Development of Speed Prediction Models for Different Categories of Roads

Teja Tallam and Bhukya Bhadru

Abstract Speed is one of the fundamental measures of traffic flow and level of service. It indicates the mobility of vehicle performance and quality of vehicles plying on roads. In the present scenario, due to increasing the more number of vehicles, the average stream speed of the traffic is becoming a bigger concern to traffic planners and engineers. For controlling traffic, optimizing vehicular operations and decreasing the conflicts and predicting the speeds of the vehicles under variable conditions help in better planning of the road network. In this paper, speed prediction equations were developed for different categories of roads network like National Highway (NH-44) at Kompally, State Highway (SH-6) at Gandimaisamma, arterial road at Himayath Nagar and sub-arterial road of Pragati Nagar, Hyderabad. Data was collected during peak hour with the help of the video camera. Vehicular volume and speeds were extracted for an interval of every 10 min. The vehicle speed varies with road geometry depends on different categories of roads. The percentile speed will also vary with functional characteristics of roads. The percentile speeds were calculated for all types of roads, i.e. 15th, 50th, 85th and 98th percentiles. The vehicle volumes are converted into passenger car unit (PCU) for each location. The vehicles classified into two-wheeler, three-wheeler; car, bus and light commercial vehicles. Graphs were drawn for each location by using Greenshield's model to obtain maximum speed capacity of roads. Regression technique is used to develop an equation for predicting speeds at each location.

Keywords Greenshield's model · Percentile speeds · Speed prediction · Different categories of roads

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T. Tallam (✉) · B. Bhadru
Department of Civil Engineering, VNR Vignana Jyothi Institute of Engineering and Technology, JNT University, Hyderabad, India
e-mail: tnteja@gmail.com

B. Bhadru
e-mail: bhanunaik295@gmail.com

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1 Introduction

Speed is one of the principal proportions of traffic execution of roadway frameworks. It shows the versatility of vehicle execution on streets and nature of vehicle employing on streets. In the present situation, because of increment in the quantity of vehicles, the vehicle portability is influenced the most prompting substantial traffic issues. In the past inquires, speed was used as a fundamental parameter for evaluating the traveller vehicle unit (PCU) for different vehicles on a road. In this way, speed models have been created by analysts to work out the working velocity on a roadway. In this exploration, speed forecast of various characterizations of streets like national highway, state highway, arterial road and sub-arterial road is talked about.

The speed of the vehicles varies with different locations depends on the category of the road and functional characteristics like lane width, number of lanes, type of median, shoulder width, side walking, pedestrian facilities, etc. Generally, in national highways, the vehicles are plying with their design speed, and no restriction takes place on highways when compared with other roads. In some cases, the speed is influenced by driver behaviour, improper geometric design and heavy truck loads. In state highways, the vehicles speed is influenced by the volume of vehicles, geometric parameters like number of lanes, width of lanes, shoulder width and functional characteristics. In arterial road, speed is influenced by volume of vehicles, width of road, type of median, size of population, number of junctions, pedestrian crosswalks and un-necessary parking on roads.

2 Literature Review

Many researchers have focuses the study on speed prediction model, especially homogeneous traffic condition.

Donnell et al. [1] developed speed prediction model for trucks on two-lane rural highways. A series of regression model was developed using a combination of field data and simulation data. Finally, a series of regression model was developed to predict 85th percentile truck operating speeds of upstream along with down streams on horizontal curve.

Crisman et al. [2] developed speed prediction model for two-lane rural roads. They studied to overcome the problem of decreasing accident rates at horizontal curves for the previous research.

Abbas et al. [3] presented the empirical research and empirical model to predict the 85th percentile operating speed models for the horizontal curves on two-lane rural highway condition and they developed multiple linear regressions to predict the 85th percentile speed of vehicles on horizontal curves in two-lane rural highways.

Dhamaniya and Chandra [4] proposed that speed information might possibly pursue the typical conveyance relying on the extent of moderately slower vehicles like three-wheelers in the rush hour in traffic stream. They introduced a new term called speed spread ratio (SSR) for predictor of normality in the speed data.

