Automobile Level of Service Analysis For Urban Road Links Carrying Heterogeneous Traffic

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Abstract- *Amongst the various modes of road transportation, automobile is the most dominant one. Hence, the safe accommodation of automobilists is a matter of utmost concern for the transportation planners and engineers. However, the automobile level of service (ALOS) criteria are not well-defined for the contexts of developing countries. In this regard, the present research has taken an initiative to analyze and model the ALOS of urban road links carrying heterogeneous traffic. For the analysis purpose, extensive data sets are collected from 70 road links of five Indian cities .The collected data sets include various information on the geometric, traffic and built-environmental characteristics of road links, and perceived satisfaction scores of automobile users. Spearman's correlation analysis has been carried out to identify six link attributes having significant influence on the ALOS criteria such as: effective width, traffic volume, traffic speed, land-use pattern, on-street parking turn-over and automobile stop rate. Incorporating these variables, an ALOS model has been developed with the help of step-wise regression analysis. The developed model has shown high reliability in the present context with a coefficient of determination (R2) value of 0.84 with averaged observations. Further, the sensitivity analysis of the model is also carried out to identify the relative importance of modelled link attributes. It is observed that ALOS of road links is largely determined by traffic speed and automobile stop rate. The key findings of this study would largely help the transportation engineering professionals for assessing the service quality of existing urban road links and taking effective decisions for further improvements.*

Keywords- Urban road link, heterogeneous traffic, automobile level of service, step-wise regression, sensitivity analysis

I. INTRODUCTION

1.1 GENERAL:

The automobile is the most dominant mode of road transportation, which includes several vehicle classes such as motorcycles, passenger cars, light commercial vehicles, and auto-rickshaws. With the tremendous increase in traffic density over the past few decades, transportation engineers are finding it greatly challenging to provide desired comfort levels to the automobile users. Researchers in developed countries have made several attempts to explore the factors influencing operational characteristics of motorists. Several methodologies are also proposed for the systematic analysis of urban street performance from the motorist's perspective. An in-depth understanding of these influencing factors along with the service prediction model plays a major role in the planning and designing of better-class transportation systems. However, the models proposed in developed countries are not transferable to the contexts of developing countries where road geometric and traffic flow conditions are considerably different from the former context. In the developed countries, the road traffic is primarily composed of identical vehicles and follows the lane discipline, called as homogeneous traffic. Conversely, the road traffic in developing countries is heterogeneous in nature, which symbolizes a diverse mix of fast and slow moving vehicles traveling with no-lane discipline. Thus, the same service prediction models cannot suitably analyze the quality of automobile operations under these two types of contexts. Although 83% of the total world population resides in developing countries, no standard handbook like the "Highway Capacity Manual" (HCM) is available for the reference of road authorities in these countries. Few studies carried out in the state of the art have considered 'travel speed' as the only measure of effectiveness. The concerned researchers have mostly followed the principles of TRB and defined the urban street level of service (LOS) in terms of travel speed ranges. However, the perceived satisfaction levels of automobile users are influenced by various other parameters (related to geometric elements, built-environmental conditions, and efficiency of the boundary intersections, etc.) and cannot be quantified in terms of travel speed alone. In this regard, this study has attempted to define the automobile level of service (ALOS) criteria through the in-depth analysis of users' opinions on the existing on-road riding environment.

Indian traffic characteristics are highly different from those in the developed countries. The ALOS of urban streets in Indian context is yet to be defined properly. Here, ALOS represents the service quality perceived by automobile users on a road facility. It is also measure of traffic service quality that compares the number of vehicles using a given road segment during a single peak hour with the number of vehicles that the facility is designed to handle safely. As per IRC 106:1994, ALOS in urban road scenario defines ALOS F as average . passenger vehicle speed below 25%-33% of free flow speed (FFS) in speed-flow graph. The free flow speed in study area has been estimated equal to 60 km/ph, which underlines that at or below avg. speed of 20 km/ph (33% FFS) in study links LOS approaches F “irrespective of flow”. There have been other attempts including Kumar and Rao (2001) in defining level of service criteria of urban streets in Indian context to estimate ALOS in heterogeneous traffic by different methods which may be more suitable than IRC methods.

