Estimation of Level of Service using Congestion on Urban Street

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***Abstract*— The rapid urbanization and growth of private vehicle ownership have caused an in increase in road traffic congestion and degradation of level of service in most of the urban areas in India. While an appropriate policy for mitigation of congestion, there has been an increasing need to have more realistic meaning of traffic congestion and its rational quantification technique. Based on congestion level 6 level of service has been defined, which is logical and better measure of effectiveness to define LOS in a quantitative manner**

***Index Terms*— Congestion, Measure of Effectiveness, Level of Service,**

I. INTRODUCTION

In the last two decades, rapid growth and urbanization brings significant issues to the under developing countries. Mainly all these issues leads towards drastic impact to the settlement. One of the main problems faced by all classes of population is road transport related problem. The tremendous rise in number of vehicles is variably accompanied by ever increasing volume of traffic and intense traffic congestion on roads. Traffic congestion on urban roads has become a serious concern to transportation engineers due to its uncontrolled growth and resulting huge economic loss, additional delay, and user cost. Traffic congestion is mainly due to heterogeneous traffic composition, increase in travel demand, government policies and political interference.

The traffic congestion refers to urban mid block congestion and congestion at or near intersection. This paper presents methodology for quantification of congestion on urban mid block section.

II. TRADITIONAL METHODS

The problem of growing congestion is due to the growth of vehicular traffic volume, less roadway capacity, and the resulting additional delay, extra fuel consumption, user cost, etc. the need for congestion mitigation measures has been emphasized without specific quantification of the problem (Deakin, 1988; Howie,1989). While high traffic volume, less roadway capacity, etc., are the causes of congestion, the delay, additional fuel consumption, increase in traffic density, etc., are the effects of congestion. Therefore, the volume-related characteristics are the causes of the congestion, while the operational characteristics are the effects of congestion.

With growing concern about traffic congestion, efforts have been made to express the severity of the problem in a quantitative manner. However, it is found that either the operational characteristics, e.g., speed, delay, travel time, density, etc., or the volume characteristics, e.g., operating traffic volume, volume to capacity ratio, traffic volume per lane, etc., have been used independently to quantify congestion on urban roads (Lomax, 1988; Lindley, 1987).

For quantification of congestion various congestion indices developed which are congestion severity index (Lindley, 1987), K factor (Lomax, 1988), Road way congestion index, etc. All of these indices and quantification techniques have provided significant insight into the problem of traffic congestion. However, these measures of congestion have not combined the volume and operational characteristics while estimating the congestion. So there is need for a quantifying technique which can combine the operational and volume characteristics.

III. QUANTIFICATION OF CONGESTION

Operational characteristics such as speed, delay, travel time, density, acceleration noise, etc., have been have been used by researchers for quantifying congestion on urban roads. However, the most commonly used operational characteristics are the speed and density, as they are directly affected by the volume of traffic. Although both operating speed and density are widely accepted traffic flow parameters, the speed or delay has been used more commonly because of the difficulty and cost of directly measuring density. The highway capacity manual (HCM) and the IRC guideline have also used the operating speed as the measure of effectiveness for defining the level of service on urban roads.

The traffic volume, volume to capacity ratio, and traffic volume per lane are commonly used volume characteristics for quantification of congestion. In the urban situation, the carriageway widths are found to vary for roads, which have the same number of operating lanes. Capacity also varies, depending on the actual lane width.

The operating traffic volume and speed are the two fundamental variables of traffic movement. As the influencing factors for representing the operational and volume characteristics of traffic movements are functionally related, the quantification of congestion is based on the observed speed- flow relationship.

IRC guidelines and HCM have defined the level of service as qualitative measure which takes into account speed, travel time, freedom to maneuver, traffic interruptions, comfort, convenience and safety. However, taking most of factors qualitatively, and operating speed level as the only quantitative measure of effectiveness (MOE), six different level of service A to F has been defined. MOE used by HCM and IRC lacks in providing a complete quantitative basis for the conceptual and logical depiction of LOS. The quantified congestion is a measure of loss in freedom of movement that accounts for the variation of speed level with increase in traffic volume. Therefore, congestion is a logical and better MOE to define LOS in a quantitative manner.

To represent the variation of level of service through congestion is a complete manner, 6 levels of service have been defined with congestion levels of 20, 40, 60, 80, 100 % distinguishing 6 LOS (A-E) within the stable flow zone, and LOS (F) with congestion more than 100%, indicating unstable flow.

IV. MODELING OF CONGESTION

The urban and suburban traffic congestion clearly refers to urban mid block congestion and congestion at or near the intersections. The paper was presented which gave methodology for the quantification of congestion on urban mid block sections. Congestion has been quantified by taking into account both the operational and volume characteristics. The congestion has been modeled by using level of service (Maitra, 1999).

$$s = s_f \left(1 + a \left({}^{V}/_{C} \right)^{b} \right) \quad (1)$$

$$V_L = \left[\frac{1}{a} \left(1 - \frac{S_L}{S_f} \right) \right]^{1/b} \quad (2)$$

$$CG_v = \left(\frac{V}{V_L} \right)^{b+1} \times 100 \quad (3)$$

$$b = \sum Pi\, mi \quad (4)$$

Where,

S = realized speed of the stream in km/hr

S_f = free flow speed of the stream

V = operating total traffic volume in PCU per hour

C = Capacity of the road section PCU per hour

S_L = Speed at operating volume V_L

V_L = operating volume at 100% congestion level

a and b are parameters to be calibrated from the data set

The modeled congestion level expressed in (3) is similar way of expressing congestion as volume to capacity ratio. It takes into account the effect of operational characteristics, through the exponent (b+1). Eq. (3) indicates that congestion on similar roads may be deferent at respective volume levels, depending on prevailing roadway, traffic and control conditions. The exponent (b+1) also supports the nonlinearity in the deterioration in level of service with negligible effect of traffic volume at lower volume levels, and sever effect at higher traffic volume near capacity.

