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DELAY ESTIMATION AT SIGNALIZED INTERSECTIONS UNDER HETEROGENEOUS TRAFFIC CONDITIONS

Rahul Sharma[1], Pinakin Patel[2], Nekzad Umrigar[3], Dr. L. B. Zala[4]

[1] P.G. student, Department of Civil Engineering, Birla Vishvakarma Mahavidyalaya (Autonomous), Anand – 388 120, Gujarat, India
[2,3] Assistant Professor, Department of Civil Engineering, Birla Vishvakarma Mahavidyalaya (Autonomous), Anand – 388 120, Gujarat, India
[4] Professor and Head, Department of Civil Engineering, Birla Vishvakarma Mahavidyalaya (Autonomous), Anand – 388 120, Gujarat, India

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Abstract - *Delay is additional travel time which one incurs while making a trip. Estimation of delay is mostly done by Webster's delay model or Highway Capacity Manual model, which are developed from homogeneous lane based traffic. But in our country traffic is heterogeneous and lane behavior is frequently violated. Thus both these conventional delay estimation models tend to provide error at time of delay estimation. Here a delay model is proposed as per Indian traffic conditions. Moreover, delay is estimated by nine models such as field delay by Simpson's one third rule, field delay by Highway Capacity Manual (HCM 2010), Webster's delay model, Highway Capacity Manual (HCM 2010) model, Arpita Saha's model, Raval and Gundaliya's model, Hoque and Imran's model, Empirical method and Reilly's model. Delay has been estimated by simulation in VISSIM as well. All the above models have been compared with respect to field delay to estimate Mean Absolute Percentage Error (MAPE).*

***Key Words*: Delay model, Level of Service, signalized intersection, heterogeneous traffic, queue length**

1. INTRODUCTION

Intersections is an area where two or more roadways cross. Signalized intersection deals with intersection where by use of signals traffic is guided to proceed in respective direction or stop accordingly. In all situations where capacity cannot be provided for peak demands, delay is inevitable. In road traffic peaking phenomenon is highly pronounced giving rise to congestion. Congestion is the impedance and delay imposed by one vehicle on another. For a given road, greater the traffic volume, greater the chances of delay and henceforth of congestion as well. The additional travel time experienced by a driver, passenger or pedestrian due to circumstances that impede the desirable movement of traffic is termed as delay. It is measured as the time difference between actual travel time and free-flow travel time.

Two of the widest spread models for delay estimation are Highway Capacity Manual (HCM) model and Webster's delay model. But both these models are developed in homogeneous and lane based traffic conditions. While traffic in our country and alike developing countries is heterogeneous and non-lane based thus despite being well known they can't estimate delay accurately. Thus, to represent heterogeneous conditions effectively a few models have been developed. Md. Shamsul Hoque and Md. Asif Imran (2007) modified Webster's formula as per traffic conditions of Bangladesh. Raval and Gundaliya (2012) also modified Webster's formula as per traffic condition of Ahmedabad city of Gujarat. Gandhi Ganim Sofia (2014) proposed a model to estimate delay as per traffic conditions in Iraq. Saha (2017) modified Highway Capacity Manual (HCM 2000) model. A probabilistic approach based on first-order second-moment method has been adopted to estimate the saturation flow and the delay caused to traffic and concluded that the delay estimated using the probabilistic approach was close to the observed values of delay. Kumar and Dhinakaran (2013), are among the few researchers who compared field estimated delay with different existing models, they measured delay directly from field data and compared it with HCM 2000 model. Field delay was found to be more accurate. Chu Cong Minh et al. (2010) modified Webster's method based on Taylor's series and compared it with field delay. The modified formula gave satisfactory result. The models developed for estimation of delay are generally considering homogeneous and lane based traffic conditions. A few models as mentioned below are developed for heterogeneous non – lane based traffic condition in developing countries.

2. MODELS FOR DELAY ESTIMATION

The proposed model is developed from data collected in Ahmedabad city of Gujarat in Western India to reduce gap of delay estimation for traffic conditions as per our nation. Delay is estimated by models as described in subsequent paragraphs. The values have been compared and relative error in % is calculated with respect to field delay.