1.2PROBLEM STATEMENT

India is in the list of developing countries and suffers from several problems of traffic management. Proper actions for road service quality enhancement can help this country to drive the path to a more secure life. Automobiles such as cars, bus and bikes are the attractive and fast mode of transport for communicating to work places, educational areas, and home, etc. However, today, the urban road networks are suffering from the problems like decreasing speeds, increased congestion, increased travel time, decreased level of service and increased accident rates. The ever-increasing demand for urban networks and variety of problems that occur daily has outstripped the ability of traditional traffic management practices. Because of space and budget constraints and environmental concerns, building new and bigger roads is not the answer to solve the present transportation problems. Instead, transportation experts are now focusing on promoting more efficient use of existing capacity of urban transport network. This is achieved by the proper management of traffic flow by giving due considerations to the factors affecting users’ perceived ALOS in the planning and designing stage itself.

To support the aforementioned process, suitable methodologies are yet to be developed. In particular, efficient ALOS models are to be developed to assess the perceive comfort level of automobile users on urban road links. The outcomes of the studies carried out in developed countries are not transferable to developing countries due to differing traffic flow and road geometric conditions. Other studies carried out previously in developing countries have mostly defined the urban street LOS based on travel speed ranges. However, LOS is a quantitative measure, and is affected by various geometrical, operational and built-environmental factors. Hence, a detailed investigation in this aspect should be carried out and suitable ALOS models should be developed for the present context.

1.3 STUDY OBJECTIVES:-

Based on the problem statements discussed earlier, the objectives of this study are:

- Identification of the factors affecting ALOS of urban road links under heterogeneous traffic flow conditions
- Development of reliable ALOS models for of urban road links
- Testing the reliability and validity of development models.
- Defining the ranges of ALOS classes (A-F)

1.4 ORGANIZATION OF THE REPORT

This report is organized into seven chapters.

The first chapter introduces the topic, defines the problem and provides the objectives and scope of the present work.

In the second section a dialog on urban road and dimension of administrations ideas have been introduced. The third chapter presents the review of literature on level of service analysis of urban streets , and application of Regression method and tools in traffic studies.

The fourth chapter presents various methods that can be applied in analyzing level of service with proper validation measures and reliability analysis in defining level of service criteria.

The fifth chapter presents study area and data collection procedure for the present study.

In sixth chapter, results and analysis of the findings have been presented. The seventh chapter presents summary, conclusions, contributions, applications and limitations with regard to the present work and highlights scope of future work.

1.5 OVERALL FRAMEWORK OF THE STUDY

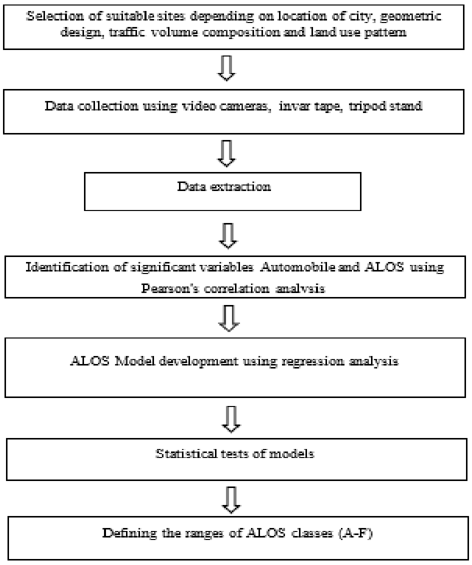


Fig 1: Flowchart

II. LITERATURE REVIEW

Quality of Automobile Traffic Management at Urban Road Links :-

In this chapter, basic aspects relating to urban streets and level of service are introduced. The term “urban street”, as used in this work, refers to urban arterials and collectors, including those in downtown areas. Urban street quality of service requires quantitative measures to characterize operationalconditions within a traffic stream. Dimension of administration is a quality measure portraying operational conditions inside a traffic stream, for the most part as far as such administration measure as speed and travel time, travel wellbeing, and comfort and convenience (*HCM 2000*).