Dhamaniya and Chandra [5] developed the equations for relating speed with density of individual category of vehicles. These equations are then analyzed for the composition of traffic stream for fixed values of traffic volumes and for varying volumes levels at fixed traffic composition. As the solution is based on iterative process, a mathematical program has been developed in MATLAB software to solve this equation.

Razzaq [6] developed a model to predict free-flow speed for multi-lane highways and created a model for evaluating normal free-flow speed and for recognizing the appropriation of individual free-flow speed.

3 Objectives

The main objectives of the study are

1. To analyze the variation of 15th, 50th, 85th and 98th percentile speeds for different types of roads.
2. To predict speeds in different classifications of the roads like national highway, state highway, arterial road and sub-arterial road.

4 Methodology

The methodology adopted in this study is shown in Fig. 1.

5 Study Locations

Four locations were selected for this research involving various categories of roads like National Highway (NH-44), State Highway (SH-6), arterial road and sub-arterial roads are shown in figures (Figs. 2, 3, 4 and 5).

Video recording method was done for capturing traffic flow and its volume at peak hour for each. Each individual vehicular volume (2w, 3w, car, bus, LCV) and speed was extracted from the videos for an interval of every 10 min.

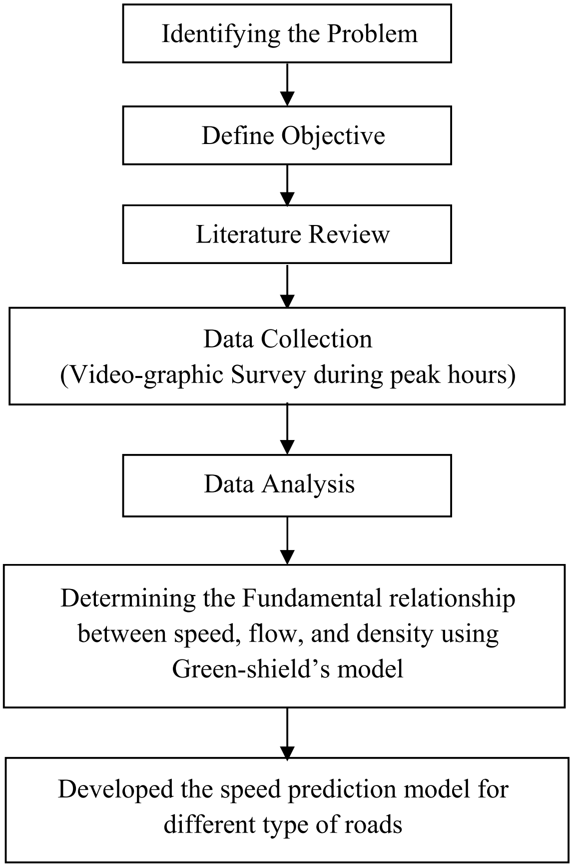

Fig. 1 Methodology adopted for the present research

Fig. 2 Kompally (NH-44)

Fig. 3 Gandimaisamma (SH-6)

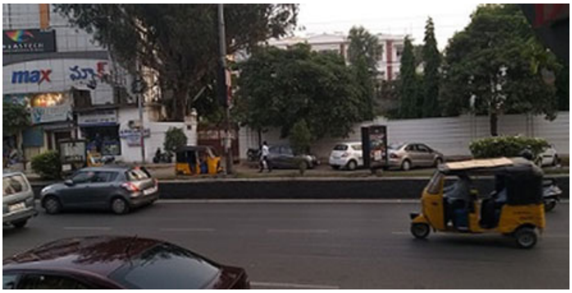

Fig. 5 Himayath Nagar (arterial road)

Fig. 4 Pragati Nagar (sub-arterial road)

6 Data Analysis

A cumulative frequency curve is being plotted between speeds and percentage of vehicles for each location to obtain variation of speeds and is shown in Table 1.

From the table, it can be observed that design speeds (98th) are higher for NH, followed by sub-arterial road instead of arterial road due to higher vehicular volume on arterial roads.

