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Evaluation of Traffic Flow Behaviors for Two-way Single Roadways

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ABSTRACT

Recently in Ethiopia massive increase in population, way of life, car ownership and economic activities resulted rise in travel demand. Increment in travel demand are highly displayed in major city from this, city of Hawassa is good preference. Hawassa city is fast growing city and all of the above parameters are significantly observed. Due to this, the traffic flow pattern will vary time to time and corridor to corridor, so estimate and analyze this traffic flow characteristics were basic for proper traffic plan and implementation. Various combinations of motorized vehicles were stated in advancement of model and the results of the developed modal bring certain guidelines to improve the traffic flow characteristics in the urban areas under mixed traffic conditions and significantly limiting the percentage of Cars, Buses and Trucks within the range and result optimal operating speed in a given urban road facilities, for instance with 30% of (Bajaj and Trucks) and 10% of (Cars and Buses) and with 20% of Motor-cycle which is in all sub-conditions (except in third sub-condition) displays that the value for operating speeds are below 50 km hr-1 between 4m-10m lane width which are dominant combinations to be within the boundaries of facilities. Consequently, average operating speed are majorly be determined by percentage of traffic volume and then with the lane width and additional factors has impacts under mixed traffic conditions.

Keywords: Advancement of Model, Flow Parameters, Lane Width, Mixed Traffic Conditions

I. INTRODUCTION

The quantifiable characteristics of vehicular traffic flow states about traffic flow characteristics, this physical extent describe the traffic flow characteristic that are the traffic flow parameters. According to [10] traffic flow parameters are the traffic per unit length, traffic speed, traffic flow rate and headway. The study of various road traffic characteristics is essential for plan, design, and operation, regulation and control of traffic roadway facilities. These characteristics are studied by observing various aspects of traffic flow in the field, which are difficult and time consuming. When different categories of vehicles share the same road space without any physical separation, the extent of vehicular interactions differs widely with variation in traffic mix [9]. As stated by [12] traffic, flow has many parameters that are related to it. The purpose of providing traffic flow parameters is to allow analysis to understand driver and vehicle behaviour in addition to identifying variations in the traffic flow. Meanwhile the traffic stream is an arrangement of vehicle and driver behaviour it is considered as a non-uniform stream. In keeping with [11] traffic flow

variability deteriorates the road network reliability by perplexing the task of monitoring and controlling the operation of road networks and doubling travel uncertainty.

The road network reliability requires understanding the changing dynamics of traffic flow variation. Monitoring and alleviating traffic flow variability, hence, has caught the attention of operating agencies for the sake of avoiding unexpected delays and ensuring a smooth travel under normal traffic flow fluctuations. Finally, real traffic flow behaviour and pattern, requires quantification of basic traffic flow characteristics such as traffic volume, traffic speed and headway under mixed traffic and depending upon the width of the road, traffic flow and composition, speed, volume, density through which the variation in traffic flow characteristics will assessed.

A. Background of study Area

Hawassa city is one of the reform cities in the country of Ethiopia and it has a city administration consisting of eight sub cities and urban as well as rural kebelles. Hawassa city is fast growing city and have large industry parks, construction of Ethiopia-Kenya trunk road and Hawassa-Mojo express freeway roads in transport aspect, which enhance movement along the city. The total population for the city of Hawassa is exceeding 315,000 and annual population growth rate is 4.02% based on 2016 census data of Ethiopian statistical agency. Enormous increase in traffic flow activity time to time along the various corridors with in city are high observed due to the above activities.

B. Statement of Problem

The traffic in most developing countries such as Ethiopia is mixed that consist of vehicles of wide range of physical proportions, weight and load, dynamic characteristics that moving on any available part of road space without lane discipline. In Ethiopia, keep left traffic rule is followed for both motorized and non-motorized vehicles and share the same road space without any separation. Because of highly varying traffic flow, physical dimensions and speeds, the vehicles do not follow lane discipline, and move freely over the entire width of roadway, based on space availability. Therefore, these variations of flow traffic characteristics have to study with the support of representative value of the parameters in the field.

