Estimation and Development of Saturation Flow Model for Heterogeneous Traffic Condition at Urban Intersection

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Abstract— Intersections are one of the most critical elements that affect the performance of urban road network. For safe and efficient movement of large volumes of traffic on city road network, majority of the intersection are usually signalized. Saturation flows, lost times and Passenger Car Units (PCU) are the significant parameters in the planning, design and control of signalized intersection. Several factors which are significant influence on saturation flow such as roadway parameters, traffic condition, operating parameters. This thesis discusses a saturation flow study conducted in various intersections of Rajkot city. The Saturation flow rate is calculated based on the observed green time. This thesis presents the results of the study on analysis of saturation flow rate conducted at intersection with heterogeneous traffic condition in Rajkot, and developed model for the saturation flow considering width of approach, traffic compositions, right turn movement and approach speed criteria. A formula was recommended for use in estimating an appropriate saturation flow value for a specific lane on an approach to an intersection. Many researchers have developed models for saturation flow. The developed Models of saturation flow give the correct value of saturation flow. These developed models are calibrated & validated with field observed data.

Key words: Saturation Flow Rate Model, Heterogeneous Traffic, Traffic Composition, Approach Speed, Right Turn Movement

I. Introduction

Traffic signals are perhaps the most important traffic control devices for at grade intersection in the urban traffic system. Proper installation of traffic signals can reduce the number of accidents and minimize delays to vehicles at intersections.

Road traffic conditions in India get worse day by day. Spending hours in traffic jam have become part and parcel of the metropolitan lifestyle, leading to health and environmental hazards. The rapid increase in vehicle ownership in India in particular has increased the traffic intensity that has created various serious problems such as congestion and formation of long queues ultimately causing heavy delays and increase in the number of accidents at various locations on roadways.

In order to solve this problem, there could be two approaches: The first approaches are to come up with infrastructure involving wider roads, flyovers, bypasses and expressways. But this approaches, solutions area very serious concern about space and money for developing countries like India. The second approach is to manage existing traffic with the same infrastructure, with the use of technology and by involving commuters in the process. Concentrating on the second approach that is an Intelligent Transportation System (ITS) which makes use of communication technology to alleviate road traffic problems. The objective of the study is to collect a large sample of field data and computation of saturation flow values. The Saturation Flow values can be used as input for determining intersection capacity and optimize signal systems.

A. *Objectives of Study*

- To find the saturation flow of KKV intersection of Rajkot city.
- To develop saturation flow model considering road width, vehicle composition, approach speed, gradient, and right turning traffic flow for non- lane based heterogeneous traffic condition.
- To validate the developed model using statistical methods.

II. Basic Concept of Saturation Flow

A. *Overview*

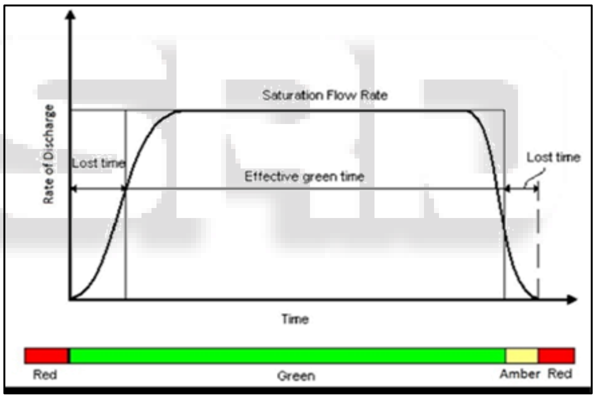

Fig. 1: Flow of traffic during the green period from a saturated approach

Saturation flow rate is basic parameter used to derive capacity. It is determined based upon minimum headway that the lane group can sustain across the stop line. Saturation flow rate is computed for each of the lane groups. Saturation rate for the prevailing conditions can be determined directly from the field measurements and be used, with no adjustments.

The traffic flow during the release of platoon is described in figure 1. It is observed that as soon as the green signal is given, the rate of discharge begins to pick up and some time is lost before the flow reaches the maximum value (Saturation flow). The flow rate will start dropping at an increasing rate when the signals are in yellow time and then stop when the signals turn red. The saturation flow is calculated by making the curved profile into a rectangle from which the dimensions can be measured. This is achieved by identifying lost time and effective green time. The lost time is the time from the start of green to a point where vehicles are flowing at half the maximum flow plus the time from where vehicles are flowing at half the maximum flow at the end of saturation to the beginning of red time.

