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TO ESTIMATE THE CAPACITY OF ROUNDABOUTS THROUGH MICROSIMULATION APPROACH

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Abstract: Roundabout is one of the kinds of Intersections which is meant for the smooth and efficient flow of traffic passing through the roadway. It is a circular intersection or a junction in which the road traffic is allowed to flow in one direction around a central island. The maximum flow rate at the roundabout entry depends mainly on two factors namely; the circulating flow and the geometric elements. Capacity in general can be defined as the maximum hourly rate at which persons or vehicles that can pass a point or uniform section of a lane during a given time period.Vissim is a microscopic, time step, and behavior-based simulation model for modelling realistic city and interurban transportation, including pedestrian movements.Different characteristics, such as lane allocation, vehicle composition, signal control, and identification of private and public transportation vehicles, are used to mimic traffic flow.

Index Terms: Capacity,CVC, Roundabout, VISSIM.

I. INTRODUCTION

The greatest flow rate that can be handled at a roundabout entry is determined by two factors: the roundabout's circulating flow, which interferes with the entering flow, and the roundabout's capacity. When the circulating flow is low, cars at the roundabout's entry can enter the roundabout quickly. Larger gaps in the circulating flow are more advantageous to incoming cars, and each gap can accommodate multiple vehicles. The size of the gaps in the circulating flow diminishes as the circulating flow grows, and the rate at which vehicles can enter lowers as well. The maximum hourly rate at which passengers or vehicles can pass a point or uniform section of a lane within a specific time period is described as capacity. There are few points that shows that why capacity estimation is important, which are as follows.

The design of any highway facility is possible only when the capacity is related to the projected requirements of traffic. The design features governed by the capacity are; The type of highway, number of lanes, geometric parameters etc.

One can examine the adequacy and deficit of existing highways by comparing current traffic volume to capacity. If capacity assessments are taken into account, improvements and adjustments in geometric characteristics, traffic control devices, and traffic management systems can be planned successfully.

II. LITERATURE SURVEY

Chen et.al.(2016) had carried out study on Multi-lane roundabouts under congestion. Multiple video cameras were employed to record vehicle turning movements at roundabouts as well as the growth of vehicle queues at roundabout entrance approaches for this study. The number of vehicles in the lineups may be reliably tallied in any single minute during peak hours using these camera records. Then, in comparison to the acquired field data, several software packages such as RODEL, SIDRA, and VISSIM were utilised to estimate several performance parameters such as capacity and latency. The study reveals that before calibration, all three software tools overstate multi-lane roundabout capacity.

Mathew et al. (2017) had carried out study on the Roundabout Capacity in Heterogeneous Traffic Condition: Modification of HCM Equation and Calibration.Here to adjust the HCM 2010 equation for Indian traffic conditions, two roundabouts in distinct regions were chosen for study. At two roundabouts, data was collected.The relationship between Entry flow and Circulatory flow was plotted, and it was discovered that it follows a negative exponential tendency. It means that as the circulating flow increases, the entry capacity decreases exponentially. When the flow on the circulating space is low, a greater number of vehicles can enter from a particular approach, according to the connection obtained.

Ramu Arroju et.al.(2015) had carried out study on the Comparative evaluation of roundabout capacities under heterogeneous traffic conditions. The capacity of the roundabout is determined in this study utilising a variety of capacity formulas, including gap acceptance models from the Highway Capacity Manual 2010 (US), German model (2001), empirical regression models, and weaving models from the IRC: 65–1976. (India).In addition, capacity values are calculated using a microscopic simulation model such as VISSIM (PTV Germany). After calibrating the simulation model (VISSIM) built for the roundabout, capacity is evaluated. Except for the German model, the capacity numbers estimated using various methods deviate significantly from the actual values, and they are either overestimating or underestimating. The capacity numbers from the VISSIM and German models are substantially identical to the field capacity, according to these findings.

Osei et al. (2021) had carried out study on the options to improve capacity and delay at roundabouts through microsimulation approach.The goal of the study were (a) assess the performance of the corridor's selected roundabouts (b) investigate alternative intersection configurations to improve capacity and delay. Two days of 2-h time stamped footages of AM and PM peak traffic patterns were obtained using video data gathering techniques.Geometric design characteristics, queue lengths, travel times, and approach flows of existing roundabouts were also recorded. The selected roundabouts' VISSIM models were created.