Table 1 Percentile speeds for each location

Type of speed	National highway (NH-44 Kompally) (kmph)	State highway (SH-6 Gandimaisamma) (kmph)	Arterial road (Himayath Nagar) (kmph)	Sub-arterial road (Pragati Nagar) (kmph)
98th percentile	80	35	45	59
85th percentile	58	29	31	44
50th percentile	42	21	22	32
15th percentile	30	16	16	26

Also, to understand the relation between category of road and maximum vehicular speeds, graphs were plotted between vehicular speed and density and are shown (Figs. 6, 7, 8 and 9).

Using Greenshield's Eq. (1), free-flow speed (V_{f}) and jam density (K_{j}) were calculated for all the locations and are shown in Table 2.

$$v = V_{\mathrm{f}} - \left(V_{\mathrm{f}} / K_{\mathrm{j}}\right)k \quad (1)$$

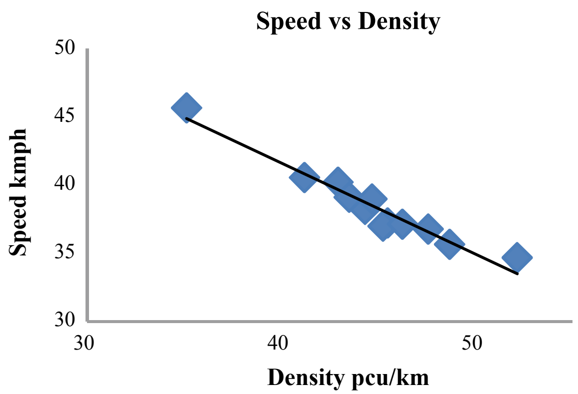

Fig. 6 Speed versus density for NH

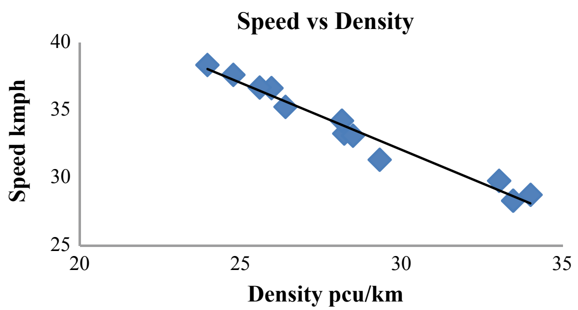

Fig. 7 Speed versus density for SH

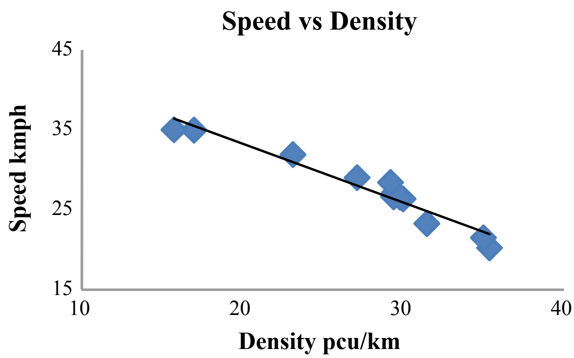

Fig. 8 Speed versus density for arterial road

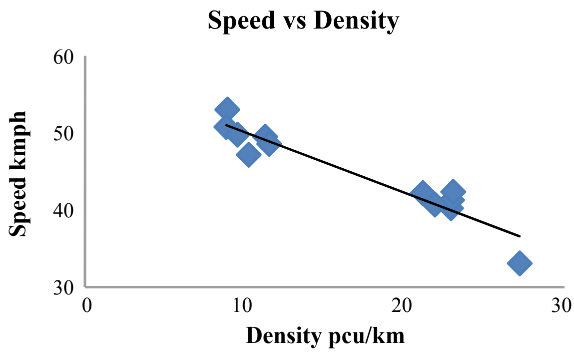

Fig. 9 Speed versus density for sub-arterial road

Table 2 Free-flow speed and jam density

Type of road	Free-flow speed (V_f) (kmph)	Jam density (K_j) (veh/km)
National highway	68.39	102.21
State highway	45.70	62.47
Arterial road	47.98	61.21
Sub-arterial road	57.93	73.89

where

V = mean vehicular speed in kmph
K = vehicular density in veh/km
V_f = free-flow speed in kmph
K_j = jam density in veh/km

Based on above data, the speed prediction models were developed for four locations, i.e. National Highway (NH-44), State Highway (SH-6), arterial road and sub-arterial road. The classification of vehicles and their individual volumes (X) were considered as speed predicting (Y) variables of this research. The speed prediction equations obtained using regression technique are shown in the below equations.