This study proposes Automobile level of service (ALOS) models for the urban road links approaches operating under heterogeneous traffic flow conditions prevailing in developing countries. Extensive data collections were carried out through field investigations, videograpy techniques and perception surveys to inspect which parameters are primarily affecting the quality of motorized on the mentioned facilities. As many method are carried on automobile Separate ALOS models were developed for road links and Automobile through movement at signalized intersections through the application of a novel evolutionary artificial intelligence technique namely, multi-gene genetic programming Artificial intelligence techniques, fuzzy logic, rule-based system. The link model included eight significant variables in total whereas the intersection model included a total of seven. With compacted structures, the two models spoke to incredible reliabilities in the present setting and created high coefficient of assurance (R2) estimations of above 0.86 with arrived at the midpoint of perceptions. These models would help the traffic planners and engineers to evaluate the service levels of urban facilities of developing countries. Statistical analysis of modeled parameters has reported that the trafficvolume have the highest influences on the quality of traffic management at urban road links and intersection approaches respectively

III. METHODOLOGY

3.1 GENERAL

This section provides the overall framework adopted to model the ALOS of urban road links.The field data on travel time and travel speed are available; this framework can be used to determine the street’s Automobile level of service. Also, the direct measurement of the travel speed along an urban street provides an accurate estimate of ALOS.

The most recent methods in the field of Automobilelevel have been indulged into the model development process. The study describes the methods briefly and the significance. Regression analysis is done for analysis Arterial and collector streets, traffic flow condition, Speed variations, traveling models. An urban street provides an accurate estimate of ALOS by using the regression analysis it is filed base method which used for developing country’s.Thus a brief discussion of these method approaches is presented below for completeness.

IV. STUDY AREA AND DATABASE PREPARATION

4.1 GENERAL

This chapter describes the suitable site selection based on their geometric design, traffic parameters and environmental condition. The study area selected for the video survey carried out on single and double lane road AlOS throughout the model development by using the artificial intelligence techniques followed by the step-wise regression analysis. The required data includes both quantitative data and qualitative data of lane.Quantitative data consists of the geometric features and characteristics of vehicle volume, percentage of vehicle composition, type of area, effective width, speed details, pavement markings, pavement conditions etc.the qualitative data contains the perception of survey that how much level of comfort feels by the Automobilist at traveling. Hence, to meet the objective of the project work, the data were collected from Bhubaneswar (Odisha), Nagpur (Maharashtra), Lucknow (Uttar Pradesh), Ranchi (Jharkhand), Tirupati (Andhra Pradesh), Anantapur (Andhra Pradesh), and Kurnool (Andhra Pradesh).

4.3 DATA COLLECTION

Data collection process was carried out by videography technique. The data was collected using the high resolution camera, tripod stand and measuring tape. The camera was set up at one end of the approach to record the videos during peak hour of traffic. Peak hour varying differently among the link or lane at both morning hour (10:00AM to 1:00PM) and evening hour (2:00PM to 5:00PM). The measuring tape was used for collecting roadway geometrics like road width, shoulder width etc. Radar gun was used to collect spot speed of moving vehicles in peak hours. The radar gun was set at the angle of 45^0 to the opposite direction of traffic flows for collecting spot speed of vehicles and the average values have been taken.

Fig 2(a): High resolution camera

Fig 2(b): Tripod stand

Fig 3(c): Measuring tape

Figure 4(d):Radar gun

Data collection procedure includes physical features, traffic parameters, and user satisfaction levels having potential influence on automobile list perceived satisfaction. Physical features represent the data of geometric details of intersection approaches, traffic control and facilities provided for cars, bikes etc. Traffic parameters correspond to the traffic volume of main-street and cross-street, average traffic speed and stopped time delay on main-street. The geometric data, traffic data and signalization factor consist of some parameters are represented with units or scale are given in the table 4.1.