V. MODEL DEVELOPMENT

Quantification of congestion has been applied on the Gurukul to Manavmandir road of Ahmedabad city which is operating under mix traffic conditions, and having two lanes in each direction.

The model requires the input of basic parameters which are capacity of road, limiting speed values representing 100 % congested operation, and free flow speed. The data collected by videography provides traffic composition, traffic volume, and corresponding speed level covering peak and off-peak hours, for the development of the congestion model.

The capacity value for each direction has been taken 4500 PCUPH. However, IRC-1990 has suggested capacity value 4200 PCUPH. The free flow speed in off peak hour is 48 km/hour. The classified traffic counts are available for every five-minute interval and converted into hourly traffic volume in PCUPH.

With the knowledge of the capacity of road C, free flow speed S_f, operating volume p_i, and traffic stream speed S, the Coefficients a and m_i of the congestion model has been calibrated after making logarithmic transformation of eq. (1).

The traffic composition and adopted PCU values for Gurukul to Manavmandir road are shown in Table I. Table II shows the calibrated coefficients of the model along with t values, R^2, and F value. It is observed that the magnitude of all the coefficients, except those of cycle and 2W are found significance against a t value of 1.94. However, the performance of the cycle and 2W are found significant at a level of significance. The R^2 value found out to be 0.94 which is good. F value obtained is greater than F critical value, so the values are not occurring by chance. The goodness of fit statistics indicates the quality of model.

In a mixed traffic condition, the contribution of different vehicle type in creating congestion is different. In the model, the effect of different vehicle type is captured through m_i. the contribution of a vehicle type depends on prevailing roadway, traffic, and control conditions.

TABLE I. Traffic Composition and Adopted pcu Values

Vehicle Type	Proportion	PCU
Two Wheeler (2W)	0.53	0.75
Three Wheeler (3W)	0.15	2
Car	0.26	1
Bus	0.01	2.2
Cycle	0.04	0.4
LCV	0.01	1.4

TABLE II. Summary of Model for Gurukul to Manavmandir Road

Vehicle type	a	m_i	t	R^2	F
2W	0.701	0.45	0.94	0.97	232.4
3W		10.99	9.05		
Car		-2.86	2.19		
Bus		19.2	5.94		
Cycle		-2.37	1.56		
LCV		44.5	4.30		

VI. CONGESTION LEVEL AND LOS

Congestion levels 20, 40, 60, 80, and 100 % which represents 5 level of service A-E respectively, congestion level greater than 100% represents level of service F. Service volumes and speed at different congestion level is given in Table III. Speed levels suggested by IRC and HCM at different six level of service are also given in table.

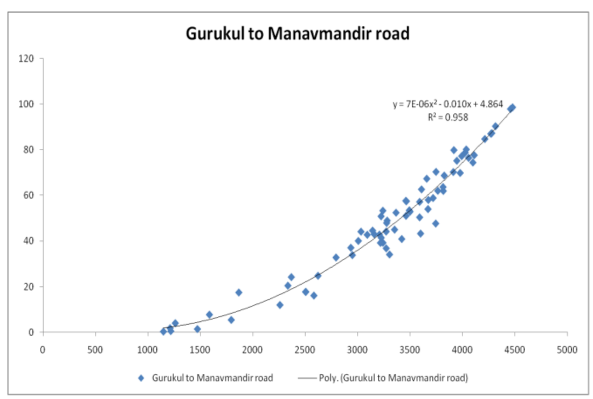

Fig. 1 Modeled Congestion at Various Flow Levels

TABLE III. Limiting Service Volume and Speed at Different Congestion Level on Gurukul- Manavmandir Road

LOS	Congestion %	Gurukul – Manavmandir Road	
		Limiting Service Volume (PCU/hour)	Speed (km/hour)
A	0-20	2349	44
B	20-40	3065	36
C	40-60	3610	31
D	60-80	4067	26
E	80-100	4470	19
F	>100	>4470	<19

TABLE IV. Speed at Different Level of Service

Level of Service	Speed as a % of Free flow speed (km/hour)	
	IRC: 106-1990	HCM-2010
LOS A	>90 (43)	> 85 (41)
LOS B	>70 (34)	>67-85 (32)
LOS C	>50 (24)	>50-67 (24)
LOS D	>40 (19)	>40-50 (19)
LOS E	>33 (16)	>30-40 (14)
LOS F	25-33 (12)	<30 (<14)

VII. CONCLUSION

Congestion is loss in freedom of movement under prevailing road-way, traffic, and control conditions. Taking into account both the operational and volume characteristics, congestion has been quantified on the basis of observed speed-flow variation. Quantified congestion can be used for deciding policies for the mitigation of congestion. Congestion is logical and better MOE to define LOS in quantitative manner. Six level of service has been defined based on congestion level which takes into account both speed and volume characteristics.

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