B. Terminology and Key Definitions

- Cycle: One complete sequence of signal indications, start green time on one phase to start of green again on the same phase is called a cycle.
- Cycle Length (C): Total length of time for the signal to complete one cycle. Phase: The sequence of conditions applied to one or more streams of traffic during which the cycle receive identical signal light conditions.
- Change Interval (Y): The "yellow" and /or "all-red" intervals, which occur at the end of a phase to provide for clearance of the intersection before conflicting movement are released.
- Green Time (G): Time within a given phase during which the "green" indication is shown.
- Lost Time: Time during which the intersection is not effectively used by any movement or the amount of a time in a cycle, which is effectively lost to the traffic movement in the phase because of starting delay, and at the end of green phase with start of amber period. Pedestrian movement at start of phase and the falling of the discharging rate, which occurs during the amber period.
- Effective Green Time: Time during which a given phase is effectively available for stable moving platoons of vehicles in the permitted movements.
- Saturation Flow Rate: Saturation flow is the maximum volume stated in passenger car unit / hour (PCUs/h), which can pass the stop line of approach lane at a green light.
- Passenger Car Unit (PCU): Vehicle of different types require variable area in the road space because of variation in size and performance.

C. Factors Affecting the Saturation Flow

- Vehicle composition: A vehicle may be motorized and non-motorized, with different operating performances and congestion of different types of vehicles affect the saturation flow.
- Width of approach: The approach width, accounts for the negative impact of narrow lane on saturation flow rate and allows for increased flow rate on wide lanes.
- Driver behaviour: Poor lane discipline and observation of traffic signals; Public transport - varied mix of bus types, stopping places and driving styles also affect the saturation flow.
- Roadside activity: Roadside land uses generate parking and non-transport activities that reduce effective lane width.
- Approach Speed: Approach speed is varies with different approach of intersection. There is one probability, saturation flow rate increase with increase approach speed.
- Gradient: As per the IRC- SP- 41, for each 1 per cent of downhill gradient, saturation flow increase by 3 per cent and for each 1 per cent of uphill gradient, saturation flow decrease by 3 per cent.
- Right-turn movements: Which is directly affect the saturation flow rate, generally right turn movement obstruct the traffic flow.
- Number of lanes: increase the number of lane with increase saturation flow rate.

III. LITERATURE REVIEW

Chang-qiao Shao, Xiao-ming Liu (2012), “Estimation of Saturation Flow Rates at Signalized Intersections” The goal of this paper is to study the nature of queue discharge headways and to develop a more accurate estimate method for saturation headway and saturation flow rate. Based on the surveyed data, the characteristics of queue discharge headways and the estimation method of saturated flow rate are studied. It is found that the average value of queue discharge headways is greater than the median value and that the skewness of the headways is positive. According to the queue discharge headway characteristics, the median value of queue discharge headways is suggested to estimate the saturation headway and a new method of estimation saturation flow rates is developed.

The average value of queue discharge headways is greater than the median value, and the skew of headways is positive. The traditional estimation of saturation headway does not accurately reflect the true value of headway. The new estimations of saturation flow rate developed in this study are more reasonable and they are suggested to be used in traffic control and measurement of intersection capacity.

N.G. Raval & P. J. Gundaliya (2012), “Modification of Webster’s Delay Formula Using Modified Saturation Flow model for Non-Lane Based Heterogeneous Traffic Condition”

Objectives of this study are developing saturation flow model considering width & vehicle composition criteria for non-lane based heterogeneous traffic condition and to modify the Webster’s delay formula under non-lane based heterogeneous traffic condition. They were collected traffic data manually at three signalized intersection of Ahmedabad city. From the data they are develop two saturation flow models:

- Model 1: Saturation Flow Model Width Approach (SFMW)
- S=626W+268
- Model 2: Saturation Flow Model Traffic Composition Approach (SFMC)

S=647W+709tw+270b+702au-1568car-1552bic
S = Saturation flow rate (PCU/h),
W =Width of approach in meter,
b =Percentage of bus,
au = Percentage of auto-rickshaw,
car =Percentage of car,
bic. = Percentage of bicycle.