II. LITERATURE REVIEW

A traffic flow characteristic encompasses traffic volume, speed and composition on the given road. The data gathered from volume studies, speed and density are used to determine the capacity and level of service of a given road. The traffic volume data is helpful in planning, designing of the road system, while the speed and density data are essential in determine safety, vehicle speed percentile and composition of the road network [3]. The study delivers the fact that [13] analysis on traffic flow is an essential component of a city's traffic and transport systems, it is complementary elaboration of the flow of traffic on road networks, which is the mathematical representation of the interactions between vehicles, their operators and the infrastructure can be explained by traffic flow theories which seek to understand and develop optimal road networks that will allow the movement of traffic efficiently and capacity. The measurement of the capacity and what influences it, lie at the core of traffic flow theory.

A. Definition of Traffic Flow

Traffic flow denotes traffic load on transportation system, their load is essential to know the traffic flow variation in temporal, spatial, modal and composition of traffic stream [1]. Empathetic traffic behaviours requires a thorough knowledge of traffic stream parameters and their mutual relationships [2]. Traffic flow is now days very crucial for forecasting and operational implementation of traffic system as there is rapid boost in road users [3]. [5] To understand

traffic flow it needs to know relationships between the two main characteristics that are flow and velocity.

B. Theory of Traffic Flow

According to [4] traffic engineering got its roots as a rather practical discipline, entailing most of the time a common sense of its practitioners to solve particular traffic problems. [6] Also described that traffic flow theory and modelling started in the 1930s, pioneered by the US-American Bruce D. Green shields. [7] Traffic flow theory is simulation where algorithms are used to study complex interrelationships that exist among the elements of a traffic stream or network.

C. Macroscopic Traffic Flow Characteristics

[8] Provides that the macroscopic traffic flow characteristics are essential for functional effectiveness of a highway is measured in terms of its ability to assist and accommodate the flow of vehicles with both safety and efficiency. In order to measure its level of effectiveness, certain parameters associated with the highway must be measured and analysed.

D. Microscopic Traffic Flow Characteristics

Road traffic flows are composed of drivers associated with individual vehicles, each of them having their own characteristics. These characteristics are called microscopic flow characteristics. The dynamical aspects of these traffic flows are formed by underlying interactions between the drivers of the vehicles [4].

III. METHODS AND MATERIALS

The methodology majorly focuses on selected road sections with in Hawassa city, which are two-way two-lane roads. The collection of data and analysis focused on three midblock and additional one-road segments for evaluating flow parameters within four sub-cities. The data were taken for three weekdays and for one weekends, this are Monday, Wednesday, Thursday and Saturday. The days were taken based on several field visits and evaluation of thematic area that means the first and third stated days were local market day whereas the second and last stated day were representative to observe the flow characteristics. For analysis, Thursday was taken as representative and design day from four designated days, due to efficient number of traffic, more inclusive for study of traffic flow parameters and mixed type of traffic were observed.

