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Technique for measurement of Delay Characteristics at Signalized Intersections for Improvement of Level of Service- Case Study

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ABSTRACT

Traffic flow in Indian is heterogeneous and characteristics of traffic such as driver behaviour, geometric of the road are taken into consideration for governing there traffic flow.one of the important thing a traffic engineer should address a situation where there is future in the volume and road way width is limited and accordingly providing the solution. The traffic engineer should provide solution in such a way that thus expressive for the important of signalized intersection shall be less than providing the interchanges. Due to the ineffective operation of the traffic signal metropolitan cities like Mumbai, Hyderabad are experiencing congestion and delay. Other reasons for delay and congestion are varying width of the pavement characteristics of driver on the city roads. Improvement to congestion and delay can be achieved by providing the alternative routes and prioritization of the lanes which also have the impact on the consumption of fuel and improves the safety of the driver. Based on this above criteria a study is carried out in Hyderabad City in three major signalized intersection near Korenti, Barkathpura, and VST and evaluated for the traffic signal facilities that was existed. For evaluation delay, queue length and LOS are the parameters taken into the consideration. From the results if simulation it was observed that all the three intersections provide lorgese delay and the queue length. For improving these interactions providing the alternative routes for u turning vehicles and the left turning vehicles can be done, by channelization. Delays and the queue lengths are improved for all the three major signalized intersections. Improvement in the level of service LOS is also achieved at all three major intersections.

Keywords: Vehicular Delay, HCM Model, Indo HCM Model, Heterogenous Conditions, Signalized Intersections.

I. INTRODUCTION:

One of the essential tasks in urban traffic management is to assess the existing state and efficiency of signalized urban intersections. The performance assessment of the signalized urban intersections focuses on delay, which is a step towards a practical calculation ofestimating the delay at signalized urban intersections. An ever-increasing number of microscopic simulation models were implemented as practical analytical instruments by personal computers and by the lookout for the Intelligent Transport Systems (ITS) for solutions to the increasingly marked intersection problems.

A traveler has a delay when they lose time while crossing. It is dependent on a number of factors, including the type of cars, intersection shape, driver behavior, and the amount of available headroom. The total delay, the acceleration-deceleration delay, the stopped delay, and the queue delay. Vehicle delay is used to evaluate the effectiveness and quality of traffic operation at signal-controlled junctions.

HCM model and Webster's delay models, which are suited for nations like the US and UK where they practice lane discipline and traffic is homogeneous in character, are two prominent ways for measuring delay for signalized junctions. However, lane discipline is very weak in nations like India, where traffic conditions vary greatly.

II. LITERATURE REVIEW

Sarna and Malhotra (1967) submitted the results and analyses of saturation flow studies conducted at various intersections with various

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approx. road widths. At the signalized intersection they have developed the relationship between the flow of saturation and the approach width.

Sutariaand Haynes(1977)usedanopinionsurveybyroadusersthat depictsandevaluates thevarioustrafficconditionsata singlesignalizedintersection.Over300driversrandomly rated, segment bysegment these filmsinterms oftheappropriate levelofservice to evaluateflimsequencesintwotypes-ageneralviewofan intersection(macroview).anda driverview (micro view).

Prasannaetal.(2012)hasestimatedthedelayatsignalizedintersections ofdeveloping countryformixedtrafficconditions.Fiveintersections areconsideredinsuchawaythat theyare fairingeometryandleastinterferencewithpedestrians,busstops, parkedvehicles.

Vinayaka&Kadam(2016)hasdoneacasestudyon modelling onsaturation anddelay usingVISSIM.ThethreeIntersections wereselectedanddataiscollectedthroughVideo recordingsurveyandthenPCUvaluesarecalculated. PCUvaluesarecalculatedbymeans ofChandra's Method. HCM Methodis adopted for Delay Study. Lane Groupingis consideredtoobtainbestresultsfor thestudy.ObservedSaturationisdetermined,Capacity and V/C ratio are also Calculated.

Arpitaetal. (2017)hascalculatedthedelayundermixedtrafficconditionsatasignalized intersection. Theproposed model hasbeen developed bymodifyingthe existing HCM model onthebasis oftrafficdatacollected from7-fourlegged signalized intersections acrossthecountry.