For national highway

$$Y = 73.36899 - 2\text{W}\ (0.06856) - 3\text{W}\ (0.11931) - \text{Car}\ (0.09371) - \text{Bus}\ (0.37164) - \text{LCV}\ (0.18644)\left\{R^2 = 0.925\right\} \quad (2)$$

For state highway

$$Y = 58.54719 - 2\text{W}\ (0.11143) - 3\text{W}\ (0.15076) - \text{Car}\ (0.25703) - \text{Bus}\ (0.26644) - \text{LCV}\ (0.35085)\left\{R^2 = 0.951\right\} \quad (3)$$

For arterial road

$$Y = 48.11562 - 2\text{W}\ (0.09134) - 3\text{W}\ (0.1459) - \text{Car}\ (0.08444) - \text{Bus}\ (0.60622) - \text{LCV}\ (0.31714)\left\{R^2 = 0.913\right\} \quad (4)$$

For sub-arterial road

$$Y = 61.72965 - 2\text{W}\ (0.09554) - 3\text{W}\ (0.17866) - \text{Car}\ (0.11342) - \text{Bus}\ (1.04777) - \text{LCV}\ (0.046675)\left\{R^2 = 0.932\right\} \quad (5)$$

The equation can be used for predicting the average vehicular speeds for the respective category of road.

7 Conclusion and Discussion

From the collected speed data, *S*-curves were drawn between vehicular speeds and % of cumulative frequencies, from that the percentile speeds of 15th, 50th, 85th and 98th speed for different types of roads were obtained.

Based on extracted data of vehicular speed, density and flow from four locations, the graphs were generated using the Greenshield's Eq. (1) to predict free-flow speeds and jam densities.

Based on individual vehicular volumes at each location, using multi-linear regression technique equations were developed to predict the average vehicular speeds. Their R^2 values for predicted speed equations for national highway ($R^2 = 0.925$), for state highway ($R^2 = 0.951$), for arterial road ($R^2 = 0.913$) and for sub-arterial road ($R^2 = 0.932$). This means R^2 values were best fit for all the above equations which are more than 90% of accuracy.

References

1. Donnell, E. T., NI, Y., Adolini, M., & Elefteriadou, L. (2001). Speed prediction models for trucks on two-lane rural highways. *Transportation Research Record, 1751,* 44–55. Transportation research board, Washington, D.C.
2. Crisman, B., Marchionna, A., Perco, P., & Roberti, R. (2004). Operating speed prediction model for two lane-rural roads. In *Proceedings of the S11V International Conference*. Florence, Italy.
3. Abbas, S. K. S., Adnan, M. A., & Endut, I, R. (2011). Exploration of 85th percentile operating speed model on horizontal curve: A case study of two-lane rural highways. *6th International Symposium on Highway Capacity and Quality of Service*, Stockholm, Sweden.
4. Dhamaniya, A., & Chandra, S. (2013). Speed characteristics of mixed traffic flow on urban arterials. *World Academy of Science, Engineering Technology International Journal of Civil and Environmental Engineering, 7*(11).
5. Dhamaniya, A. & Chandra, S. (2013). Speed prediction models for urban arterials under mixed traffic conditions. In *2nd Conference of Transportations Research Group of India (2nd CTRG).* Department of Civil Engineering. Indian Institute of Technology, Roorkee-247 667, India.
6. Razzaq, A. K. (2017). *Model development to predict free flow speed for multi-lane highways.* Research & Reviews: Journal of engineering technology. Civil Engineering Department, Faculty of Engineering, University of Kufa, Iraq.