2.1 Webster's Delay Model

Using deterministic queuing analysis, Webster developed a model for estimating the delay incurred by motorists at under saturated signalized intersection.

$$d = \frac{C(1-\lambda)^2}{2(1-\lambda X)} + \frac{X^2}{2V(1-X)} - 0.65\frac{C^{\frac{1}{3}}}{V^2} * X^{(2+5\lambda)} \qquad (1)$$

Where,

d = average overall delay per vehicle for the approach or movement (s); λ = proportion of the cycle that is effectively green for the approach or movement (g /C); C = cycle time (s); g = effective green time (s); X = degree of saturation [ratio of volume to capacity (v/c)]; v = flow rate (average number of vehicles passing a given point on the road in the same direction per second) and c = capacity for the lane group (in vehicles per second).

The first term represents the average delay to the vehicles, assuming uniform arrivals. The second term gives the additional delay due to random arrivals and signal cycle failures. The third term is an adjustment factor to account for specific field conditions.

2.2 Highway Capacity Manual (HCM 2010) Model

Average control delay per vehicle (dc)

$$dc = d_1*(PF) + d_2 + d_3 \quad (2)$$

$$d_1 = 0.5 * C * \frac{[(1-\frac{g}{C})^2]}{\{1-\min[(X,1)]*\frac{g}{C}\}} \quad (3)$$

$$d_2 = -900 * T * \{(X-1) + \sqrt{[(X-1)^2 + \frac{4X}{cT}}\} \quad (4)$$

$$PF = \frac{(1-1.33)*\frac{g}{C}}{1-\frac{g}{C}} \quad (5)$$

Where,

d_c = control delay per vehicle (s/veh); d_1 = uniform control delay assuming uniform arrivals (s/veh); PF = adjustment factor for the effect of the quality of progression in coordinated systems; d_2 = incremental delay to account for the effect of random arrivals and oversaturation assuming no initial queues at start of analysis period (s/veh); d_3 = initial queue delay (s/veh); C = traffic signal cycle time (s); g = effective green time (s); X = volume to capacity ratio; c = capacity of lane group (veh/h) and T = evaluation time.

2.3 Arpita Saha's Model

The model was developed from varied locations (Delhi, Patiala, Chandigarh) all over India and validated at varied other locations from data collected (Chandigarh, Panch Kula and Mumbai) across the country as well.

Average control delay per vehicle (dc)

$$dc = d_1 + d_2 + d_3 \quad (6)$$

$$d_1 = 0.5 * C * \frac{[(1-\frac{g}{C})^2]}{\{1-\min[(X,1)*\frac{g}{C}\}} \quad (7)$$

$$d_2 = 6.23 - (15.35*R_p) \quad (8)$$

$$d_3 = 0 \quad (9)$$

where,

d_c = control delay per vehicle (s/veh); d_1 = uniform control delay assuming uniform arrivals (s/veh); d_2 = incremental delay to account for the effect of random arrivals and oversaturation assuming no initial queues at start of analysis period (s/veh); d_3 = initial queue delay (s/veh); C = traffic signal cycle time (s); g = effective green time (s); X = volume to capacity ratio; c = capacity of lane group (veh/h); K = incremental delay factor (0.50 for pre timed signals); I = upstream filtering adjustment factor (1 for an isolated intersection); T = evaluation time and P = proportion of vehicle arriving during green interval.

$$R_p = PVG / PTG \quad (10)$$

R_p = Platoon ratio; PVG = Percentage of vehicle arriving during green and

PTG = Percentage of green time.

2.4 Raval and Gundaliya's (Modified Webster's) Model

The model was developed from three intersections in Ahmedabad city. The model along with its mathematical form is as follows:

$$adj = 7.82*Q + 0.057*C + 7.6*X + 3.98*\lambda + 32.35*t_w \quad (11)$$

Where,

adj = adjustment term for the model; Q = vehicle arrival rate (PCU/sec); C = cycle time in seconds; X = degree of Saturation; λ = effective green ratio and tw = percentage two-wheelers.

$$d = \frac{C(1-\lambda)^2}{2(1-\lambda X)} + \frac{X^2}{2V(1-X)} + 7.82 * Q + 0.057 * C + 7.6 * X + 3.98 * \lambda + 32.32 * t_w \quad (12)$$

Where,

d = average overall delay per vehicle for the approach or movement (s); λ = proportion of the cycle that is effectively green for the approach or movement (g /C); C = cycle time (s); g = effective green time (s); X = degree of saturation [ratio of volume to capacity (v/c)]; v = flow rate (average number of vehicles passing a given point on the road in the same direction per second); c = capacity for the lane group in vehicles per second.