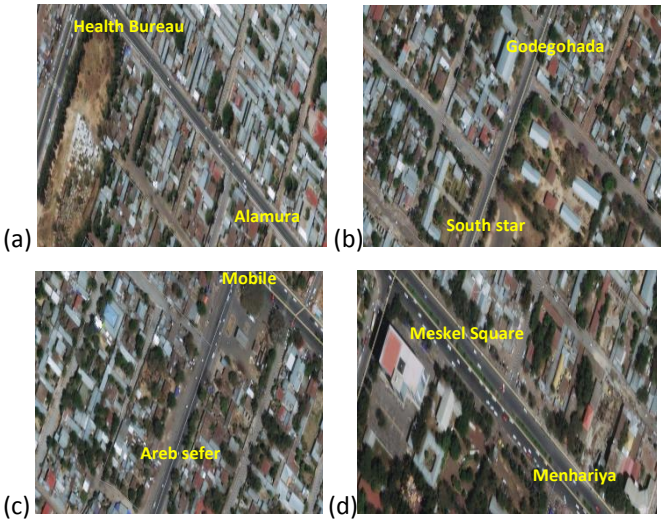

Figure. 1 Study area

A. Collection of Data

The gathered data were more of primary data. Practical gathering of the parameter were done on filed for the road corridors in different location with considerable procedures and guidelines. Traffic volume, Traffic speed, Time headway and Road width were collected for selected road corridors in different sub-city with in Hawassa city. The tools that adopted for collection of filed data were data collection format, plastic tape, chuck, digital camera and stopwatch respectively. Excel solver and SPSS are used. The location detail for all road sections were described in Table I below.

Table I Location detail for road sections

N.o	Name of locations	designation	road width(m)
1	Alamura- Health Bureau	RI	11.6
2	South star-Godegohada	RII	9.4
3	Mobile-Areb sefer	RIII	11
4	Meskel square - Menhariya	RIV	11.1

IV. RESULT AND DISCUSSIONS

A. Traffic volume (PCU)

Volume counting is done for 13 hour at 15-minute interval both direction. Traffic flow rate were determined at 15 minute rate and equivalent passenger car unit (PCU) was calculated based on PCU factors of ERA 2013. Starting from 6:00-9:00 am duration displays gradual increment in traffic volume (PCU) and then gradual increment and declines are observed throughout duration of time in Fig. 2 below. Compare to the rest road sections the peak period stays for short duration at peak period for Meskel square-Menhariya road section. Highest value in traffic volume at peak time from four study days were observed in Thursday. Their PCU and respective duration for all midblock were labelled below and (620.9pcu, 8:00-9:00am) for Alamura-SNNPR Health Bureau, (1260.4pcu, 12:00-1:00pm) for South star-Godegohada, (1753pcu, 8:00-9:00 am) for Mobile Areb sefer and (1271pcu, 9:00-10:00 am) for Meskel square-Menhariya midblock respectively.

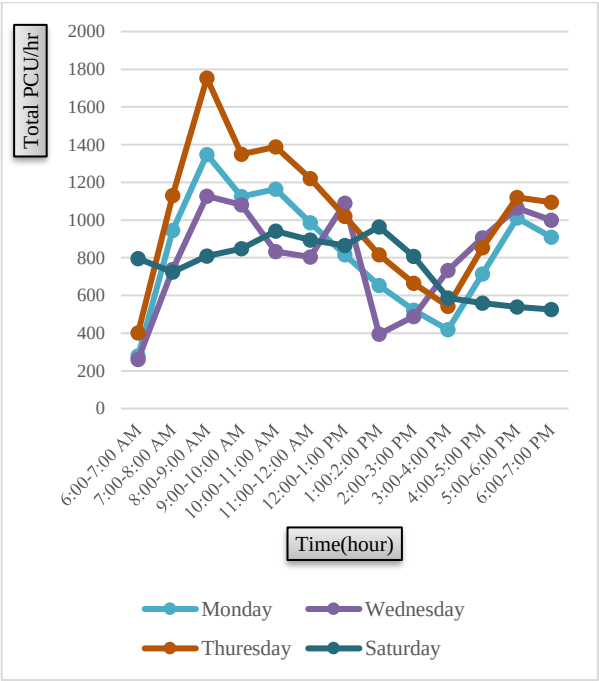

Figure. 2 volume (PCU) for Mobile-Areb sefer road section (typical route)

B. Traffic speed

After having the input traffic speed data, it is possible to determine frequency distributions and percentiles of speed. In the percentiles of speed are determined at 15th, 50th, 85th and 98th from the total sample. In Table II below shows that Meskel square-Menhariya section observed that their speed were less in value compare to the rest road routes because of presence of number of obstruction within the carriageway that results the motorized vehicles not to entertain their speed freely like, illegal on-street parking of taxis and other commercial vehicles, different market loading and unloading activities within the edge of the road and absence of fully functional pedestrian walkway.