Wang et.al. (2012) had carried out study about the Research on Capacity of Roundabouts in Beijing.The present method for determining the approach capacity at a roundabout mostly relies on data from vehicles entering and exiting the roundabout. The goal of this study is to model weaving gap acceptance at the weaving sections in order to determine the capacity of a roundabout. In terms of capacity estimation, only a few studies have been undertaken from the perspective of the weaving section. The goal of this study is to model weaving gap acceptance at the weaving sections in order to determine the capacity of a roundabout.

Giuffre et al. (2018) had carried out study on Capacity-based calculation of passenger car equivalents using traffic simulation at double-lane roundabout.This study proposes a criterion for determining passenger car equivalents that represent

traffic circumstances in double-lane roundabouts, where each entry lane's capacity is typically calculated. Heavy vehicles have a far greater impact on traffic than passenger cars, and their presence in mixed traffic streams can skew traffic analysis results. For expressing traffic volume, the passenger car equivalent is required.

Martin-Gasulla et al. (2016) had carried out study on Capacity and operational improvements of metering roundabout in Spain .On uneven flow roundabouts, metering systems can improve traffic flow and capacity. After metering, the fraction of long gaps on the conflicting flow increased, resulting in longer entering platoons and shorter follow-up headways, according to this study. Unlike earlier research, the potential benefit was calculated using the Highway Capacity Manual (HCM) analysis process. At every level of entering flow, there is a significant reduction in delay, and capacity might be increaced for high clashing flow rates.

Hamim et.al. (2021) had carried out study on Developing empirical model with graphical tool to estimate and predict capacity of rural highway roundabouts**.** The goal of this research is to create a model for measuring and projecting roundabout capacity on rural routes with a large volume of heavy vehicles. Field data from six roundabouts with variable shape and traffic composition at highway crossings were used to build the capacity model, which took into account both geometric and traffic features. The roundabouts' field entry capacity was compared to the capacity estimated using the HCM 2016 approach.

Cheng et.al. (2016) had carried out study on Capacity Model for Large Signalized Roundabouts.This work establishes the corresponding calculation model for calculating the capacity of a signalised roundabout. The model specifies that the maximum number of cars on the approach that can be imported into the island is the roundabout capacity, based on gap acceptance theory. The capacity model's important factors include traffic flow, critical gap, follow-up time, duration of green time, and cycle time.

III. STUDY AREA, DATA COLLECTION AND METHODOLOGY

Gandhinagar, The capital of Gujarat is selected for the study area in which two roundabouts namely Maharana Pratap circle, Pethapur, GH 7& press circle are the two intersections in Gandhinagar are taken as study area.

III.I PROPOSED METHODOLOGY

The aim of the present study is to estimate the capacity of the said intersections. There are a number of measures that must be taken in order to achieve this goal. First the problem is identified and then the look for previous research in this topic. After this, to have a better understanding, a literature study was conducted. Then suitable study area was selected. Following the selection of the study area and the examination of the literature, the data collecting phase was carried out. For the collection of data videography was done. The data are of peak hours in week days for both of the locations. From the survey data such as CVC (classified volume count), spot speed and Headway were derived. These data can be used for the estimation of Capacity using the VISSIM software.

Various steps of proposed method:

Step 1: Objective of the study.
Step 2: Literature Review.
Step 3: Selection of study area.
Step 4: Data collection- Classified Volume Count, Spot speed, Headway.
Step 5: Analysis using VISSIM software
Step 6: Estimation of Capacity of Roundabout

IV. DATA COLLECTION

The survey was conducted as discussed in the methodology. A total of four cameras were fitted inside the intersection to calculate the number of vehicle. Data collection was started at 9 A.M. in the morning to 11 A.M. The Spot speed survey was carried out with the help of other group members simultaneously. PCU values the vehicle are: 0.5 for Two wheeler, 1.2 for 3W, 1 for 4 wheeler, 3 for bus and 1 for Light Commercial Vehicle(LCV).

IV.I CLASSIFIED VOLUME COUNT SURVEY

The Classified Traffic Volume Counts Survey is carried out to obtain an understanding of traffic characteristics such as average daily traffic, traffic composition, peak hour traffic, and directional split at individual survey locations.This Survey was carried out using Vediography at Maharana Pratap Circle, Pethapur and GH7& Press circle,Gandhinagar.As per the general trend of the study area the peak hours are 9:00 A.M. to 11:00 A.M. CVC data for Maharana Pratap circle are shown in table 1 to 4 along with graphs.