And modify Webster’s delay formula under non-lane based heterogeneous traffic condition can be accomplished by adding an empirical adjustment term as follow:

$$d=\frac{c(1-\lambda)^2}{2(1-\lambda x)}+\frac{x^2}{2q(1-x)}+7.82Q+0.057C+7.6x+3.98\lambda+32.35tw-26.55$$

c=Cycle time in sec.,
λ=Effective green ratio,
x=Degree of saturation,

Q=Vehicle arrival rate (PCU/sec.)

They are observed that proportion of two-wheelers is more in the traffic, so it is included in the adjustment factor in the delay's formula.

IV. METHODOLOGY

For the data collection to measure saturation flow there are different methods, ranging from manual to complex automatic techniques. All these methods have some merits and demerits. Any method, which should be selected for any study depends on many factors like the type of study, availability of manpower, ease of analysis, cost and should provide a permanent record of data for further analysis at any time.

Since it will need two or more observers to collect the necessary data manually, it was decided to use a Video Recording technique for data collection. Figure 2 represent the study methodology:

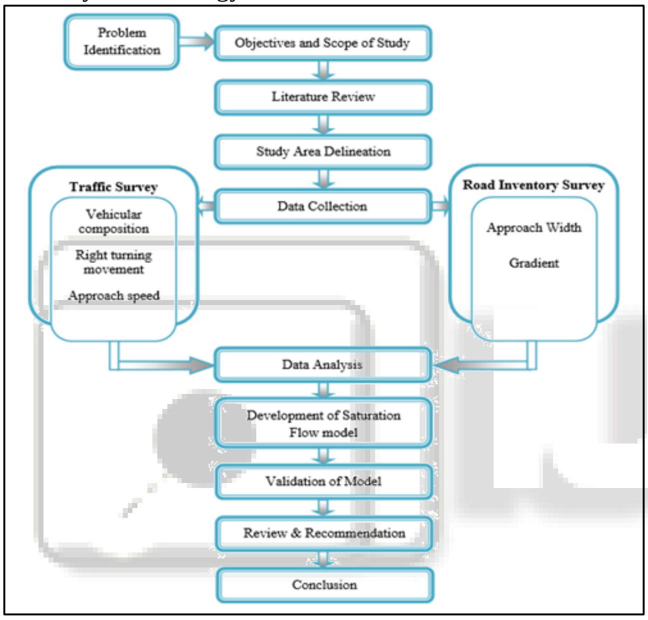

Fig. 2: Methodology Flow Chart

V. DATA COLLECTION & ANALYSIS

KKV Intersection is four-legged intersection. During peak hours (Morning peak and Evening peak), the intersection gets over saturated. The road surface condition at study approaches is fairly good, which is affecting the speed of vehicles. Traffic flow at intersection, approaching from Kalawad, Madhapar chowk, Kotecha circle and Gondal chowk. The geometrical features at this intersection as shown in figure 2. Traffic consists of two wheelers, Car, Auto, LCV, HCV, Bus, and Bicycle.

A. Traffic Composition at KKV Intersection Approaches

Following vehicles composition is observed during morning and evening peak period for the KKV intersection.

Types of Vehicle	Number of Vehicles			
	Morning Peak Hours		Evening Peak Hours	
	Total Traffic	Right Turning Traffic	Total Traffic	Right Turning Traffic
2W	4333	817	4007	728
Car	849	157	916	188
Bus	36	0	33	1
Auto	882	137	662	116
LCV	141	30	59	33
HCV	0	0	0	0
Bicycle	104	38	8	8