Table II Summary of Percentiles speed for all road sections

Percentiles speed(km/hr)	Road sections			
	RI	RII	RIII	RIV
15	43.16	30.03	30.76	28.12
50	48.62	39.26	34.26	30.7
85	54.13	43.44	37.83	36.05
98	58.38	46.4	47.32	47.09

C. Time Headway

The summaries of Time Headway for all road routes were labelled in chart below in Fig. 3 below. The minimum gap acceptance in Meskel square-Menhariya road route was more compare to other route because of various obstruction within the carriageway those results the motorized vehicles not to maintain their minimum gap properly and entertain their speed freely.

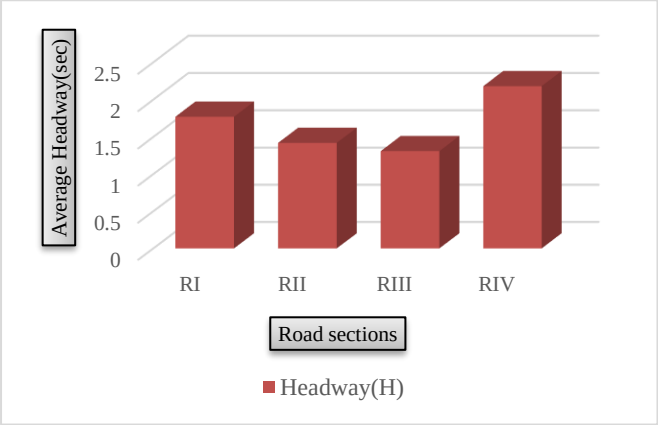

Fig. 3 Time headway for all routes in their main flow direction

D. Traffic Concentration

In this work traffic concentration is calculated from the traffic flow and traffic speed inputs data for all road routes. The analysis extends to determine capacity volume for all routes from set of collected data at four days and assessing level of service (LOS) in 15-minute time interval at design day. The summary for level of service (LOS) for all route is displayed in Table III below at peak time. The level of service in Meskel square-Menhariya route is entering in to congestion stage compare to the rest routes.

Table III LOS for all route in their main flow direction

Routes	Capacity volume(pcu)	Avg speed(km/hr)	V/C	LOS
RI	134.7	62.41	0.85	C+D=D
RII	272.34	48.77	0.9	D+E=E
RIII	309.75	37.74	0.84	E+D=E
RIV	215.5	33.36	1.58	E+F=F

E. Advancement of Model

The study focuses on three midblock, which are suitable and mixed traffic condition, were highly observed. Excel solver and Statistical package for social science (SPSS).

(a). Regression Modelling

Regression analysis are done for all two-way road sections by considering the basic requirements to fit the correlation of average speed with percent of volume of individual group of vehicles and lane width within in each section. This modelling are done in order to know the extent of correlation of percent of volume of motorized vehicles and lane width on the average operating speed and to know the pattern of the average speeds in each vehicle category with changing in lane width.

Both multiple linear and non-linear regression techniques will used in the analysis. In the modelling, all parameters in each section are prepared as input data's in regression modelling in combine manner. The multiple non-linear regression modelling does not fit perfectly with constraint that means the R2,standard error, F-value and significance level were close-fitting but the coefficient of the input motorized percentage volume of vehicles(specially for motor-cycle and buses are positive). This kind of problem was solved by adopting the multiple linear regression modelling. For all road sections, the parameters used for regression analysis input are percent of volume of individual vehicle groups, approaching lane width and average traffic speed. In this study, main flow direction data is taken as training data for correlation analysis and the opposing flow direction data's in each section taken as testing data for regression modelling. Number of samples in each section is 52 entities and 156 entities used for regression modelling. Excel solver and statistics package for social science (SPSS) tools are used for this analysis.