The detailed results of one of the four leg are shown here, a similar procedure was conducted at the other location as well.

Table1: CVC Data for Pethapur-Mahudi (Maharana Pratap Circle, Pethapur)

Sr No.	Start time	End time	2W	3W	4W	BUS	LCV	Total veh	Veh/hr	PCU/hr
1	9:00	9:15	32	13	15	3	12	75	300	67.6
2	9:15	9:30	41	7	8	1	8	65	260	47.9
3	9:30	9:45	44	20	22	2	11	99	396	85
4	9:45	10:00	55	11	13	0	6	85	340	59.7
5	10:00	10:15	40	8	17	4	3	72	288	57.6
6	10:15	10:30	47	12	11	1	9	80	320	60.9
7	10:30	10:45	59	7	15	1	5	87	348	60.9
8	10:45	11:00	41	15	24	2	8	90	360	76.5

Table 2: CVC Data for Gandhinagar-Pethapur (GH7 & Press Circle, Gandhinagar)

Sr No.	Start time	End time	2W	3W	4W	BUS	LCV	Total veh	Veh/hr	PCU/hr
1	9:00	9:15	66	21	13	2	1	103	412	84.2
2	9:15	9:30	45	18	11	2	1	77	308	62.1
3	9:30	9:45	49	17	9	1	1	77	308	57.9
4	9:45	10:00	60	23	19	2	2	106	424	84.6
5	10:00	10:15	57	20	12	4	1	94	376	77.5
6	10:15	10:30	44	27	8	0	0	79	316	62.4
7	10:30	10:45	48	25	11	2	1	87	348	72
8	10:45	11:00	52	15	15	1	1	84	336	63

IV.II SPOT SPEED SURVEY

A spot speed is calculated by measuring the individual speeds of a sample of vehicles passing through a certain location on a street or highway. The purpose of a spot speed study is to determine the speed distribution of a traffic stream at a single point. The survey was performed by manual observation. Here the Spot speed data table for one of the roundabouts (Maharana Pratap Circle) is shown below.

Table 3: Spot speed data for Maharana Pratap Circle. Pethapur

2w	Speed	3w	Speed	4w	Speed	Bus	Speed	Lcv	Speed	Dist.
10	4.633782	4	2.163294	6	1.943574	0	0	1	2.472089	31
11	5.057096	2	2.561983	3	3.1	0	0	1	1.229671	31

12	2.671756	3	1.964453	5	1.143791	0	0	2	1.259748	21
9	2.699229	8	1.4	10	1.197263	1	0.832342	0	0	21
11	3.033268	4	2.755556	3	1.55	1	1.327623	0	0	31
15	3.206107	2	2.231668	5	2.625	0	0	0	0	21
12	2.1	1	1.986755	6	2.380952	0	0	0	0	21
10	1.998097	2	1.674641	10	2.405498	2	0.939177	0	0	21
7	1.735537	7	1.612903	4	1.060071	3	1.487252	0	0	21
6	1.826087	5	1.269649	3	2.034884	1	1.260504	0	0	21
14	1.897019	2	1.362751	7	1.135135	0	0	1	1.269649	21
13	3.563218	1	2.478018	4	2.2694	1	2.570481	2	1.950913	31
10	3.444444	1	3.192585	3	1.66309	1	1.295445	0	0	31
8	3.1	1	3.103103	4	1.156285	1	2.097429	1	3.153611	31
8	2.557756	2	2.818182	9	1.703297	2	1.486811	1	2.195467	31
10	2.607233	7	3.954082	7	2.375479	0	0	1	3.219107	31
7	1.664025	3	1.718494	3	2.542373	2	1.074169	1	1.728395	21
12	2.102102	4	1.533966	6	2.908587	1	1.039604	0	0	21
14	2.45614	5	1.674641	4	1.076371	1	0.89172	1	1.260504	21
9	2.149437	11	1.478873	8	0.826772	0	0	1	0.926334	21
15	2.557856	4	1.769166	8	0.856095	0	0	0	0	21
12	3.362256	2	2.941176	13	3.150407	3	1.733781	0	0	31
11	3.538813	1	2.311708	5	3.249476	1	1.388267	1	2.097429	31
9	3.131313	3	3.730445	5	3.498871	0	0	2	1.733781	31
5	4.654655	5	3.625731	7	1.687534	2	1.873112	1	1.965758	31
11	3.147208	5	4.183536	4	3.169734	1	1.310228	3	2.068045	31
13	2.04878	6	2.419355	5	1.741294	1	0.72942	1	0.970874	21
25	2.149437	4	1.975541	3	1.584906	1	0.759219	4	2	21
17	3.803681	2	2.472089	6	2.214286	1	1.431871	0	0	31
12	2.315161	1	2.231821	8	1.979566	0	0	1	1.873112	31
14	2.466189	4	3.033268	5	1.224812	0	0	1	1.798144	31
11	2.770331	7	2.755556	1	1.056938	1	1.216641	0	0	31
13	2.557756	10	3.664303	5	1.111908	2	1.560141	1	1.706109	31
10	1.476793	4	2.55164	6	0.794251	2	0.818076	2	1.238208	21
11	1.909091	7	2.752294	11	0.879765	1	0.854353	1	1.448276	21
14	1.478873	12	1.732673	7	1.161504	0	0	0	0	21
8	3.780488	2	2.695652	8	1.374113	1	1.585678	1	2.26774	31
6	2.683983	6	4.428571	2	1.583248	1	1.612903	0	0	31
12	3.475336	9	3.699284	5	1.705171	0	0	2	2.514193	31
11	3.066271	7	3.160041	10	1.500484	2	1.436515	3	1.742552	31