Table 1: Number of vehicles at Kotecha approach

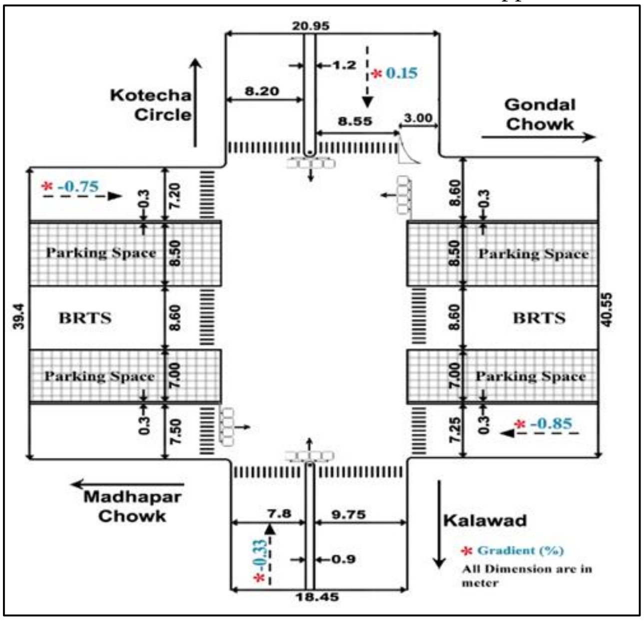

Fig. 3: Road features of KKV Intersection

Types of Vehicle	Number of Vehicles			
	Morning Peak Hours		Evening Peak Hours	
	Total Traffic	Right Turning Traffic	Total Traffic	Right Turning Traffic
2W	1681	742	1499	613
Car	488	204	410	160
Bus	10	3	16	4
Auto	448	122	344	59
LCV	97	26	20	4
HCV	40	1	22	0
Bicycle	34	11	56	6

Table 2: Number of vehicles at Gondal approach

Types of Vehicle	Number of Vehicles			
	Morning Peak Hours		Evening Peak Hours	
	Total Traffic	Right Turning Traffic	Total Traffic	Right Turning Traffic
2W	3742	804	2887	643
Car	943	260	770	244
Bus	48	10	56	21
Auto	914	127	611	83
LCV	224	56	92	15
HCV	45	24	10	5
Bicycle	55	7	61	11

Table 3: Number of vehicles at Kalawad approach

Types of Vehicle	Number of Vehicles			
	Morning Peak Hours		Evening Peak Hours	
	Total Traffic	Right Turning	Total Traffic	Right Turning

		Traffic		Traffic
2W	1250	283	1085	272
Car	462	115	377	91
Bus	6	1	7	3
Auto	422	123	327	63
LCV	145	35	26	8
HCV	36	33	16	16
Bicycle	37	4	49	6

Table 4: Number of vehicles at Madhapar approach

B. *Field Measurement of Saturation Flow*

Measurement of Saturation flow involves measuring times from the beginning of the green phase until certain vehicles cross a reference line. Studies obtain average Saturation flow values from calculating the Saturation flow for each observed cycle using pre-determined PCU values. From the analysis, the approach width, accounts for the negative impact of narrow lane on saturation flow rate and allows for increased flow rate on wide lanes.

Approach	Kotecha		Gondal		Kalawad		Madhapar	
	Morning	Evening	Morning	Evening	Morning	Evening	Morning	Evening
TW (%)	68	70	60	63	62	64	53	58
Auto (%)	14	12	17	15	15	14	18	17
Car (%)	13	16	18	17	16	17	20	20
Bus (%)	1	1	0	1	1	1	0	0
Bicycle (%)	2	0	1	2	1	2	2	3
LCV (%)	1	1	4	1	4	2	6	1
HCV (%)	0	0	1	1	1	0	1	1
Saturation flow (PCU/Hour)	7303	7586	6585	6609	6763	6498	6445	6360
Width (m.)	8.55		7.25		7.8		7.2	
Gradient (%)	0.15		-0.85		-0.33		-0.75	

Table 5: Data of field saturation flow at KKV Intersection in both Peak hours

C. *Approach Speed of Vehicles*

An approach speed is varies with different approach of KKV Intersection. The video recording technique is done at same time of morning peak (10:00 AM to 1:30 PM) and evening peak (6:00 PM to 8:30 PM) for find approach speed. Various base length of 24.76 m, 23.5 m, 30.1 m, and 23.5 m is taken for Kotecha, Gondal, Kalawad and Madhapar Approaches respectively. For video recording camera are fixed after maximum queuing length of vehicles at particular approach. The Maximum queue length at Kotecha, Gondal, Kalawad, and Madhapar is 300 m, 175 m, 250 m, and 140 m respectively. Studies obtain average approach speed from observed speed for each approach of KKV intersection.