In the input data. preparation volume of individual motorized vehicles at 15 minute time interval between (6:00am-7:00pm) duration for each vehicle category are used and this volume is converted in percent from the total counted traffic volume are used for this analysis and the approaching lane width of each road sections and average operating speed that are determined in the above sections at 15 minute time interval are adopted for this analysis at design and representative day.

In the correlation, average operating speed was dependent variable and percent of number individual motorized vehicles in each category and lane width were independent variable in all two-way road sections. Input Data's adopted for this analysis is taken from design day (Thursday) in each section. After having the input data for all selected midblock then it is possible to make correlation between analysing parameters are done. The value indicate that the extent of correlation between the independent variable each other and with the dependent variable. From Table IV, the value for percentage of motorized vehicle are negative and for lane width is positive which displays that the increment in percentage traffic volume result decline in average operating in given lane width.

Table IV extent of correlation between the parameters

Correlation	%MC	%Bajaj	%Cars	%Bus	%Truck	Lane width
%MC	1.00					
%Bajaj	-0.48	1.00				
%Cars	-0.31	-0.59	1.00			
%Buses	-0.40	-0.12	0.07	1.00		
%Trucks	-0.50	-0.02	0.06	0.76	1.00	
Lane width	0.26	0.56	-0.84	-0.17	-0.19	1.00
Avg speed	-0.75	-0.37	-0.39	-0.18	-0.25	0.36

R2 value, F-value, standard error and significance level are the basic criteria and should be within the limit in order to have proper advancements and very strong correlation to create between the independent and dependent variables. In this advanced model all, the above parameters are within the criteria shown in Table V below.

Table V output for Regression statistics modeling in two-way two-lane road sections

SUMMARY OUTPUT		Coefficients		Standard Error
Regression Statistics		Intercept	403.238	28.157
Multiple R	0.993	Motor-cycle	-3.298	0.280
R Square	0.987	Bajaj	-4.044	0.280
Adjusted R Square	0.986	Cars	-4.057	0.281
Standard Error	0.862	Buses	-0.345	0.285
Observations	156	Trucks	-5.513	0.280
ANOVA		Lane width	2.777	0.287
	df	SS	MS	F
Regression	6	8218.366	1369.728	1843.618
Residual	149	110.701	0.743	Significance F
Total	155	8329.067		0.000

In this model observed that all parameter have significant impact on the average operating speed in all two-way road corridors shown in constraint (1) below.

$$\textbf{Avg speed} = 403.298 - 3.298(\textbf{PTV of Motor cycle}) - 4.044(\textbf{PTV of Bajaj}) - 4.057(\textbf{PTV of Cars}) - 0.345(\textbf{PTV of Buses}) - 5.513(\textbf{PTV of Trucks}) + 2.777(\textbf{Lane width}) \quad (1)$$

Where: PTV-Percent of traffic volume

The increase in lane width results the routes to have more space to travel and to entertain their drivers freely and to operate at their design speed. Generally, the composition of mixed traffic condition, obstruction with the road and approach road width are highly influence correlation formed between the above parameters and to suit in other route properly.

(b). Validation of Model

Validation of the model is done by fitting the advanced regression model in to testing data's (opposite flow direction parameters) and checking the extent of approaching of the actual available data in testing condition to the predicted set of data using the model. In Fig. 4 below that the points in predicted and actual condition are much close to the draw imaginary line which implies that the validation is acceptable for this model.