The first term represents the average delay to the vehicles, assuming uniform arrivals. The second term gives the additional delay due to random arrivals and signal cycle failures.

2.5 Empirical (Formula Based) Method

Here total delay is taken as sum of stop delay, queue clearance delay and free flow vehicles clearance time.

Stop delay = (Red time/2) * Queued vehicles (13)

Queue clearance $delay_1$ = (Queued vehicle clearance time/2) * Queued vehicles (14)

Queue clearance $delay_2$ = (Vehicle joining queue clearance time/2) * Vehicle joining queue (15)

Free flow vehicles clearance time = (Free flow vehicle time/2) *Number of free flow vehicles (16)

Total delay = Stop delay + Queue clearance $delay_1$ + Queue clearance $delay_2$ + Free flow vehicles clearance time (17)

2.6 Md Shamsul Hoque and Md Asif Imran's Model

They modified Webster's delay formula under non lane based mixed road traffic condition by adding an empirical adjustment term with the sum of first and second terms. The model was developed from three intersections in Dhaka capital of Bangladesh.

$$d = \frac{C(1-\lambda)^2}{2(1-\lambda X)} + \frac{X^2}{2V(1-X)} + \text{adj} \quad (18)$$

adj = 46.93 - 46.04*Q - 37.32*X - 0.3608*pnmv (19)

where,

(PCU/sec); C = cycle length (seconds); X = degree of

adj = adjustment term for model; Q = vehicle arrival rate saturation; pnmv = percentage Non-Motorized Vehicles (NMV) in traffic; d = average overall delay per vehicle for the approach or movement (s); λ = proportion of the cycle that is effectively green for the approach or movement (g /C); C = cycle time (s); g = effective green time (s); X = degree of saturation [ratio of volume to capacity (v/c); v = flow rate (average number of vehicles passing a given point on the road in the same direction per second) and c = capacity for the lane group in vehicles per second.

2.7 Reilly's Model

In preparing model for the Highway Capacity Manual (HCM 1985), Reilly and Gardner (1977) conducted extensive field studies to measure delays. The formed delay model as blow by modifying Akcelik's delay model.

$$OD = 450[(X-1) + [(X-1)^2 + \sqrt{\{\frac{12*(X-X_0)}{c*T}\}}]] \quad (20)$$

where,

OD = Overflow delay

where X >= X_0, if X < X_0 then overflow delay is zero

$$X_0 = 0.67 + \frac{s*g}{600} \quad (21)$$

T is the analysis period in hours; X is the v/c ratio; c is the capacity in vehicles/hour; s is the saturation flow rate in vehicles/s_g (seconds of green) and g is the effective green time in seconds.

$$UD = \frac{C}{4} * (1 - \frac{g}{C}) \quad (22)$$

where,

C = cycle time in seconds.

Thus, total delay = Uniform delay (UD) + Overflow delay (OD). (23)

3. DATA COLLECTION AND EXTRACTION

Ahmedabad city of Gujarat was chosen for the study. Data were collected at three isolated signalized intersections. Two intersections of which were four legged and one was five legged with different cycle lengths and other characteristics as shown in Table 1. The intersection approaches had two to three lanes with no influence of roadside parking, bus stops or any other side frictions. Moreover, videography of Stadium Chowk (Noida) intersection was used as secondary data which is a four legged intersection.

Table- 1: Intersection inventory

No	Inter-section	City	Width (m)	Cycle (s)	Green time (s)	Number of observed cycles
1	Swastik	Ahmedabad	9.2	109	20	28
2	Panchwati	Ahmedabad	7.0	188	27	30
3	Fortune Landmark	Ahmedabad	10.0	142	26	42
4	Stadium Chowk	Noida, Uttar Pradesh	10.3	126	33	27

3.1 Classified Volume Count (CVC)

An interval of 15 minutes was chosen for conducting the survey manually for 10 hours. 3 persons were placed at each leg to record left turning, right turning and straight movement of vehicles. The survey was carried out from 8:00 AM to 6:00 PM. The motive of conducting the survey was to determine the peak hours of traffic flow for which videography was to be done for determination of delay further leading to determination of Level of Service (LOS). Traffic compositions of all the intersections were extracted as shown in Table 2.