		TW	Car	Auto	Lcv	Bus
Morning	Number	1689	753	740	120	32
	Mean	40.83	31.84	31.49	31.00	25.58
	Minimum	15.87	16.59	14.16	19.09	21.23
	Maximum	73.36	49.55	61.43	44.78	38.09
Evening	Number	1149	671	583	39	30
	Mean	40.83	31.84	31.49	31.00	25.58
	Minimum	14.94	16.12	13.77	21.48	18.27
	Maximum	75.15	51.14	60.48	44.57	34.78

Table 6: Approach speed analysis of Kotecha approach

		TW	Car	Auto	Lcv	Hcv	Bus
Morning	Number	1508	454	440	81	38	10
	Mean	29.58	23.49	26.56	21.73	17.61	19.21
	Minimum	13.97	12.16	17.13	13.61	12.51	15.4
	Maximum	68.67	37.6	38.46	28.73	22.58	26.52
Evening	Number	1508	454	440	81	38	10
	Mean	29.58	23.49	26.56	21.73	17.61	19.21
	Minimum	13.97	12.16	17.13	13.61	12.51	15.4
	Maximum	68.67	37.6	38.46	28.73	22.58	26.52

Table 7: Approach speed analysis of Gondal approach

		TW	Car	Auto	Lcv	Hcv	Bus
Morning	Number	1511	784	779	113	44	40
	Mean	29.25	27.73	23.78	24.57	23.35	22.97
	Minimum	15.48	11.69	13.76	15.87	19.07	17.71
	Maximum	50.61	52.45	36.47	36.16	30.69	30.07
Evening	Number	1604	621	543	64	8	38
	Mean	28.87	27.70	22.77	23.11	22.79	24.11
	Minimum	14.45	10.92	13.61	15.56	18.7	11.81
	Maximum	51.3	53.49	33.9	31.25	27.61	34.68

Table 8: Approach speed analysis of Kalawad approach

		TW	Car	Auto	Lcv	Hcv	Bus
Morning	Number	1092	454	435	72	41	37
	Mean	27.62	24.25	23.16	20.65	16.48	15.77
	Minimum	13.76	14.98	12.78	13.14	14.06	13.09

	Maximum	59.33	39.61	35.91	30.79	20.3	21.28
Evening	**Number**	1078	370	284	19	13	6
	Mean	26.00	25.15	23.09	21.57	19.77	19.89
	Minimum	11.63	14.29	10.97	14.19	15.47	15.9
	Maximum	51.09	39.61	32.54	27.14	26.94	27.47

Table 9: Approach speed analysis of Madhapar approach

App. Speed (kmph)	**Frequency (%)**				
	2W	**Car**	**Auto**	**LCV**	**Bus**
10 to 20	0.00	0.00	1.08	0.00	0.00
20 to 30	2.78	19.52	8.92	10.00	71.88
30 to 40	22.85	42.76	32.97	67.50	25.00
40 to 50	46.48	37.18	38.24	22.50	3.13
50 to 60	19.78	0.53	16.62	0.00	0.00
60 to 70	5.98	0.00	0.00	0.00	0.00
70 to 80	2.13	0.00	2.16	0.00	0.00

Table 10: Frequency distribution of approach speed at Kotecha Approach in Morning

App. Speed (kmph)	**Frequency (%)**				
	2W	**Car**	**Auto**	**LCV**	**Bus**
10 to 20	0.00	0.00	1.54	0.00	0.00
20 to 30	3.05	24.89	16.64	15.00	33.33
30 to 40	20.80	37.41	52.32	23.75	63.33
40 to 50	47.00	36.07	25.90	10.00	3.33
50 to 60	22.28	1.64	3.26	0.00	0.00
60 to 70	4.87	0.00	0.34	0.00	0.00
70 to 80	2.00	0.00	0.00	0.00	0.00

Table 11: Frequency distribution of approach speed at Kotecha Approach in Evening

App. Speed (kmph)	**Frequency (%)**				
	2W	**Car**	**Auto**	**LCV**	**Bus**
10 to 20	11.79	47.58	15.91	50.62	76.32
20 to 30	48.81	35.90	63.86	49.38	23.68
30 to 40	27.22	16.52	20.23	0.00	0.00
40 to 50	9.74	0.00	0.00	0.00	0.00
50 to 60	2.32	0.00	0.00	0.00	0.00

