

13. Sahoo PK, Roa SK, Kumar VM. A study of traffic flow characteristics on two stretches of national highway-5. Indian Highways, Indian Roads Congress, New Delhi, India; 1996. p. 11–18.

14. Swaminathan CG, Kadiyali LR. Road user cost study in India. Journal of Indian Roads Congress. 1983 Nov; 44(1):191–289.

15. Haight FA, Mosher WW. A practical method for improving the accuracy of vehicular speed distribution measurements. HRR341, Highway Research Board, Washington D.C; 1962. p. 92–116.

16. Katti BK, Raghavachari S. Modelling of mixed traffic speed data as inputs for the traffic simulation models. Highway Research Bulletin 28, Indian Road Congress, New Delhi, India; 1986. p. 35–48.