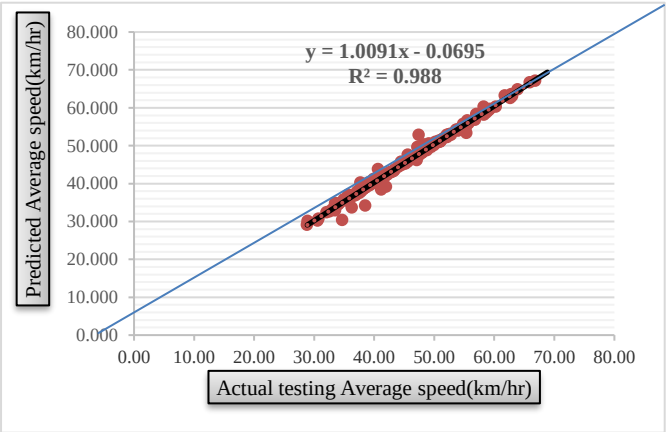

Fig.4 Actual and Predicted values in validation of model

(c). Analysis of Model

Analysis of the advanced model is done for all motorized vehicles with altered combination techniques and takes the minimum and maximum range of percent of traffic volume from set of existing collected data's in all route which is important to keep the boundary and observing there average operating speed. The width of lanes in all routes is used between 4m-10m range and in this analysis five motorized vehicle category also adopted. Four conditions are used for each motorized vehicles with varying percentage of traffic volume and approach lane width in all routes (a total of 20 conditions or 80 sub-conditions) for all motorized vehicles, it possible to conclude that significantly limiting the percentage of Cars, Buses and Trucks within the range and result optimal operating speed in a given urban road facilities. Again, when the lane width goes from 4m to 10m gradually significant operating speed variation are not observed in all combinations. So, the average operating speed are majorly be determined by percentage of traffic volume and then with the lane width and additional factors also has impacts under mixed traffic conditions and tries to recommend suitable and proper combination to urban road corridors and facilities to maintain their speed up to 70 km hr-1 are displayed in Table VI below.

Table VI Proposed combination of motorized vehicles with different composition for urban road corridors

Avg Speed with 5% Buses				Avg Speed with 10% Buses			
28.57	36.04	43.45	50.86	32.25	54.41	62.00	32.37
34.12	41.59	49.00	56.41	37.80	59.96	67.55	37.92
39.68	47.15	54.55	61.96	43.36	65.52	73.11	43.48
45.23	52.70	60.10	67.51	48.91	71.07	78.66	49.03
Avg speed with 40% Cars				Avg speed with 30% Trucks			
39.23	35.55	43.02	46.70	25.15	17.68	47.08	25.03
44.78	41.10	48.57	52.25	30.70	23.23	52.63	30.58
50.34	46.66	54.13	57.81	36.26	28.79	58.19	36.14
55.89	52.21	59.68	63.36	41.81	34.34	63.74	41.69

The proposed and selected combination is shown below in Fig.5 in chart form for different composition of individual motorized vehicles.

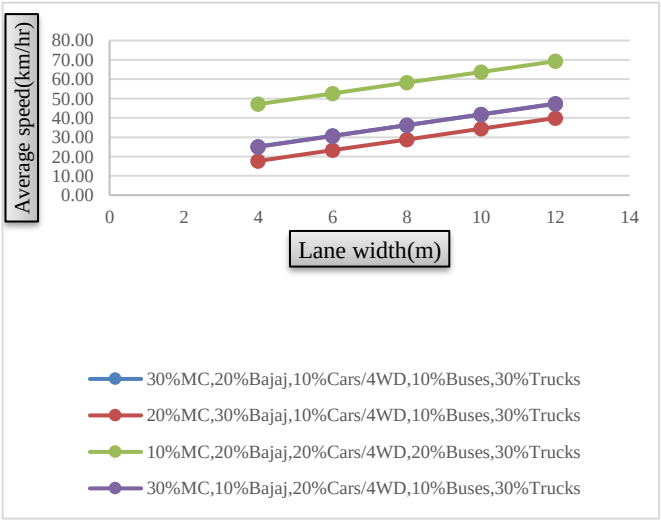

Fig. 5 proposed combination under 30% of Truck

V. CONCLUSIONS

In large scale the present study is conducted to analyse the traffic flow characteristics in urban areas under mixed traffic conditions. The model is further

