

**LITERATURE REVIEW ON COMPARISON OF CAPACITY MODELS OF
ROTARY INTERSECTION**Vasim Shaikh¹, Khushbu Bhatt², Siddharth Gupte³¹Civil Engineering Department, Parul University²Civil Engineering Department, Parul University³Civil Engineering Department, Parul University

Abstract - Tanner Model of Capacity and IRC model of Capacity are two different traffic analysis model in terms of capacity that are capable of modeling urban roads with rotaries. This study compares the performance of the two different methods in modeling dual lane rotaries under different scenarios such as traffic volume, proportion of left turning movement, and proportion of trucks in the traffic flow. However; in the case of high traffic volumes, Tanner Model showed higher average delays compared to nearly identical results in the case of low traffic volumes. The present traffic scenario is usually used to characterize the present traffic condition to access the different parameters at different types of intersection.

Keywords- CAPACITY, DELAY, IRC MODEL, ROTARY INTERSECTION, TANNER MODEL, VOLUME OF TRAFFIC.

I. INTRODUCTION

Rotaries are appropriate for many intersections including locations experiencing high number of crashes, long traffic delays, and approaches with relatively balanced traffic flows. In order to avoid the conflict between entry vehicles and circulating vehicles, there are a mass of confluence operations at rotary weaving sections. The performance parameters are difficult to be determined due to the great complexity of traffic performances at rotary weaving areas. According to the analysis of various kinds of data can be obtain by using video cameras, several performance parameters can be calculate, including the velocities of circulating lanes and confluence sections, the gaps of circulating vehicles and confluence vehicles and the position of lane changing. Rotaries are consensually recognized as safe and efficient intersections, being widely used in urban and suburban areas in many countries. Rotaries offer high capacity levels under a large range of demand scenarios, particularly when compared with other at-level intersections such as priority junctions or even traffic lights. The choice of a specific geometric layout may have a significant effect in the rotary operational conditions and the implementation of new rotaries is usually preceded by capacity studies both for present and future demand scenarios. The Highway Capacity Manual (HCM) contains a stochastic simulation model that can integrate the statistical model and the analytical model. Besides a regression model and a gap-acceptance model, microscopic simulation can also predict roundabout performance.

The reduced number of conflict points at a roundabout indicates the reduction of crash propensity. The increased use of roundabout as a traffic facility needs an overall assessment on potential accident rates. For the safe movement of the vehicles, it is essential to understand the operational performance of the roundabout. Capacity is one such parameter which explains the operational performance, traffic scenario, and level of service. In contrast to traffic flow condition in developed countries, Indian traffic condition is totally different. Apart from the different driver classes, vehicles with various performance and dimensional characteristics (especially traffic is predominantly occupied by small sized vehicles such as motor two wheelers and auto rickshaws), non-lane discipline, and creeping behavior are characterized a totally complex traffic environment. It requires special attention in modeling traffic flow behavior.

There are various studies on capacity estimation of roundabouts that have been done all over the world in the past. Kimber proposed the detailed capacity model of a roundabout in the UK, which is a linear regression model between the entry capacity and conflicting flow rate. IRC: 65-1976 established a method for estimating practical capacity of the weaving section of a rotary, which is mainly based on the geometry of the Rotary. Rotaries have many advantages compared to other regular signalized intersections. The main advantages are traffic safety, operational performance, environmental factors, pedestrian safety, and aesthetics. Signalized intersection has 32 conflict points whereas rotary with one circulating lane and one entry lane have 8 traffic conflict points. But the number of conflicts increases to 16 in the case of roundabout with two circulating and two entry lanes. Conflict points at signalized intersection and rotary with one circulating and one entry lane are depicted in Figs-1 and 2, respectively.

