Research Paper Engineering

Heterogeneous Traffic Flow Simulation at Urban Roundabout using 'VISSIM'

* Dipti S. Thanki ** Asst. Prof. Ashutosh K. Patel

* M.E. Sem IV Transportation Engineering, L.D. College of Engineering, Ahmedabad, India

** Civil Engineering Department, Government Polytechnic, Himmatnagar, India

ABSTRACT

Roundabouts have proven to be more efficient than traffic circles and in some cases than signalized and stop-controlled intersections. Traffic simulation represents the real traffic scenario and enables to test the feasibility and performance of a proposed system before implementation. It also helps to optimize the existing system. This paper suggests a methodology for traffic flow simulation at roundabout using VISSIM. It also discusses about uses of simulation, VISSIM model and it's limitation. It's also compares analytical and empirical models for roundabout capacity evaluation.

Keywords : Traffic simulation, Roundabout, VISSIM

I. INTRODUCTION

Modern roundabouts were first introduced in England in the early 1960s. They were introduced in order to solve the problems of traffic circles. Roundabouts are made up of a one-way circulating roadway which has priority over approaching traffic. The approaching traffic which has to yield to the circulating traffic can make a right turn only into the intersection (circulating roadway). At the yield line, the driver has only one decision to make and that is whether the gap in the circulating traffic is large enough for him to merge. The Capacity of roundabout is highly affected by behavioral, geometrical and vehicular characteristics at roundabout. So this phenomenon adds complexity to the traffic analysis at roundabout. Figure 1 is a representation of vehicles paths deflected by Central Island.

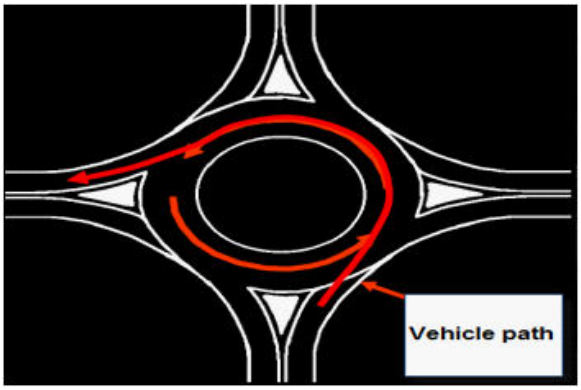

Figure 1 Deflection of Vehicle path by Central Island

A refined simulation analysis model of vehicular circulation for roundabouts would allow improved estimation of roundabout capacity and emissions. Since not all possible scenarios can be observed at existing roundabouts and not enough data could be collected, using simulation models makes it easy to create these conditions and study them.

II. Traffic scenarios

Traffic simulation has been used to study the performance of non-signalized and signalized intersections but has not often been used in modeling or study of roundabouts. This is due to the difficulty in modeling different roundabout parameters using simulation software. The theory of gap-acceptance has led to complex assumptions regarding driver behavior and often it is not easy to obtain good results for a typical roundabout geometry.

Not all simulation software allows the user to model roundabouts exactly. There are two categories of simulation software used for roundabouts: deterministic and stochastic simulation models. A summary of the main roundabout software models is shown in Table 1.

Table 1 Principal Roundabout Software Models

Country	Name	Model
U.K.	RODEL	Deterministic
U.K.	ARCADY	Deterministic
U.K.	PARAMICS	Stochastic
Australia	SIDRA	Deterministic
Germany	KREISEL	Deterministic
Germany	VISSIM	Stochastic
U.S.A	INTEGRATION	Stochastic
U.S.A.	HCS/SYNCHRO	Deterministic
France	GIRABASE	Deterministic

III. Simulation model 'VISSIM'

VISSIM is a microscopic, time step and behavior based simulation model developed to analyze the full range of functionally classified roadways and public transportation operations. VISSIM is used for the design of vehicle actuated control systems. The model was developed at the University Of Karlsruhe, Germany during the early 1970s. Commercial distribution of VISSIM began in 1993 by PTV Transworld AG, who continues to distribute and maintain VISSIM today. VISSIM is used in many engineering disciplines, has become an indispensable instrument for the analysis of complex technical systems. It is an invaluable cost reducing tool. It offers a wide variety of urban and highway applications, integrating public and private transportation. Even complex traffic conditions are visualized in great detail providing realistic traffic models.

VISSIM consists of two different programs as the traffic simulator and the signal state generator. The traffic simulator is comprising car following logic and lane changing logic. The signal state generator is signal control software that polls de-

tector information from the traffic simulator on a discrete time step basis.

IV. USES OF SIMULATION

- The study develops a methodology for heterogeneous traffic flow simulation at roundabout
- The methodology can be applied to any urban controlled and/or uncontrolled roundabout intersection.
- The methodology can be used for evaluating various traffic controlling and management schemes before their implementation.
- It can be also used for the optimization of existing traffic controlling system.

V. METHODOLOGY

This paper presents the methodology of a traffic simulation at roundabout by the use of the simulation model VISSIM. Simulation is developed using the following variables: geometric elements (inscribed circle radius), characteristics of traffic flow (truck percentage, turning movements of major and minor streets) and behavioral features (time gap).

Since a wide variety of traffic scenarios can be created and a large amount of data collected, regression equations can be developed to describe to clearly investigate the interaction between geometric elements, characteristic of traffic flow and behavioral features with capacity and emissions at roundabouts.

1. Performance measures of roundabout intersections

A roundabout has three interesting basic performance measures. The first global measure is which represents the ability of roundabout to process traffic when all approach arms have queues and will be referred to as the roundabout capacity. Without taking geometric and behavioral features into consideration, this measure relies on the origin- destination (O-D) flow. The second measure consists of under saturated approach lanes. The third set of measures consists of delays and queue lengths for each approach lane under given operating conditions.