Nageetal. (2018)haddoneanalysisondelayusingdifferentmethods.Astochasticmodel wasusedtostudythechanging probabilityof delay.Thismodelisbased onanytypeof arrival process. Forthis, differentdegree saturation and arrival types was investigated. Varianceofdelayincreaseswithdegreeofsaturation whichisinverselyproportional tothe approachcapacity.Saturationflowandcycletimedo nothaveasignificanteffectondelay distribution.DifferentmethodslikeHCM'sTriangle Method, Webster'sDelayModel, Simpson'sone-thirdRule,FieldmethodofDelayanalysis&VISSIM Softwareareadopted inthisstudy

III. METHODOLOGY

The sequential procedure for the study is as follows:

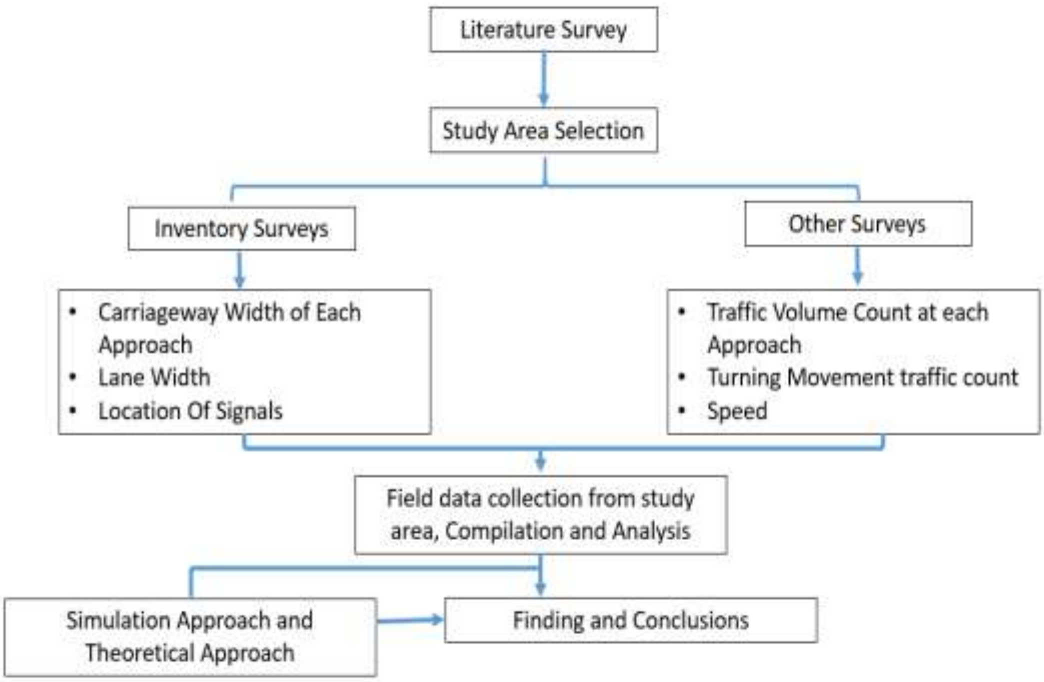

Fig 1:Pictorial Representation of Methodology adopteD

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IV. DATA COLLECTION AND EXTRACTION

1.1 Study Locations:

Korenti Intersection Barkathpura Intersection VST Intersection

Fig 2: Elevated view of study locations

1.2 Parameters Considered

Parameters considered for the study are categorized below:

A) Road Features
- a) Number of lanes
- b) Approach Width

B) Traffic Signal Features
- a) Type of signal
- b) Cycle Length
- c) Red, Amber and Green Lengths

C) Traffic Features
- a) Traffic volume along with directional and classified volumes
- b) Number of vehicles crossing green internal.

1.3 Estimation of Parameters

a)Saturation Flow:

$$S = \frac{N}{g_e} \times 3600 \qquad \text{Eqn. 1}$$

Where, S= saturation flow in (veh/hr) of green, = effective green time (sec), N = number of vehicles crossing stop line during effective green time.

b)Saturation Flow (Indo-HCM)

$$USF = \begin{Bmatrix} 630; \quad w < 7.0m \\ 1140 - 60 * w; \quad 7.0 \le w \ge 10.5\,m \\ 500; \quad w > 10.5\,m \end{Bmatrix} \qquad \text{Eqn. 2}$$

$$SF = w * USF \qquad \text{Eqn. 3}$$

USF = Unit base saturation flow rate (PCU/hr), w = effective width of approach (m), SF = Prevailing saturation flow.

c) Capacity

$$c = n \times S \times \left(\frac{g_e}{C}\right) \qquad \text{Eqn. 4}$$

Where,c=capacity(veh/hr), C=cycle time(secs), = effectivegreen time (secs), n =No. oflanes

1.4 Intersection Inventory

Geometrical Characteristics:

Table 1: Geometrical Characteristics of each location

Intersection	Approach Width (m)			
Direction	**North**	**East**	**West**	**South**
Barkathpura Intersection	**7**	**7**	**7**	**7**
Korenti Intersection	**7**	**7**	**7**	**7**
VST Intersection	**7**	**7**	**7**	**7**

Control Characteristics: The Table 2 depicts about the cycle time (secs), total green time (secs), effective green time (secs) and no of observed cycles (No's) at each location.

