R4TLI
ISSN: 2513-2504

A COMPARATIVE STUDY OF TRAFFIC FLOW MODELS: A CASE STUDY IN COLOMBO, SRI LANKA

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ABSTRACT - The hassle-free travelling environment is one critical factor that will make any city attractive to its residents and visitors. However, Colombo, the commercial capital of Sri Lanka, faces massive traffic problems. Therefore, recalibrating and revalidating traffic model parameters are essential to better predict Colombo traffic characteristics for better transport planning and operation. The attribute values estimated for Sri Lanka from previous studies have become outdated. Moreover, no comparison of traffic flow models has been conducted based on current or recent Sri Lankan vehicle mix or road designs. Further, finding models developed to derive traffic flow variables on different road sections are hard to find. Hence, this study fulfils the above gap by estimating new attribute values using R software for different road sections in the Colombo District using Greenshields, Greenberg, Underwood models and their extended modifications.

Keywords: Greenshields; Greenberg; Traffic Flow; Model Comparison; Sri Lanka Traffic

1. INTRODUCTION

With the development of society, environment and technology, the behaviour of the people's travel patterns and the variance of those vehicles' performance capacity, the traffic flow mix have changed. Hence, from time to time, updating the traffic flow variables is very important. However, using the same traffic flow variables and models is inaccurate and calculated from other countries or international standard values. The variables are affected by social, economic, and environmental behaviour, not only country-wise but also region-wise. Therefore, existing traffic flow models published by other countries cannot be directly applied to Sri Lanka without proper validation. Many variables have been identified to capture the road traffic fluctuations. Out of those variables, several model creators have used Speed, Flow, and Density as the three key variables to identify the traffic flow with a high success rate [1] [2]. Therefore, the main objective of this research is to develop and validate a new model for Sri Lanka under different road categories. Many studies have been conducted to identify the relationship between Speed, Flow and Density. Greenshields model shows the linear relationship between Speed and Density. But in the field we can hardly find such a relationship between speed and density. The Greenberg model and Underwood model represents logarithmic relationship and exponential relationship respectively between Speed and Density [1]. Therefore, the derived free flow speed from Greenberg's model will be infinite while the derived Jam density from Underwood's model will be infinite, and speed will never reach zero. Those disadvantages can be lessened from Greenshield's model. Hence, calculated variables will be used to identify the most suitable traffic flow model for Sri Lankan roads, comparing Greenshield's model, Underwood's exponential model and Greenberg's model [2].

2. MATERIALS AND METHODS

With recent developments in technology, transport professionals have rich data sources to calculate their jurisdictions' attributes. The advantages of video as an observational technique have been proven to be accurate, detailed, and complete than observations made by the bare human eye. Therefore, the following two methods were used in the data collection process: (1) manual vehicle counting method using video playback at laboratory and (2) on-site manual vehicle counting method to ensure the accuracy of the data set as much as possible. Since both manual and video traffic data collection need to be conducted at the same location to achieve the survey's objectives, the survey locations are selected carefully from Colombo district, Sri Lanka.

2.1. Estimating Traffic flow Variables

Speed - The time of a specific vehicle passing the provided two points is collected using the NP survey. The difference between the times was calculated to gain the travel time of the vehicle. This process was done simultaneously for a selected number of vehicles during both peak and off-peak periods.
Flow - All the vehicles were divided into selected ten categories. A Classified Vehicle Count was then conducted at a chosen point to collect the number of vehicles passing that point during a selected period.
Density - Video footage were taken to identify the Density of each location. First, an hour was split into four quarters and selected the first five minutes in each quarter, then captured the five pictures of the road areas and counted the vehicles in a selected area. Average density values of each five minutes were calculated, and these were measured in Passenger Car Unit (PCU) per lane per km. PCU value of each class of vehicle is very important for any mixed traffic flow studies at highways [3]. For this study, PCU values were taken from the manual document of Road Development Authority, Sri Lanka [4].

3. RESULTS AND DISCUSSION

The primary objective of this paper is to identify the relationships among Speed, Flow and Density by comparing main models; Greenshields', Greenberg and Underwood, by linear regression analysis. Traffic related data were collected from five different location, four different locations from highway and one location from expressway. After cleaning the data 64 data points were used for the analysis. During the time period of the survey, traffic conditions of the roads and the effect of the parked vehicles besides the roads were considered in deciding the number of lanes. The p-value obtained from the Kruskal-Wallis test conducted using R software is 2.2e-16. Therefore, it can be concluded that there are significant differences
in traffic flow patterns between the locations. Hence categorical variable analysis with dummy variables is conducted to build the regression models from traffic flow variables. The relationship between Speed and Density has been derived from the three traffic flow models based on Expressway Road category (Athurugiriya; 4 lanes) location, as shown in Table 1. The models for other four locations were derived relative to the base model, as shown in Table 2.

Table 1. Vehicle categories used for manual classified vehicle counting

Model	Linear Regression	Base Model	R^2	t-value
Greenshield	U = Uf - (Uf/Kj)*K	U = 83.59 - 0.19*K	0.954	0.0599
Greenberg	U = Uo*lnKj - Uo*lnK	U = 93.84 - 4.70*lnK	0.953	0.116
Underwood	ln(U) = ln(Uf) - (K/Ko)	ln(U) = 4.52 - 0.006*K	0.919	0.0104

Where,
U = Speed K= Density Kj = Jam Density Qm= Maximum Flow
Q = Flow Uf= Free flow speed Uo= Optimum speeds Ko = Optimum Density

Table 2. Developed regression models for other location

	Developed Model
Greenshields	U = 83.59 – 41.12*m - 47.94*p - 44.12*pe - 38.84*w - 0.19*K
Greenberg	U = 93.84 - 41.46*m - 48.25*p - 44.35*pe - 38.88*w - 4.70*lnK
Underwood	ln(U) = 4.52 - 0.70*m - 0.939*p - 0.79*pe - 0.679*w - 0.006*K

For, MLC (3 lane, Urban, One way): m = 1 ; if the location is at MLC along Duplication road, 0 otherwise
For, Pannipitiya (4 lane, Suburban): p = 1 ; if the location is at PDV along High Level road, 0 otherwise
For, Pettah (4 lane, Urban): pe = 1 ; if the location is at Fort RS along Olcott Mawatha, 0 otherwise
For, Wellawatta (4 lane, Urban) : w = 1 ; If the location is at Wellawatta RS along Marine Drive, 0 otherwise

As shown in Table 1 highest R^2 value has the Greenshields model. The R^2 value of the Greenberg model also has a similar significant level. Since R^2 values of both models are equal to 0.95. Comparing to these two models, the t-significant **v**alue of the Greenshields model is less than 0.1 while the value of Greenberg is higher than 0.1.

4. CONCLUSION

According to the results obtained and the evaluation of the results, it was identified that there is a significant difference (p-value - 2.2e-16) in traffic flow patterns at different road segments. Therefore, the developed location specific traffic flow models can derive the traffic flow variables in selected five locations. Furthermore, it was identified that Greenshield's model has the best fit based on the R - significant value, t - significant value and the normality distribution of these three models. In application of this methodology to other road segments may generalize the developed model by finding more results.

ACKNOWLEDGEMENT

This work is supported by the Accelerating Higher Education Expansion and Development (AHEAD) Operation of the Ministry of Higher Education funded by the World Bank grant (#6026-lk/8743-LK).

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