Table 12: Frequency distribution of approach speed at Gondal Approach in Morning

App. Speed (kmph)	**Frequency (%)**				
	2W	**Car**	**Auto**	**LCV**	**Bus**
10 to 20	1.38	3.13	0.92	0.00	12.50
20 to 30	38.26	58.75	41.54	72.22	87.50
30 to 40	34.48	30.55	41.23	27.78	0.00
40 to 50	20.12	7.57	16.31	0.00	0.00
50 to 60	5.76	0.00	0.00	0.00	0.00

Table 13: Frequency distribution of approach speed at Gondal Approach in Evening

App. Speed (kmph)	**Frequency (%)**				
	2W	**Car**	**Auto**	**LCV**	**Bus**
10 to 20	0.00	1.53	1.16	0.00	0.00
20 to 30	28.39	35.20	64.96	50.44	65.91
30 to 40	51.49	53.83	33.25	47.79	34.09
40 to 50	17.07	9.18	0.64	1.77	0.00
50 to 60	3.04	0.26	0.00	0.00	0.00

Table 14: Frequency distribution of approach speed at Kalawad Approach in Morning

App. Speed (kmph)	**Frequency (%)**				
	2W	**Car**	**Auto**	**LCV**	**Bus**
10 to 20	0.12	1.77	3.87	0.00	0.00
20 to 30	30.36	34.14	71.45	68.75	62.50
30 to 40	53.30	55.56	24.68	31.25	37.50
40 to 50	14.03	7.89	0.00	0.00	0.00
50 to 60	2.18	0.64	0.00	0.00	0.00

Table 15: Frequency distribution of approach speed at Kalawad Approach in Evening

App. Speed (kmph)	**Frequency (%)**				
	2W	**Car**	**Auto**	**LCV**	**Bus**
10 to 20	0.92	0.88	3.91	1.39	20.69
20 to 30	36.82	62.64	56.78	87.50	79.31
30 to 40	48.67	31.65	31.72	11.11	0.00
40 to 50	10.65	4.62	0.92	0.00	0.00
50 to 60	2.94	0.00	0.00	0.00	0.00

Table 16: Frequency distribution of approach speed at Madhapar Approach in Morning

App. Speed (kmph))	**Frequency (%)**				
	2W	**Car**	**Auto**	**LCV**	**Bus**
10 to 20	22.82	24.86	23.94	42.11	46.15
20 to 30	52.97	56.49	73.59	57.89	53.85
30 to 40	19.02	18.65	2.46	0.00	0.00
40 to 50	4.45	0.00	0.00	0.00	0.00
50 to 60	0.74	0.00	0.00	0.00	0.00

Table 17: Frequency distribution of approach speed at Madhapar Approach in Evening

VI. DEVELOPMENT OF MODEL

To estimate the saturation flow for heterogeneous traffic condition, following models are developed using multiple regression analysis.

A. Model 1:

This model is developed using the width of an approach of selected intersection.

S = 710.25 * W

B. Model 2:

This model is developed using the Approach Speed, Traffic composition of all traffic flow direction and Gradient of an approach of selected intersection.

S = 11.22 Stw + 20.53 Sc + 7.06 Sa + 2.62 SL +1645.98 Ctw + 4196.24 Cc + 1915.48 Ca + 99.13 CL - 520.47 G +2477.86

C. Model 3:

This model is developed using the Approach Speed, Traffic composition of Straight traffic direction and Gradient of an approach of selected intersection.

S = 1.05 Stw + 43.54 Sc + 1.89 Sa + 1.30 SL + 5544.62 Ctw + 6643.47 Cc + 4826.84 Ca + 4754.80 CL - 2225.76 G - 2563.33

D. Model 4:

This model is developed using the Approach Speed, Traffic composition of Right traffic direction and Gradient of an approach of selected intersection.