IV.III HEADWAY CALCULATION

Time headway is a critical microscopic traffic flow metric that is defined as the time interval, commonly measured in seconds, between subsequent cars in the traffic stream.It is the time interval between the passage of the fronts of successive vehicles at a specified point and it is measured in seconds.

Table 4: Time Headway for Maharana Pratap circle, Pethapur

Mode	Leg1	Leg 2	Leg 3	Leg 4
2W	3.8	3.55	3.89	3.31
3W	4.1	3.7	3.93	3.54
4W	4.3	4.66	4.25	4.2
Bus	5.66	5.14	5.88	5.3
LCV	5.02	5.14	5.45	5.3

Table 5: Time Headway for GH7 & Press circle,Gandhinagar

Mode	Leg1	Leg 2	Leg 3	Leg 4
2W	3.22	3.45	3.19	3.21
3W	3.11	4.27	3.27	3.4
4W	4.64	4.46	4.08	4.66
Bus	5.62	5.10	5.78	4.99
LCV	5.01	5.24	4.45	4.93

V. DATA ANALYSIS

The analysis was done using PTV VISSIM software to estimate the Capacity of the said Roundabouts. PTV Vissim is powerful traffic simulation software that is used in cities to achieve accessibility, sustainability, and a balanced mobility ecology. The scope of application includes traffic engineering (transport engineering,transportation planning),public transportation, urban planning and 3D visualisation (computer animation, architectural animation) for illustrative purposes and communication to the general public.The input data required for the VISSIM software are as follows:

Network Geometry: Network plan viewing whole study area, link type (e.g., urban interurban, footpath etc) and number of lanes in link, lane widths and link connectors for turning movements.

Traffic Flow Data: Inputs flows for each entry link and turning movements for each junction, vehicle mix, desired speeds (actual speed of a vehicle at free flow) at all entries of the study area and for all speed changes inside the study area.

Two Roundabouts are selected for this study, which are located in Gandhinagar.The first one is Maharana Pratap circle,Pethapur and the other one is GH7&Press circle,Gandhinagar.The study locations are shown in Fig.13 &Fig.14 for GH7&Press circle and Maharana Pratap circle respectively.For the analysis of the roundabouts through VISSIM. CVC, spot speed data and Time headway were used and the general geometric features of the roundabout were also taken into consideration.The capacity for both roundabout was then estimated using the microsimulation software. PTV Vissim helps to master a wide variety of traffic-related challenges. The following use cases cover several fields of applications: Junction layout comparison (roundabout vs. signal control, multi-modal etc.

V.I STEPS INVOLVED IN ESTIMATION OF CAPACITY

- **Background Images:** Background maps are used to set up the Vissim network to scale. Therefore, it is important to position and scale background images properly.