Table 1: Geometric and operational characteristics:

Data type	Parameters	Units/scale
Geometric data	Number of lanes	1,2 or 3
	Road width	meter
	Cross width	meter
	Curb radius	meter
	Number of intersection legs	3-legged or 4-legged
	Pavement condition index	Rating from 1 to 5
	Area type	Commercial area(1) Official area(0.5) Residential area(0)
	Presence of cross-markings	Yes(1), no(0)
	Presence of median	Yes(1), no(0)
	Presence of auto stand or bus stand	Yes(1),no(0)
	Shoulder width	meter
	Presence of crosswalks	Yes(1),no(0)
	Presence of kerb and gutter	Yes(1), no(0)
	On-street parking turnover	Yes(1), no(0)
	Surrounding environment or land use pattern	–
Traffic data	Total peak hour volume	PCU/hr
	Percentage of heavy vehicles	%
	Average stopping delay	seconds
	Pedestrian volume	No.s/hour
	Queue length	vehicles
	Automobile length capacity	Seconds Vehicles per hour
	volume	Vehicles per hour
	Saturation flow rate	Vehicles per hour
Lane factor	green period	seconds
	Type of traffic control	Fixed type(1), manual(0)
	g/C ratio	_

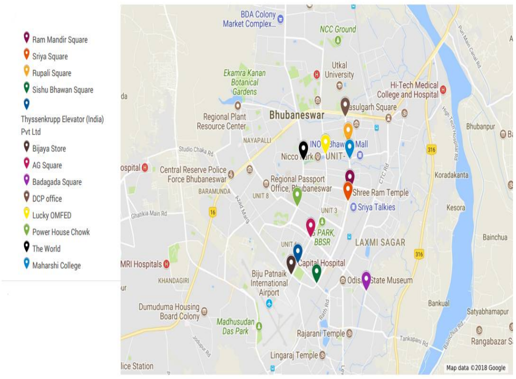
The parameters like type number of lanes, type of control, presence of cross-markings, kerb and gutter, bicycle lane were determined by visual inspection. These parameters are tabulated below in the table 4.2.

Table 2: Details of name, location, type of approach, number of lanes, type of control:

Intersection name	location	Type of approach	No. of lanes	Type of control
Ram mandirchowk	BBSR	3-legged	4	Signal
Sriyachowk	BBSR	3-legged	3	Manual
Rupali square	BBSR	4-legged	4	Manual
Maharshichowk (from Rupali square)	BBSR	3-legged	4	Manual
Maharshichowk (from Satya nagar)	BBSR	3-legged	4	Manual
Shishubhawanchowk	BBSR	4-legged	3	Manual
Capital hospital chowk	BBSR	4-legged	2	Manual
Hospital chowk	BBSR	4-legged	2	Manual
AG square	BBSR	4-legged	3	Manual
Badagadachowk	BBSR	3-legged	3	Manual
DCP office chowk	BBSR	3-legged	2	Manual
Nicco park	BBSR	4-legged	2	Manual
Nirmanasoudhchowk	BBSR	4-legged	3	Manual
The world square	BBSR	4-legged	2	Manual
Marghilinagar	Nagpur	4-legged	2	Signal
Omkarchowk	Nagpur	4-legged	3	Signal
Orange city chowk	Nagpur	5-legged	3	Signal
Pratapnagar square	Nagpur	4-legged	2	Signal
Lalbahadurshastrichowk	Nagpur	4-legged	2	Signal
Dighorichowk	Nagpur	4-legged	2	Signal
Manewada square	Nagpur	3-legged	3	Signal
Karodi square	Nagpur	4-legged	3	Signal
Ashok nagarchowk	Lucknow	4-legged	3	Manual
Daliganzpulchowk	Lucknow	3-legged	2	Manual
Hazarathganz	Lucknow	4-legged	3	Signal
Lorettochowk	Lucknow	4-legged	2	Manual
Lucknowuniversity1	Lucknow	3-legged	2	Manual

Lucknowuniversity2	Lucknow	4-legged	2	Manual
Sapthagiri circle	Anantpur	3-legged	2	Manual
Sri kantam circle	Anantpur	4-legged	2	Signal
Sri kantam circle 2	Anantpur	4-legged	2	Signal
Anand theatre	Kurnool	4-legged	2	Manual
Mouryachowk	Kurnool	3-legged	2	Manual
Annamaiha circle 3	Tirupati	4-legged	2	Manual
Balaji colony	Tirupati	3-legged	3	Manual
Bhavaninagarchowk	Tirupati	4-legged	2	Manual
Bus-stand circle	Tirupati	4-legged	3	Manual
Central park chowk	Tirupati	3-legged	2	Signal
Leelamahalchowk	Tirupati	4-legged	2	Signal
Market yard bypass road	Tirupati	3-legged	2	Manual
NTR circle 7	Tirupati	3-legged	2	Manual
Babu bazaar chowk1	Ranchi	4-legged	2	Manual
Munda chowk	Ranchi	4-legged	2	Manual