S = 12.46 Stw + 4.47 Sc + 2.42 Sa + 2.10 SL + 722.09 Ctw + 1563.56 Cc + 1174.95 Ca + 2373.95 CL - 736.23 G - 558.46

Where,

W= Width of Approach in m
S = Saturation Flow Rate in PCU/hr
Stw = Approach Speed of Two Wheeler in kmph
Sc = Approach Speed of Car in kmph
Sa = Approach Speed of Auto in kmph
SL = Approach Speed of LCV in kmph
Ctw = Composition of Two Wheeler in Percentage
Cc = Composition of Car in Percentage
Ca = Composition of Auto in Percentage
CL = Composition of LCV in Percentage
G = Gradient in Percentage

E. Assumptions for the Regression Model:

1) Vehicle composition is must be in percentage, e.g. 0.10, 0.20 etc.
2) The total summation of Ctw, Cc, CA and CL is 1.00.
3) Width of approach should be measured as carriageway width only in m.
4) Negligible composition must be neglected.
5) Approach speed of vehicles must be measured after some distance from maximum queuing length of particular selected approach.
6) Gradient must be measured parallel to traffic stream direction at particular approach.

F. Validation of Model

The statistical test is carried out for validation as below:

	R^2 Value	F observed	F critical
Model-1	0.69	5.29	1.22
Model-2	0.48	2.10	1.22
Model-3	0.79	1.28	1.22
Model-4	0.31	3.16	1.22

Table 18: Statistical test for Models

1) Summary of validation:

$F_{observed} > F_{cri}$ is showing the probability of acceptance of independent variables with the dependent. It is observed from the validation that observed saturation flow is affected by the variables like width of road, traffic composition, and gradient.

G. Comparison of Observed Saturation Flow and Model Output

Sr. No.	Width (m)	Observed Saturation Flow (PCU/hr)	Estimated Saturation Flow (PCU/hr)	Diff. in %
1	Model 1	5476	5469	0.13
2	Model 2	5476	5268	3.79
3	Model 3	3249	3513	8.14
4	Model 4	1415	1561	10.35

Table 19: Comparison of observed saturation flow and model output

All four models are having least difference as show in table 19 but the model -1 and model -2 are giving more fair results compare to other two models. The difference between the model output and observed capacity are very less. Hence, the models can be used for the estimation of saturation flow rate for the cities having similarity with Rajkot City.

VII. CONCLUSION

- The estimation of saturation flow rate is carried out for the four approach of KKV intersection in Rajkot city.
- The mathematical model-1 is developed based on the saturation flow rate with width as independent variable.
- The mathematical model-2 is developed based on the saturation flow rate with each direction of traffic flow composition, approach speed of vehicles and gradient.
- The mathematical model-3 is developed based on the saturation flow rate with straight direction of traffic flow composition, approach speed of vehicles and gradient.
- The mathematical model-4 is developed based on the saturation flow rate with right direction of traffic flow composition, approach speed of vehicles and gradient.
- The developed models of saturation flow gives the value in PCU/hr considering width, gradient, approach speed and vehicle composition of intersection. It gives the satisfactory results nearer to the field observations.
- The models are developed using Excel. All models are validated using statistical tests.
- The model output and observed capacity are compared. The difference between the model output and observed capacity are very less. Hence, the models can be used for the estimation of saturation flow rate for the cities having similarity with Rajkot City.
- The saturation flow analyzed for this intersection shows that it does not depend only on width of the approach (w); therefore the empirical formula 525w suggested for Indian conditions in Special Publication IRC: SP: 41-1994 of the Indian Roads Congress is inappropriate for obtaining saturation flow.
- Traffic composition of two wheeler and car is also affecting on the saturation flow due to higher composition.
- An increase in the Approach speed of two wheeler, car, auto, LCV leads to an increase in the saturation flow rate.
- An increase in the gradient leads to a decrease in the saturation flow rate.
- The developed models can be used for similar intersection of any cities of India and should be checked for its usefulness.

VIII. FUTURE SCOPE

- Recommended model of Saturation flow must be verified by applying it in other cities. In present study analysis has been carried out for only one intersection in Rajkot city. Similar analysis should be carried out for large number of intersection approaches.
- It is recommended to use greater number of observational cycles including greater number of intersections for model calibration and validation.
- It is recommended to find actual PCU values for the present vehicle.
- Saturation flow also gets affected by parking facility, bus blockage, turning radius, roughness etc. near intersection. All these factors needs to studied and

develop new model taking into account maximum possible variables.

– The estimated saturation flow rate of the intersection can be simulated in the VISSIM software for the validation.

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