- **Links and connectors :** Links and connectors form the backbone of every Vissim network: They are used instead of nodes and edges.It helps to create virtually any kind of junction**.**The network is created using this feature and all links are connected using connectors. After that vehicle route is created in the links in order to make vehicular movements.
- **Vehicle input:** Vehicle inputs define the number of vehicles that should travel within the Vissim road network. They are located at the start of every link that enters the Vissim network and define the absolute vehicle volume per hour (veh/h)

Table 6: Vehicle Input

Vehicle Inputs / Vehicle Volumes By Time Interval

Vehicle volumes by

Count: 4	No	Name	Link	Volume(0)	VehComp(0)
1	1		1	550,0	1: Default
2	2		2	480,0	1: Default
3	3		3	120,0	1: Default
4	4		4	300,0	1: Default

Table 7: Capacity values for both roundabouts

Description	Maharana Pratap circle, Pethapur				GH7&Press Circle,Gandhinagar			
	Leg 1	Leg 2	Leg 3	Leg 4	Leg 1	Leg 2	Leg 3	Leg 4
Capacity of Roundabouts (Veh/hr)	847	835	907	911	875	1058	1122	947

For Maharana Pratap Circle:

Leg 1: Pethapur-GEC Gandhinagar

Leg 2: Pethapur-Randheja

Leg 3: Pethapur-Mahudi

Leg 4: Pethapur-Pethapur village

For GH7 & Press Circle,Gandhinagar:

Leg 1: GH7 & Press-GH6

Leg 2: Gandhinagar-Samarpan

Leg 3: Gandhinagar-Pethapur

Leg 4: GH7 & Press- G7

V.II THE INDIAN ROAD CONGRESS METHOD

The capacity of roundabout is a function of entry flow and circulating flow. As driver behavior appears to be the significant variable affecting roundabout performance, consideration of critical gap and follow-up time is highly recommended to produce accurate capacity estimates. The following exponential model from US HCM (2010) can be used by the analyst for the estimation of entry capacity of roundabout:

$$C = A * Exp(-B*Q_c) \quad \text{(Eq 1)}$$

$$A = 3600/T_f \quad \text{(Eq 2)}$$

$$B = (T_c - 0.5*T_f)/3600 \quad \text{(Eq 3)}$$

Where, T_f = Follow-up time in seconds T_c = Critical Gap in seconds Q_c = Circulating flow in PCU/hr.

Table 8: Critical gap and Follow-up time for different Diameter of roundabout

Diameter(m)	Critical Gap(s)	Follow-up Time(s)
20<D≤30	**2.01**	**1.51**
30<D≤40	1.87	1.40
40<D≤50	1.65	1.24
50<D≤70	1.61	1.21

Using the above equations capacity as per IRC method can be computed. Capacity for Maharana Pratap circle is 2328.62 pcu/hr and that of for GH7 & Press circle is 2329.53 pcu/hr as per the IRC method.

VI. RESULTS

Both the roundabouts have different geometric features.Maharana Pratap circle, Pethapur has diameter of 11.3 m and GH7 & Press circle has diameter of 22.8 m. The Values of Capacity as per IRC:65-2017 are 2328.62 pcu/hr for Maharana Pratap Circle and 2329.53 pcu/hr for GH 7 & Press circle.The capacity as per VISSIM are shown in table 9.

Table 9: Comparision of Capacity by different methods

Capacity	Maharana Pratap circle, Pethapur				GH7&Press Circle,Gandhinagar			
	Leg 1	Leg 2	Leg 3	Leg 4	Leg 1	Leg 2	Leg 3	Leg 4
VISSIM	847	835	907	911	875	1058	1122	947
IRC:65-2017	2328.62				2329.53			

VII. CONCLUSIONS

For the estimation of roundabout capacity, data collection was carried out and several data such as classified volume count, Spot speed data, Headway were calculated from the suvey. After that, these data were used for the capacity estimation using PTV VISSIM software.IRC method gives the capacity of a weaving section and also this method overestimates the capacity value. On the other hand, in VISSIM the geometry of the roundabout is incorporated and is coded using links and connectors with more precision.The capacity for Maharana Pratap Circle as per VISSIM is 847,835,907,911 veh/hr for each leg and that of for GH7&press circle is 875,1058,1122,947 veh/hr for each leg.The circulating flow for Maharana Pratap circle is 67.653 pcu/hr and for GH7&press circle it is 66.528 pcu/hr. These values are used for the capacity estimation as per IRC:65-2017.The values of capacity as per IRC:65-2017 are 2328.62 and 2329.58 for Maharana Pratap circle and GH7&press circle respectively.

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