Table 2: Control Characteristics of each location

Intersection	Cycle Time (Secs)	Total GreenTime (Secs)				EffectiveGreenTime (Secs) (AccelerationLost Time:2 Secs) (DecelerationLost Time: 2 Secs)				No. of Observed Cycles
Directi	-	**North**	**East**	**West**	**South**	**North**	**East**	**West**	**South**	-
Barkathpura	180	48	45	58	21	45	42	55	18	80
g/C	-	-	-	-	-	0.27	0.27	0.32	0.12	-
Korenti	121	30	45	40	-	27	42	37	-	90
						0.25	0.37	0.33	-	
VST	121	30	45	40	-	27	42	27	-	90
g/C	-	-	-	-	-	0.25	0.37	0.33	-	-

1.5 PCU Values Considered in study:

Table 3 indicates the passenger car unit value for different classes of vehicles as per Indo – HCM 2017 Manual.

Table 3: Passenger Car Unit Value for each Type of Vehicle

Category ofVehicle	PassengerCarUnit Value
Bike (2W)	0.4
Auto (3W)	0.5
Car (4W)	1
LCV	1.2
Bus	1.6
Truck	1.6

1.6 Directional Peak Traffic Volume, Capacity, Saturation Flow, X= v/c:

Table 4 indicates the directional peak traffic volume (veh/hr) , capacity (veh/hr), saturation flow (veh/hr) and X (volume/capacity ratio) for each location.

Table 4: Directional Peak Traffic Volume, Capacity, Saturation Flow, X= v/C

Intersection	Volume (Veh's/hr)				Saturation Flow (Veh's/hr)				Capacity (Veh's/hr)				X = v/c			
Direction	N	E	W	S	N	E	W	S	N	E	W	S	N	E	W	S

Barkathpura Intersection	2572	3884	833	4488	6396	3884	5560	9111	3411	5141	1297	5872	0.75	0.76	0.64	0.77
Korenti Intersection	869	3885	3022	2885	2791	7226	5726	6162	1384	5374	5726	4074	0.63	0.72	0.53	0.71
VST Intersection	2632	599	2029	-	7738	1311	4408	-	3837	975	2914		0.69	0.61	0.70	-

V. DATA ANALYSIS

Based on the delay a vehicle experiences, a signalized intersection's level of service is evaluated. A vehicle's waiting time can be directly observed to determine delay, or journey times can be compared.

5.1 Indo - Highway Capacity Manual Model (2017):

The Indo - HCM 2017 model (CRRI 2017) estimates the average control delay per vehicle (d):

$$d = 0.9 * d_1 + d_2 + d_3$$

$$d_1 = 0.5 * C * \frac{(1-\frac{g}{CY_{Time}})^2}{(1-\min(X,1)*\frac{g}{CY_{Time}})}$$

$$d_2 = 900 * T * \left[(X-1) + \sqrt{(X-1)^2 + \frac{4*X}{C_{SI}*T}}\right]$$

Where,
d = Control delay, (sec/PCU), g = effective green time (in Secs), CY_Time = Overall cycle time (in Secs), T = Analysis Period (in Hours), X = Degree of saturation, CSI = Capacity of the candidate signalized intersection (in PCU/hr)

5.2Field Delay (HCM Method):

Field delays are determined through the implementation of vehicles in queue counts at fixed intervals and the preparation of formulas and correction factor applications as per the HCM 2010 worksheet.

Delay estimated as,

$$d = d_{vq} + d_{ad}$$

$$d_{vq} = 0.9 * (I_s * \frac{\sum V_{iq}}{V_{Tot}})$$

$$d_{ad} = FVS * CF$$

$$FVS = \frac{V_{Stop}}{V_{Tot}}$$

d = control delay per vehicle; dvq = time in queue per vehicle and dad = acceleration / deceleration correction delay.
Is = survey count interval (s); ΣViq = total vehicle in queue and Vtot = total vehicles arriving.
Vstop = stopped vehicles count; Vtot = total vehicles arriving and CF = acceleration / deceleration correction factor (HCM 2016).