Table- 2: Vehicle compositions (%)

No	Inter-section	Two wheelers	Rick shaw	Cars	Bus	Heavy vehicles
1	Swastik	61.93	19.55	17.90	0.21	0.41
2	Panchwati	62.13	17.60	19.85	0.28	0.14

3	Fortune Landmark	40.79	37.27	13.85	7.53	0.56
4	Stadium Chowk	47.34	5.72	09		

3.2 Measurement of Field Delay

Field delay has been estimated by two methods by use of Simpsons's one third- rule and by Highway Capacity Manual (HCM 2010) the former method has been developed taking into consideration heterogeneous non-lane based traffic condition of our country while the latter has been developed for homogeneous lane based traffic conditions present in developed countries.

3.2.1 Measurement of Delay on Field by Simpson's One – Third Rule

Simpson's one – third rule was used to estimate area between queue length and cycle time. Area obtained will give total delay of that cycle in seconds. Average delay of an individual vehicle can be obtained by dividing total delay by total number of vehicles arriving in a cycle.

$$\int_0^C f(Q)\,dq = \frac{h}{3}[(q_0 + q_n) + 4\,(q_1 + q_3 + \ldots\ldots + q_{(n-1)}) + 2\,(q_2 + q_4 + \ldots + q_{(n-2)})] \qquad (24)$$

where,

$$h = \frac{(C-0)}{n} \qquad (25)$$

C – 0 **=** difference between the start and end time of queue observations; Q = queue length; C = cycle length; n = number of five second intervals and $q_0, q_1, q_2, \ldots q_n$ = queue length at 1st, 2nd, ..., nth interval. Table 3 gives sample data of Fortune Landmark intersection.

In below data n = 28 thus h = 5. Chart 1 is graphical representation of change in queue length (in meter) with cycle time (in seconds).

Table- 3: Queue length determination for Fortune Landmark intersection

Time (in seconds)	Queue length (in m)	Time (in seconds)	Queue length (in m)
5	2	75	27
10	5	80	28
15	6	85	30
20	8	90	31
25	9	95	32
30	11	100	33
35	13	105	35
40	15	110	37
45	15	115	34
50	17	120	28
55	18	125	17
60	20	130	6
65	22	135	2
70	24	140	0

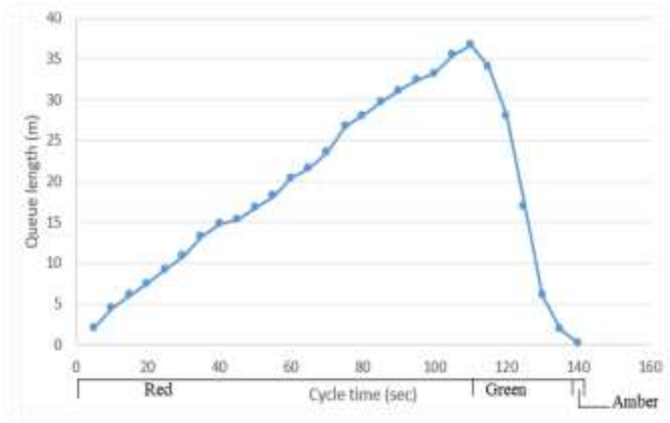

Chart- 1: Simpson's one third rule curve for Fortune Landmark intersection

3.2.2 Field Delay by Highway Capacity Manual (HCM 2010) Method

Field delay is found out by carrying out vehicle in queue counts at fixed intervals and making use of formulas and applying correction factors as per HCM 2010 worksheet is prepared.

Here delay is determined as,

$$d = d_{vq} + d_{ad} \qquad (26)$$

d = control delay per vehicle; d_{vq} = time in queue per vehicle and d_{ad} = acceleration / deceleration correction delay.

$$d_{vq} = (I_s * \frac{\sum Viq}{Vtot}) * 0.9 \qquad (27)$$

I_s = survey count interval (s); $\sum V_{iq}$ = total vehicle in queue and V_{tot} = total vehicles arriving.

$$d_{ad} = FVS * CF \qquad (28)$$

$$FVS = V_{stop}/V_{tot} \qquad (29)$$

V_{stop} = stopped vehicles count; V_{tot} = total vehicles arriving and CF = acceleration / deceleration correction factor (Ex. 31- 48, HCM 2010).