The location of signalized intersections of every studied sites are given below in the figure 3



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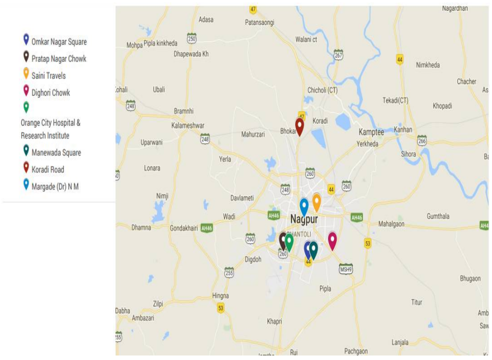

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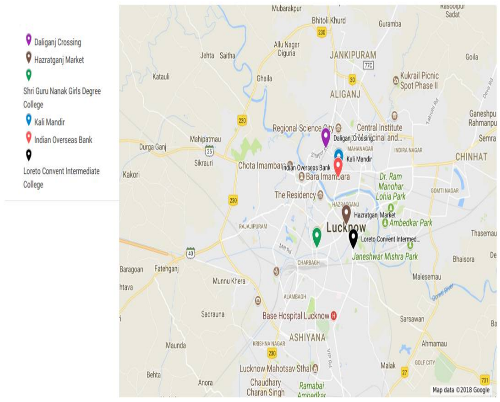

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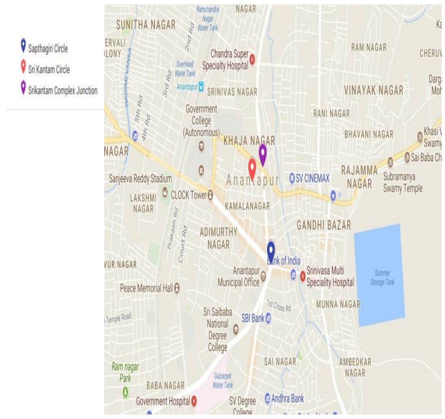

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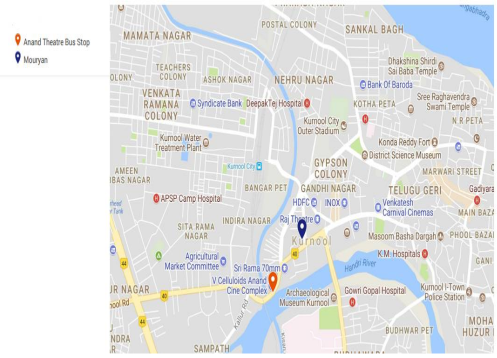


Kurnool

V. RESULT AND DISCUSSION

5.1GENERAL

The study gives a brief discussion on the area of the urban road that influences the automobile lists on a particular manoeuvre i.e. the through movement from both the direction. Finally, the study focuses on the development of automobile level of service models using stepwise regression analyse method. By using SPUS method, and calculation automobile analysis of heterogeneous traffic flow condition in various area and urban road. This result shows various data and flow condition of traffic in urban road.

5.2 DEVELOPMENT OF URBAN AUTOMOBILE LEVEL OF SERVICE

5.2.1 Variable selection

Both ceaseless and ordinal or categoricaltypes of factors were contained inside the database. For example, traffic volume, traffic speed are persistent factors, while encompassing formative example, asphalt condition record and saw ALOS score are ordinal.This variable demonstrate all critical of path and street starting with one path then onto the next path work .all information, for example, stopping ,garage ,speed, remove this all factor are determined in relapse investigation strategy in exceed expectations and R needs to fined after that Hence, the Spearman's relationship examination was favored for the recognizable proof of huge factors as it is well equipped for managing both ceaseless and ordinal kinds of factors. Spearman's relationship coefficient (i.e., Spearman'srho was assessed for every free factor versusthe subordinate variable, and its hugeness (p-esteem) was tried. Acquired outcomes ar deciphered beneath. variable, for example, MPHV/L,Speed,Driveway,Parking,Stop,LU