utilized for the purpose of analysing the variation of traffic speed under different volume levels and road widths and also under different proportion of traffic and road widths. The results obtained indicated that the traffic speed decreases enormously as the traffic volume increases and moreover, the impact of higher size of vehicles, such as Buses, Trucks are having more influence on the traffic speed reduction rather than light vehicles. The results also indicate that the traffic speed increases as the approach road width increases and vice versa. This clearly indicates that the traffic speed is a function of traffic volume, composition of the traffic and the available road width in case of mid blocks in the urban areas.

The operating speed for all midblock are studied and shows variations from section to section and influenced by their current condition, the speed of incoming vehicles in opposite flow direction, approach lane width and external factors like on-street parking within the carriageway. Especially these effects of on-street parking in operating speed are observed in Mobile-Areb sefer and Meskel square around-Menhariya sections. It conclude that, this two-way two-lane roads are proper and major task to analyse in service and operation period in order to evaluate their status in current conditions with advancement of correlation to know the pattern and extent of flow characteristics within the carriageway.

VI. REFERENCES

[1]. A. D. May, Traffic flow fundamentals, Virigina: Adivision of Simon and Schuster Englewood Cliffs, New Jersey 07632, 1990, p. 83.

[2]. T. V. Mathew and K. V. K. Rao, "Fundamental Parameters Of Traffic Flow," in Introduction to Transportation Engineering, Bombay, 2007, pp. 30-38.

[3]. P. M. Shah and N. Gupta, "Analysis of Speed Parameters of Mixed Traffic Flow on the Sections of Arterial Streets (Jalandhar and Chandigarh Cities)," Indian Journal of Science and Technology, vol. 9, no. 47, p. 1, December 2016.

[4]. S. Maerivoe and B. D. Moor, "Traffic Flow Theory," Katholieke Universiteit Leuven, vol. I, no. 2, p. 2, 2 Feaburary 2008.

[5]. S. Yamuna, "Study of Traffic Flow Characteristics for Heterogeneous Traffic," IOSR Journal of Engineering (IOSRJEN), vol. 04, no. 05, p. 42, 2014.

[6]. M. Treiber and A. Kesting, Traffic Flow Dynamics, Verlag Berlin Heidelberg: Springer, 2013, p. 55.

[7]. N. J. Garber and L. A. Hoel, in Traffic and Highway Engineering, 4th ed., vol. III, Virginia, Printed in the United States of America, 2009, p. 213.

[8]. M. Rogers, Highway Engineering, 1st ed., vol. I, Ireland: TJ International Ltd, Padstow, Cornwall, 2003, p. 73.

[9]. V. T. Arasan and R. Z. Koshy, "Methodology for Modelling Highly Heterogenous Traffic flow," Journal of Transportation Engineering, vol. 131, no. 7, pp. 544-551, 2015.

[10]. Z. Haizheng, S. Yuelong, Y. Danya and Z. Yi, "Evaluation of Imbalanced developement vehicles and urban road classical traffic flow model," Journal of Highway and development research and development, vol. 6, no. 2, pp. 86-90, 2012.

[11]. A. Ermagun and D. Levinson, "Traffic Flow Variation and Network Structure," in Presentation at 97th Annual Transportation Research Board Meeting, Minnesota, 2017.

[12]. Y. Amnay, "An Initial Study for a Proposal for Handling Traffic Flow in Ifrane during Tourist Season," Ifrane, 2015.

[13]. E. L. Mararo, A. Gariy and M. Josphat, "A Macroscopic Fundamental Diagram for Spatial Analysis of Traffic Flow: A Case Study of Nyeri Town, Kenya," American Journal of Civil Engineering, vol. 3, no. 5, pp. 150-156, 2015.

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