4. DEVELOPMENT OF DELAY MODEL

In the developed model field delay obtained by Simpson's one third rule is regressed against varied parameters involved in estimation of delay to determine most satisfactory model.

Table- 4: Model development statistics

Variable	Variable Co-efficients	t Stat	p-value	Multiple R	Adj R^2
Intercept	80.640	18.98	4.5E-26	0.70	0.49
Capacity (c)	0.039	4.68	3.2E-07		
Flow rate (V)	-0.048	-5.79	1.8E-05		
Rp	– 5.539	-5.04	5.1E-06		

The model is as below:

$$Delay = 80.640 + 0.039*c - 0.048*V - 5.539*R_p \quad (30)$$

Where, c = capacity in vehicles/hour, V = flow rate in vehicles/hour, R_p = platoon ratio.

The t-statistics came out to be high enough with low p-values indicating that the independent variables are fairly significant.

The statistical analysis is carried out for validation. *F* test is carried out for the observed results at a confidence level of 95%. The value of observed F (0.08) is lower than critical F value (0.76). Hence model is good for statistical support.

4.1 Model Validation

Validation is the process of determining whether the selected model is appropriate for the given conditions and work to be performed. The objective of validation is to assess the adequacy of the proposed prediction models and measure the error or accuracy of the prediction for the validation period. There are several methods used for models validation. One amongst them is to compare the model with another data set that is not included in model building. The data used for this purpose is peak hour video recording data from two different intersections i.e. Parimal intersection and Tanishq intersection from the same city on C.G. road.

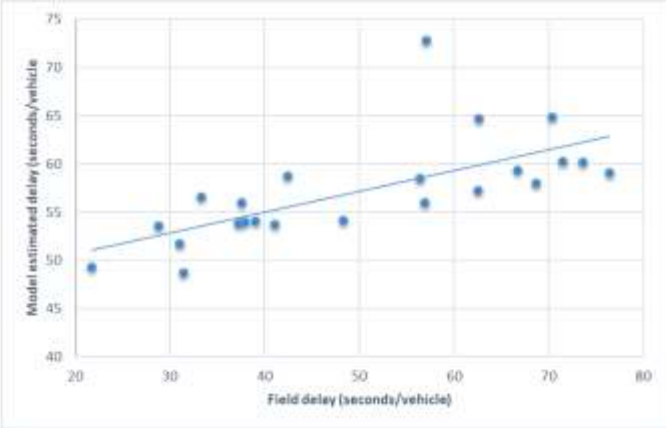

Chart- 2: Model validation

The goodness of the model was checked by plotting the expected values of delay computed by using the model against the field delay ones of the collected data. Chart 2 shows that the observed and expected delays are in good agreement although there is some scatter here R^2 = 0.46.

5. PARAMETERS FOR DELAY ESTIMATION FOR VARIOUS MODELS

All models have a set of parameters which are used for estimation of delay. Table 5 shows list of such parameters for delay estimation models.

Table- 5: Parameters involved in models

Sr. No	Delay model	Parameters used in model
1	Field delay by Simpson's one third rule	Queue length
2	Field delay by HCM 2010 method	Counts of number of vehicles in queue and number of vehicles stopping
3	HCM 2010 delay model	Flow rate (V), Saturation flow rate (S), Capacity (c), Degree of saturation (V/S), Platoon ratio (Rp)
4	Webster's delay model	Flow rate (V), Saturation flow rate (S), Capacity(c), Volume to capacity ratio (V/c)
5	Arpita Saha's model	Volume to capacity ratio (V/c), Platoon ratio (Rp)
6	Modified Webster's (Raval and Gundaliya's) model	Flow rate (V), Saturation flow rate (S), Capacity (c), Degree of saturation (V/S), % two wheelers

7	Empirical formula based method	Number of free flow vehicles, vehicles joining queue, queued vehicles, clearance time of above class of vehicles
8	Md Shamsul Hoque and Md Asif Imran's model	Flow rate (V), Volume to capacity ratio (V/c)
9	Reilly's model	Flow rate (V), Saturation flow rate (S), Capacity (c), Volume to capacity ratio (V/c)

5.1 Delay Estimation

Estimation of delay has been done by nine models as represented in Table 4 by extracting the mentioned parameters from video graphic data collected and feeding them as input in model equations along with carrying out the necessary calculations.