Table 4: Error estimation and forecast productivity of the proposed ALOS

Regression statistics	R	R^2	Adjusted R-square	Standard error	observations
	0.89133	0.84	0.891	0.33	44

Table 5: ANOVA test of proposed Automobiles level of service model

	df	SS	MS	F	Significance F
Regression	6	34.582	5.76411	50.5807	2.4E-16
Residual	37	4.21648	0.11396		
Total	43	38.8011			

Table 6: Significance test of input variables of proposed ALOS model

Variables	coefficients	Standard error	t-stat	P-value	Lower 95%	Upper 95%
Intercept	2.7627	0.48066	5.74779	1.4E-06	1.789	3.7366
MPH V/L	0.00072	9.7E-05	7.4421	7.4E-09	0.00053	0.00092
SPEED	-0.0258	0.01163	-2.2168	0.03287	-0.0494	-0.0022
Stops/km	-0.1465	0.19	3.93	0.000155	0.38	1.18
Drive way	0.30778	0.07921	3.885	0.00041	0.14728	0.4682
Parking	0.00024	8.7E-05	2.8198	0.00768	6.9E-05	0.0042
LU	-0.0753	0.18134	-0.4154	0.68022	-0.4428	0.2920

From above table, it was seen that the factors were critical at $p<0.05$ and the ALOS model was fitting fundamentally.

5.2.2 ALOS Model Development

The created model for ALOS is given underneath: =0.21784+0.00587*ln(CPHV)*delay+0.59901

ln (PV/AW)+0.000107*MPHV*(1+P)*(1+LU) (5.2) Where MPHV=main road top hour volume AW= Approach width CPHV= cross road crest hour volume LU=land use design/encompassing formative example P= crossing passerby volume over the way of through bicyclists

The model created with the R2value of preparing information is 0.78 and approved with the R2of testing information is 0.81. The measurable relapse coefficients and their criticalness was appeared in the table beneath.

Table 7: Error estimation and forecast effectiveness of the proposed ALOS model.

Regression statistics		R	R^2	Adjusted R-square	Standard error	observations
		0.89	0.78	0.873	0.33	44

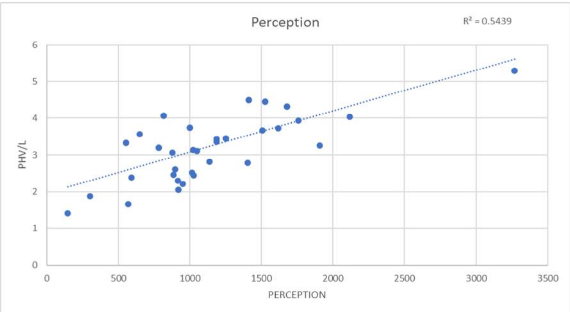
Table 8: ANOVA test of proposed BLOS model

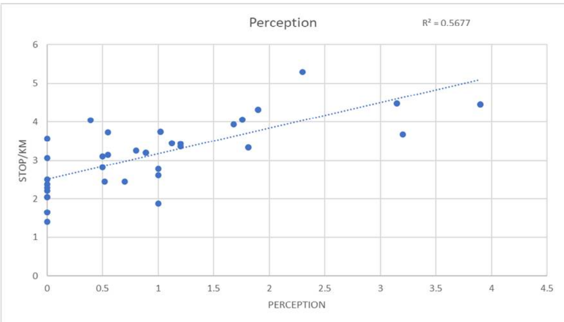
	df	SS	MS	F	Significance F
Regression	5	35.0152	7.0030	70.2897	3.7E-18
Residual	38	3.785	0.099		
Total	43	38.801			