Table 6 indicates the summary of different delay models for individual approach at Kingkoti Intersection

5.3Model Development:

SVM model was developed using R Software by taking field delay as dependent variable and Proportion of vehicles during green interval (P), vehicular volume, capacity, g/C Ratio, and number of lanes as independent variables. The R-Squared of the developed model is 0.80 and observed standard error as 3.58.

The Developed Model based on Field delay:
Field Delay = -45.25 – 0.165 (P) + 48.58 (Log. Volume) – 31.20 (Log.Capacity) -38.38 (g/C) + 5.2 (No. of Lanes)

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Correlation Matrix

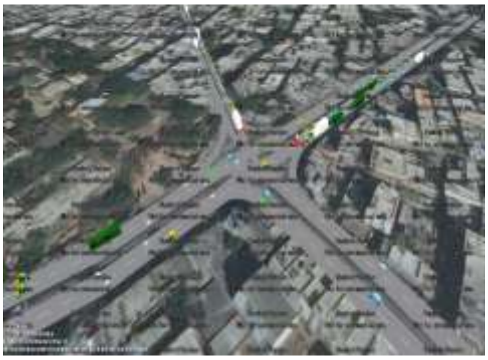
	Field Delay	Proportions of Vehicles in Green Interval (P)	Log.Volume (V)	Log.Capacity C	g/C	No.Of Lanes
Field Delay	1					
Proportions of Vehicles in Green Interval (P)	-0.59	1				
Log.Volume (V)	0.78	-0.79	1			
Log.Capacity C	-0.91	0.56	0.91	1		
g/C	0.62	-0.71	0.89	0.8	1	
No.Of Lanes	0.86	-0.62	0.72	0.72	0.5	1

SVM Errors

SVM MODEL PARAMETER	Values
R Square	0.8
RMSE	25.14
MAD	1.15
MSPE	36.45
MAPE	0.62

5.4 Simulation

The simulation of the existing intersection(Lane based and Non Lane Based) were conducted using PTVVissimbelongstothePTVVisionTrafficSuite,whichincludingalsothe PTV Visumusedfortrafficforecastingandtrafficanalysisand PTVVistowhichisusedfor trafficimpactsandsignaloptimization.

Inter Section Name	Lane Based	Non Lane Based
Barkathapura		
Korenti		
VST		

The simulation parameters considered.

Table 5.1: The Simulation Parameters considered.

Parameters	Barkathapura Intersection			Korenti Intersection			VST Intersection		
	Lane	Non-Lane		Lane	Non-Lane		Lane	Non-Lane	
		Default	Calibrated		Default	Calibrated		Default	Calibrated
Simulation Period	3200	3200	3200	3500	3500	3500	5000	5000	5000
Simulation	5	5	5	5	5	5	5	5	5

Resolution									
Random Seed	100	100	100	100	100	100	100	100	100
Number of Runs	125	125	125	150	150	150	180	180	180
Random Seed Increment	10	10	10	10	10	10	10	10	10

VI. RESULTS AND DISCUSSIONS

The following are the results from the study:

Table 10: Aggregated Intersection delay values for 3 locations

Intersections/			Barkathpura intersection		Korenti Intersection		VST Intersection	
delay models			Delay (s/veh)	LOS	Delay (s/veh)	LOS	Delay (s/veh)	LOS
HCM Models	Field delay		52.16	D	15.26	C	16.25	C
	Indo HCM		75.92	A	38.71	B	32.37	C
VISSIM model	Lane Based		49.35	C	25.16	C	21.04	D
	Non-Lane	Default Values	51.82	C	26.42	C	22.09	D
	Based	Calibrated Values	41.46	B	18.49	B	15.46	C

VII. CONCLUSIONS

1. Field delaycan beeasilycalculatedfromthe developed model using Proportion ofvehicles during greeninterval(P), Vehicular Volume, Capacity,g/CRatio,Number of Lanes,astheseparameters areeasyto extract compared to field delaycalculation from HCM Method.
2. Indo-HCM models are overestimating the delay as there is no adjustment factor involved while estimating the delay.
3. The percentage error for Field delay compared with calibrated VISSIM model delay comes to be 5 % is < 15% which means according to Dowling et. al. the calibrated VISSIM model is acceptable.
4. The Field delay for BarkathpuraIntersection ,KorentiIntersetion and VST Intersection are as follows 52.16,15.26,16.25.
5. The Indo HCM Delay for BarkathpuraIntersection ,KorentiIntersetion and VST Intersection are as follows 75.92,38.71 and 32.37.

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