5.2 Comparison of delay estimation models

Total ten models including proposed model where compared with field delay. Vital parameters for analysis and delay estimation which include saturation flow rate (vehicles per hour), effective green time ratio (g/C), capacity rate (vehicles per hour), volume rate (vehicles per hour), X = V/c, Degree of saturation (V/S) and Platoon ratio (R_p) are represented in Table 6 for all intersections.

Table- 6: Parameters for analysis

Sr. No	Inter-section	S	g / C	c	V	V/c	V/S	R_p
1	Swastik	5884	0.18	917	1158	1.31	0.20	1.51
2	Panch-wati	9365	0.14	1195	1360	1.15	0.15	1.22
3	Fortune Land-mark	5918	0.18	958	1075	1.33	0.18	1.25
4	Stadium Chowk	5826	0.26	1387	1638	1.19	0.28	1.10

Delay estimation was done for one approach per intersection considering high amount of traffic, congestion, queue formation and feasibility for videography. Approaches selected were, for Swastik intersection – Girish cold drinks approach, for Panchwati intersection - C. G. road approach, for Fortune Landmark intersection – Times of India approach and for Stadium Chowk Noida – DND approach.

Table- 7: Comparison of field delay and proposed delay models

Sr No	Delay model	Swastik inter-section	Panch-wati inter-section	Fortune Land-mark inter-section	Stadium Chowk inter-section
1	Field delay by Simpsons one third rule	51.29	54.79	63.62	57.13
2	Field delay by HCM method	29.81 (41.88)	57.93 (5.72)	45.15 (29.04)	36.89 (35.43)
3	Pro-posed delay model	59.11 (2.26)	49.26 (0.77)	52.66 (6.51)	67.50 (12.41)

* All values in seconds per vehicle

** Number in parentheses represent Mean Absolute Percentage Error (MAPE)

Table- 8: Comparison of delay estimation models

No	Delay model	Swastik inter-section	Panch-wati inter-section	Fortune Land-mark inter-section	Stadium Chowk inter-section
1	Webster's delay model	37.36 (36.79)	69.55 (26.93)	47.26 (25.72)	35.08 (38.59)
2	HCM 2010 delay model	34.51 (31.29)	70.14 (21.79)	47.69 (28.44)	36.00 (42.31)
3	Arpita Saha's model	30.90 (39.75)	70.03 (27.81)	46.86 (26.34)	39.34 (31.13)
4	Raval and Gundaliya's model	63.70 (24.18)	30.90 (43.61)	35.08 (44.86)	28.00 (51.00)
5	Empirical formula based method	37.63 (26.64)	74.88 (36.66)	49.68 (21.91)	42.01 (26.46)
6	Md Shamsul Hoque and	22.25 (56.61)	58.15 (6.13)	29.00 (54.41)	16.59 (70.95)

	Md Asif Imran's model				
7	Reilly's model	74.37 (44.99)	106.42 (94.22)	80.52 (26.56)	88.57 (55.03)

* All values in seconds per vehicle

** Number in parentheses represent Mean Absolute Percentage Error (MAPE)

Delay was estimated by simulation in VISSIM as shown in Table 9. In which data such as traffic conditions, geometric conditions and signal timings were entered as per the actual scenario at specific intersection. Further Level of Service was determined from delay value estimated. Calibration was done before delay estimation.

Table- 9: Delay estimation by simulation in VISSIM

Sr No	Inter-section	Delay (sec/veh)	Delay from VISSIM (sec/veh)	Mean Absolute Percentage Error (MAPE) %	LOS
1	Swastik	51.29	37.96	25.99	D
2	Panchwati	54.79	117.46	114.38	F
3	Fortune Landmark	63.62	75.78	19.11	E
4	Stadium Chowk	57.13	60.95	6.68	E

Average values of MAPE was computed for all four intersections for all mentioned models as represented below. As clear from Chart 3 proposed model yields least amount of MAPE followed by Webster's delay model.