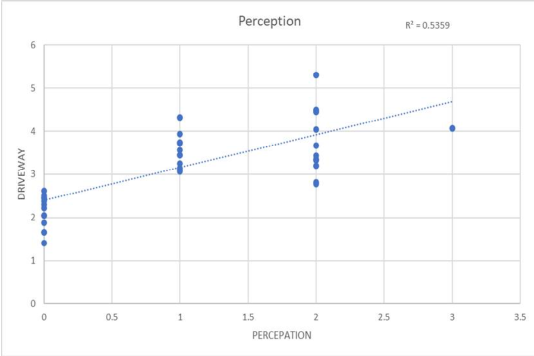
Table 9: Significance test of input variables of proposed ALOS model

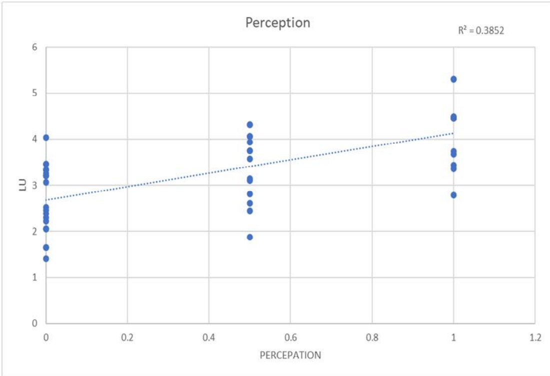
Variables	coefficients	Standard error	t-stat	P-value	Lower 95%	Upper 95%
Intercept	2.74637	0.43378	6.331	2E-07	1.86823	3.62451
MPHL/l	0.00076	9E-05	8.477	2.7E-10	0.00058	0.00094
Speed	-0.02744	0.01064	-2.578	0.01393	-0.04899	-0.0059
Driveway	0.27004	0.07453	3.683	0.00085	0.11918	0.42091
Parking	0.00026	6.7E-05	3.875	0.00041	0.00012	0.0004
Stop*LU	-0.2013	0.08006	-2.514	0.01628	-0.36338	-0.3922

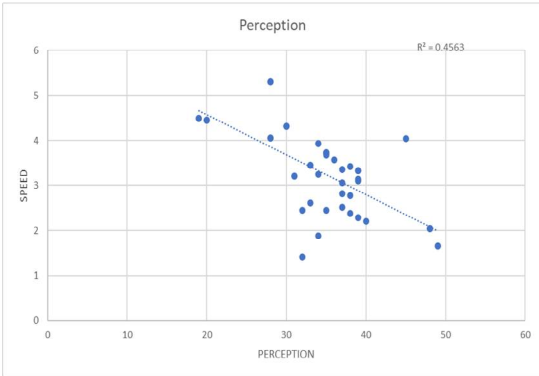
From above table, it was observed that the variables were significant at $p<0.05$ and the ALOS model was fitting significantly.

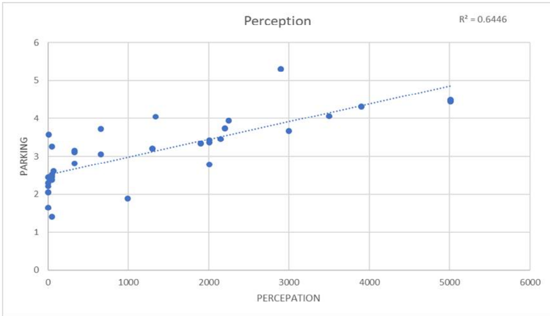












5.2.3 linear regression-based automobile

The Automobile linear regression analysis was executed using the SPSS statistic. For the development of the model, different types assumptions of priors were considered for study. Various relapse is an expansion of basic direct relapse. It is utilized when we need to anticipate the estimation of a variable dependent on the estimation of at least two different factors.

The variable we need to anticipate is known as the reliant variable or here and there, the result, target or paradigm variable.. The priors are chosen based on the convenience rather than the experience of the user about the actual distribution of parameters. If priors are chosen so that the corresponding posterior distribution belong to the same family of distributions then, the priors are called priors. The priors are generally denoted by $\Pi(\beta)$ and $\Pi(\sigma^2)$ and most commonly used prior is the normal inverse gamma conjugate model. Here, $\Pi(\beta/\sigma^2)$ represents the multivariate Gaussian distribution and $\Pi(\sigma^2)$ represents the inverse gamma distribution. In this study the conjugate prior was used for the posterior distribution as the prediction using the conjugate prior gave the best result.