2. Empirical models and analytical models for capacity calculations

There exist two distinct methods on which capacity equations are based. These are the analytical or gap-acceptance based method and the empirical or regression based method.

Empirical methods correlate geometric features and performance measures, such as capacity, average delay and queue length, through the regression of field data. Via this method they generate a linear or exponential relationship between the entering flow of an approach and the circulating flow in front of it. Empirical methods require a large number of oversaturated or congested. Empirical models provide no real understanding of the underlying traffic flow theory of determining the accepted gaps upon entering the intersection. The models are typically based on driver behavior in oversaturated conditions, thus requiring sites with continuous queuing.

From uncongested sites, analytical models (gap-acceptance models) can be developed. The gap is the headway between two consecutive vehicles in the circulating flow; therefore, the “critical gap” is the minimum headway an entering driver would find acceptable. This means the driver would reject any gap less than the critical gap and accepts any gap greater than the minimum gap.

3. Selection of a simulation model

VISSIM provides some advantages over many other traffic simulation models since it is based on human psychology and behavior. The actual movements of the vehicles in VISSIM are based on behavioral assumptions regarding the desired speed and gap acceptance of drivers. These movements are based on a natural distribution of various behavioral elements. These include differences in driving abilities, human perception, desired safety and speed, and the relative levels of driver aggressiveness characterized by different maximum values for accelerations and decelerations. These phenomena are normally distributed within the model allowing random selection of various values during the simulation process.

4. Data collection and analysis

VISSIM provides a microscopic simulation model which is heavily dependent on the parameters and data input used during the network c coding. The basic data set needed for a basic VISSIM network is as shown in table 2. By using the collected set of data peak hour traffic flow, average speed, delays, capacity of the intersection, frequency distribution of the vehicle is calculated. Generally among numbers of data collected simulation is done by using peak hour traffic data.

Table 2 Basic Data sheet

Types of Data	Example
General Data	Simulation time
Network Data	Digital images of plan showing the entire study area
	Digital plans for each junction showing lane width, markings, signal heads and detectors
	Location of bus stops
Signal Control Data	Cycle Length
	Green, Amber and Red times for each signal group
Traffic Flow Data	Input flow in vehicles per hour
	Turning movements for each legs
	Traffic composition
	Vehicle speed at free flow (Speed limit of the road)
	Travel time
	Saturation Flows

5. network coding, data input and model calibration

Coding and data input of the network includes the building of road network, the placement of priority rules and signal heads and input of the data collected. Road networks are created in VISSIM through a series of links and connectors. Links are generally straight or follow the curvature of the road. Connectors, which are used to connect links, are typically used to model turning areas and lane expansions and contractions. The placement of priority rules and signal controls can attribute to the large amount of time taken to build the network. Figure 2 shows Priority rules for a two-lane roundabout with a two-lane entry. The calibration is an important process in the methodology as it provides credibility to the results by closely representing the actual conditions.

Calibration is the process by which the individual components of the simulation model are refined and adjusted so that the simulation model accurately represents field measured or observed traffic conditions. Typical calibration measures

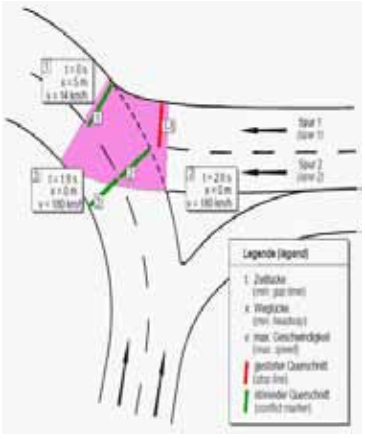

Figure 2 Priority rules for a two-lane roundabout with a two-lane entry

consist of volume, delay, and travel speeds. VISSIM simulation model contains default values for each variable, but also allows a range of user-applied values for each variable.

6. Model validation

Model validation is typically a process related to model calibration. The model validation is proposed to conduct using a different data set of another network within the same area to check if the calibrated model parameters are suitable. Model validation regards as a final stage to investigate if each component adequately reproduces observed travel characteristics and overall performance of the model is reasonable.

7. Result analysis and conclusions

The result values obtained by simulation are than compared with field observed values of travel time, average travel speed, delays, average and maximum queue lengths, etc. If the conclusion is positive than this model can be used for simulation of another roundabout intersection with similar characteristics.

VI. LIMITATIONS OF SIMULATION USING VISSIM

- VISSIM is complex and requires extensive knowledge of the program and its features.
- Due to the number of variables within the VISSIM software, there are many opportunities for adjustment within the model (such as driver and vehicle characteristics, gap acceptance, yield characteristics, and speed change characteristics).
- Coding of input data is extremely time consuming.
- Learning curve is steeper due to depth of software features.
- Runtime can be slow especially for 3D more or for large network.
- Occasionally get cryptic German error messages (more rarely now).
- High cost of software.

VII. CONCLUSIONS

- Since VISSIM uses links and connectors to construct both links and intersections, it permits flexibility when working with complex geometries and superior graphics.
- The most important and hard-hitting task in the simulation is the data collection, as the quality of simulation totally depends upon the accuracy of the data.
- VISSIM itself can be considered as a difficult program to handle due to its complexity and brief explanation in the manual.
- VISSIM is the most appropriate tool to be used for this kind of analysis because some functions and interface provided by VISSIM has made the modeling of road networks more users friendly.

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