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

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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.

II. LITERATURE REVIEW

2.1 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 operational conditions 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 traffic volume have the highest influences on the quality of traffic management at urban road links and intersection approaches respectively.

2.2 ALOS of Urban street segments

Several researchers have proposed both quantitative and qualitative measurement approaches for the quality of the driving experience on urban street segments. Maître et al. (1999) developed an empirical model to estimate congestion level on urban road sections with the help of fundamental diagram of speed-flow; volume and operational characteristics of the mixed traffic. The authors have proposed 10 levels of service categories based on the congestion level, out of which 9 categories were computed for stable flow zone (A-E) and one for unstable zone (F). This congestion model is useful for accessing the effect of roadway width on congestion levels and service volumes.

J Hackney and F Marshal*(*2003*)* assessed service quality of road network with the help of three GPS-equipped floating cars**.** The authors described the experimental approach, data gathering, data reduction, map matching, and speed results**.** A map matching algorithm was developed with the available GIS network models, which relate the speed of a link to a series of explanatory variables, such as***:*** time-of-day, day-of-week, type of road, population density, network density, density of motorway access points, distance to the main centers in the region**.** The study has shown the possibility of measuring LOS of a regional road system with sufficient accuracy**.** However, GPS map matching algorithms was suggested as more useful for speeding up the process**.**

Pecheux et al. (**2003**) carried out an in-vehicle opinion survey of drivers based on road geometrical, operational and environmental conditions on urban arterials**.** The authors have arranged an inventory of 45 Quality of Service**(**QOS**)** factors identified by the drivers of urban arterial, which fall into a group of eight investment areas**.**

Romana et al. (2006) proposed "threshold speed" (which is the minimum speed acceptable by drivers on a uniform road section under heavy flows and plotting traffic), and "percentage of traffic in platoons", as alternative Measures of Effectiveness (MOE),governing ALOS of two-lane roads. The threshold speed was chosen as 80 km/ph, which reflect user expectations more than free-flow speed under heavy traffic conditions. To detect major which MOE governs ALOS, thisstudy considered two types of two-lane highways, i.e. "Type I: where, both MOE are relevant to how the user perceives LOS" and "Type II: where, only percent time spent following (PTSF) is relevant". The authors concluded that, only PTSF needs to be examined If users' considered speed will be reasonable. Else, platting would have less importance in as compared to speed.(2006*)* carried out a perception survey in which participants were asked to evaluate traffic conditions presented in video clips**.** The authors revealed that **"**the number of lanes**"** have an important effect of on perceived level of service**.**

Abdul Rawoof Pinjari and Chandra Bhat (2006) identified and demonstrated the importance of nonlinear responsiveness to travel time as well as travel time unreliability in travel mode choice modeling. This was achieved by comparing the distributions of the travel time and unreliability response coefficients from a model with linear and nonlinear responsiveness for heterogeneity. Both the models took the form of a mixed multinomial logit structure. Systematic response heterogeneity was included in mode choice models by interacting individual characteristics with ALOS attributes, whereas random response heterogeneity was normally captured through estimation of parameters characterizing an assumed distribution for response heterogeneity. The example for examination is gotten from an expressed inclination practice that incorporates rehashed decisions from 317 people. This paper thinks about every one of the three wellsprings of reaction heterogeneity, for example, nonlinear responsiveness, varieties in responsiveness brought about by watched singular attributes, and in secret individual heterogeneity. such as: nonlinear responsiveness, variations in responsiveness caused by observed individual characteristics, and unobserved individual heterogeneity.

Aimee Flannery et al. (2008) developed a LOS model of urban streets based on automobile drivers' perception. Drivers' response was recorded and analyzed using video laboratory survey. cumulative logistic regression modeling approach was selected, which would be appropriate to predict the probability of responses in each LOS based on a combination of explanatory variables, describing the geometry and operational effectiveness of urban street facility. The model uses the number of stops per mile and the presence of exclusive left-turn lanes at intersections, which was best fit to the data.

Richard Dowling et al. (2008) predict traveler perceptions of service quality on an urban street, considering the modal-specific requirements for street design as well as operation of four types of travel modes, such as: automobile, transit, bicycle and pedestrian. To collect data sets of the quality of service perceived by the general public, Video laboratory survey with 90 video clips of 30 secs to 8 min duration and transit on-board surveys were used the across US urban streets. Four LOS models were developed, sharing a common measure, i.e. user satisfaction. For the auto mode, stepwise regression was applied on the input variables taken from Florida DOT research. For bicycle and pedestrian LOS, intersection models were used. The transit LOS is based on a combination of the access experience, the waiting experience, and the ride experience. Regression analysis was done to find the weights to combine the segment and intersection components of the street model of individual modes. The models assign a letter grade LOS (A–F) based on the street cross section, intersection controls, and traffic characteristics. The result concludes that the model took into account the trade-off implicit to assign scarce urban street right-of-way to each of the modes of travel. Hence, these models reflected better insights of the travelling public compared to HCM.

Werner Brilon and Anja Este (2010) presented standardized methods that allow a differentiated evaluation of oversaturated flow conditions beyond a static consideration of traffic conditions. The authors suggested that, there are five levels (LOS A to E) to distinguish under saturated flow conditions and one oversaturated traffic flow condition (LOS F). This study divides LOS F into differentiated sublevels of saturated flow (F1 to F4), as the growth in daily congestion requires a differentiated evaluation of oversaturated operating conditions. The evaluation based on a 24-h analysis that offers the largest degree of information, since congestion effects outside the peak hour are evaluated as well. Hence, this concept is highly suitable to evaluate and compare oversaturated situations in a multidimensional way. The method can also be used to assess the service quality on existing congested facilities depending on traffic demand.

2.3 Automobile Level of Service Analysis of Urban Streets*:* -

The classification and analysis of the results achieved using various tools for the estimation of automobile level of service **(**ALOS**)** of urban streets**.** The basic premise of urban streets and ALOS are discussed**.** ALOS is analyzed quantitatively and qualitatively**.** Average travel speed **(**ATS**)** on street segments is considered as the measure of effectiveness in defining LOS criteria of an urban street using quantitative methods**.**

The movement speed information gathering strategy has been changing after some time from the customary pursued moving eyewitness strategy to a separation estimating instrument and now worldwide situating framework is being extensively used worldwide**.** Classifying urban streets into number of classes and ATSs on street segments into number of ALOS categories are essential components of ALOS analysis**.** Emphasis is put on use of delicate registering strategies, for example, fluffy set hypothesis, hereditary calculation, neural system, bunch investigation and displaying and reenactment for the ALOS examination of urban streets both quantitatively and qualitatively**.** Nature of administration of urban lanes is broke down utilizing the fulfillment level that the street client saw while utilizing the urban street foundation.

III. 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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