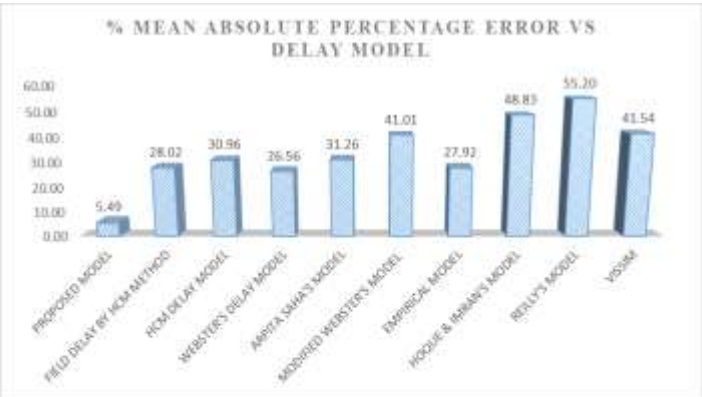

Chart- 3: Comparison of average values of MAPE of delay models

Level of Service (LOS) denotes level of facility one can derive from a road under different operating characteristics and traffic volumes. Six LOS are defined for each type of facility from level A to F. From above estimated delay values Level of Service (LOS) was determined by use of Highway Capacity Manual (HCM 2010). LOS values ranges from class B to F as shown in Table 10.

Table- 10: Level of Service (LOS) from delay models

No	Delay model	Swastik inter-section	Panchwati inter-section	Fortune Land-mark inter-section	Stadium Chowk inter-section
1	Field delay by Simpsons one third rule	D	D	E	E
2	Field delay by HCM method	C	E	D	D
3	Proposed delay model	E	D	E	E
4	Webster's delay model	D	E	D	D
5	HCM 2010 delay model	C	E	D	D
6	Arpita Saha's model	C	E	D	D
7	Raval and Gundaliya model	E	C	D	C
8	Empirical formula based method	D	E	D	D
9	Md Shamsul Hoque and Md Asif Imran's model	C	E	C	B
10	Reilly's model	E	F	F	F

6. INFERENCES FROM DELAY ESTIMATION MODELS

Field delay estimation by Simpson's one – third rule is a tedious, time consuming but simple method. Comparison of varied models are done with Simpson's one third rule method.

Field delay by Highway Capacity Manual (HCM 2010) shows less MAPE when cycle length increases. The method is a bit tedious as vehicle in queue counts are to be carried out at periodic intervals. Under estimates delay as it is developed for homogeneous lane based traffic conditions except for long cycle timings where it over estimates.

Highway Capacity Manual (HCM 2010) model is fairly precise as MAPE remains in a considerably close range. Under estimates delay except for long cycle timings.

Webster's delay model yields least amount of MAPE and the precision is best amongst all models. Under estimates delay except for long cycle timings.

Arpita Saha's model carried out modification of Highway Capacity Manual (HCM 2000) model. MAPE reduces as cycle length increases. Under estimates delay except for long cycle timings.

Raval and Gundaliya's model carried out modification of Webster's delay model. Yields considerable MAPE value. Under estimates delay.

Empirical (formula based) model gives fairly precise value of MAPE except for high cycle timings. It is a bit tedious method as time for clearance has to be obtained of queued vehicles, vehicles joining queue and free flow vehicles for each cycle. Under estimates delay except for long cycle timings.

Md Shamsul Hoque and Md Asif Imran's model yields considerable amount of MAPE except for high cycle times. Under estimates delay except for high cycle time where delay is over estimated.

Reilly's model has a high MAPE and overestimates delay.

7. CONCLUSIONS

Instead of estimating delay by methods which are derived on basis of homogeneous lane based traffic an attempt is made to develop model for non-lane based heterogeneous traffic condition. Traffic flow data along with various parameters which play vital role in delay estimation were extracted from videography. For determining field delay, queue length is a vital parameter for which marking was done on road at interval of 2.5 m and was measured for every 5 second interval. Delay was estimated by a total of nine models which included field delay by Simpson's one third rule, field delay by Highway Capacity Manual (HCM 2010), Webster's delay model, Highway Capacity Manual (HCM 2010) model, Arpita Saha's model, Raval and Gundaliya's model, Hoque and Imran's model, Empirical method and Reilly's model. Moreover, delay was estimated by simulation is VISSIM. Model was proposed from conditions existing in study area. The proposed model had least amount of MAPE (Mean Absolute Percentage Error) with respect to field delay. The usefulness of model could be checked for other conditions as well.

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