The Bayesian approach does not believe in the single point estimate of the parameters. The inference was drawn from the posterior distribution of the parameters consisting of a probable range of variation of the parameters. The posterior distribution stores all the information about the parameters after incorporating the data. Parameter estimates and inference are based mainly on integrals of functions of the parameters with respect to the posterior distribution. The Bayesian linear regression model does not provide any empirical model as the coefficients of the variables considered are random instead of point estimate as provided by the step-wise regression method. Thus, the prediction values were also forecasted from the posterior distribution using linear regression in SPSS.

Rows of the summary table corresponds to regression coefficients and the disturbance variance, and columns represent the characteristics of the posterior distribution. The characteristics include:

CI95) contains the 95% Bayesian equitized credible intervals for the parameters. For example, the posterior probability that the regression coefficient of EWM is [-0.184, -0.072] is 95%.

1. Positive contains the posterior probability that the parameter is greater than 0. For example, the probability that CV is greater than zero is 0.982.
2. Distribution contains descriptions of the posterior distributions of the parameters. For example, the marginal posterior distribution of intercept is 't' with mean as 3.06, standard deviation as 0.30 and degrees of freedom as 46.

VI. CONCLUSION

Following are the important conclusions that are drawn from the present study on defining level of service criteria for urban streets in Indian context.

- Different cluster validation measures, based on their applicability, can be used to find the optimal number of clusters in *k*-means, *k*-medoid, regression method , fuzzy *c*-means and hierarchical agglomerative clustering. After thorough interpretation of the several optimal numbers of cluster plots, it was concluded to classify urban streets into four classes (I-IV) in Indian context. Free-flow speed ranges of urban street classes were different for each clustering methods. Free-stream speed extend for urban road class IV acquired in Indian setting is essentially lower than that referenced in HCM (2000). The presence of high percent of slow moving vehicles on Indian urban roads can be one of the major causes for this lower free-flow speed range.
- In the present context, speed ranges for level of service categories of urban street classes were also found to be significantly different for each of the clustering methods. In order to select the best clustering method in defining LOS criteria, "Silhouette" validation parameter was used. Average silhouette width and silhouette coefficient for urban street classes using each clustering method were added and shown in the Table 6.12. From this table, it was found that the added value is highest for *k*-medoid clustering method among all the methods. Hence, *k*-medoid clustering method is selected in defining LOS criteria of urban streets in Indian context. These lower esteems are because of very heterogeneous traffic stream on urban street halls with changing geometry in India.
- Speed ranges for level of service categories (A-F) expressed in percentage of free-flow speeds were found to be 85, 75, 60, 45, 33 and 20-30 respectively in the present study. Whereas, HCM (2000) and IRC (1990) have mentioned these values as 90, 70, 50, 40, 33 and 25-33 percent respectively. The main reason for suggesting higher percent FFS values, especially, at lower LOS categories is that the absolute value of FFS themselves were found to be at the lower side.

- Using the four clustering methods on "Silhouette" validation parameter it is concluded that, in Greater Mumbai region less number of road segments are of high speed design (street class-I) or highly congested (street class-IV). Increasingly number of street fragments are of rural (road class II) or moderate (road class III) type. Also, it is concluded that vehicles move on urban streets at poor levels of service of "D", "E" and "F" more often than good quality of services of “A”, “B” and “C”. It can be suggested that Greater Mumbai region needs substantial geometric improvements to provide better quality of service to the road users.

- It was found that 2km/h is the threshold speed below which vehicles are assumed to be at stopped condition in the present context. Among four applied clustering methods, *k*-means clustering was found to be the most suitable method in defining level of service categories (A-F) at lane. In case of level of service categories found from this study are shown in the Table below. It is generally observed that the level of service V/C ratio and constrained generally due to the surrounding environment. The higher ranges of level of service at, based on regression method, for defining LOS are justified considering the prevailing delay conditions in Indian context. From this study it is concluded for level of service categories in Indian context is roughly twice the ranges mentioned in HCM (2000).

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