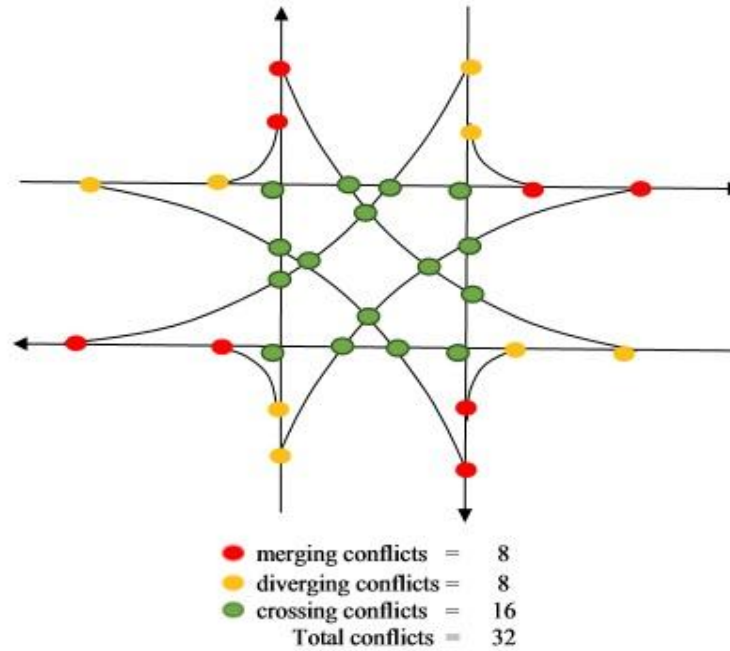


Fig. 1 Conflict points at signalized intersections

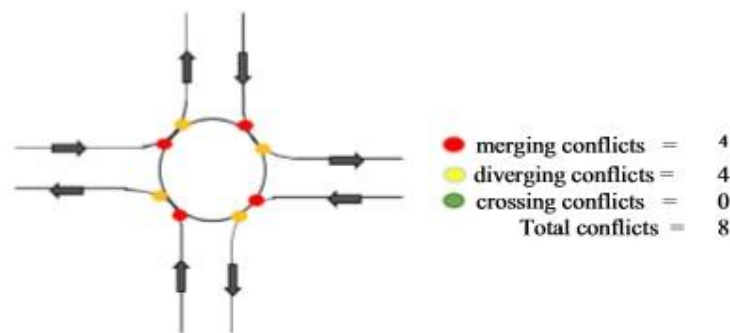


Fig. 2 Conflict points at a single-lane Roundabout

II. LITERATURE REVIEW

The roundabout concept was first introduced in early 1900's and deployed throughout Europe and America. The first concept of gyratory operation was invented by Eugene Henard (1903), where all the traffic would be required to circulate in one direction. The gyratory operational concept, or 'circus', continued to spread and was frequently recommended for busy intersections of more than four legs. Design was based solely on commonsense and experience at that time. The first use of the word 'rotary' appeared in the Ministry of Transport. Knight and Beddington (1936) suggested an adaptation to a circular central island, since better performance had been observed. In the US, the first design guideline for a roundabout (called rotary) was published in 1942 by the American Association of State Highway Officials (AASHO). A rotary was defined as an intersection where all traffic merges into and emerges from a one-way road around a central island. The general concept was that large radii gave long weaving sections, on which both high speeds and high capacities could be maintained.

Al-Omari et al. (2004) developed a model for estimating roundabout delay as a function of traffic and geometric factors. A total of twenty hours of field traffic and geometric data were collected from fourteen rotaries located throughout Jordan. Data were collected on sunny days from locations with good pavement conditions and during times when there were no policemen in the area. It was not possible to collect data during congested conditions because traffic police control roundabouts at these times. Circulating volume, entry volume, and entry delay were measured during peak and non-peak periods using video cameras. Geometric design elements such as entry width and rotary diameter were obtained through field measurements.

Troutbeck and Kako (1999) developed a gap acceptance model for the merging process at congested unsignalized intersections. Unlike traditional gap acceptance models, which typically assume absolute priority of major stream vehicles over those of the minor stream, the proposed model assumes limited priority of major stream vehicles. Limited priority is a type of shared priority that is based on the assumption that major stream vehicles are slightly delayed in order to accommodate merging vehicles from the minor stream. Field studies were conducted at three roundabouts located in Brisbane, Australia. All three roundabouts had two circulating lanes and two entry lanes, and normally operated under fairly high traffic volumes during peak hours. One hour of traffic data were collected with a videotape recorder at one entry of each roundabout during its morning or afternoon peak period. From each set of 1-hr data, two sets of 15-min data were extracted based upon traffic conditions at the entry approach being either “high saturation” or “low saturation.” The frequency of events in which circulating vehicles were forced to slow down by entering vehicles was observed for each of these six data sets. The two-lane circulatory roadway was treated as a single lane and the times for circulating vehicles to cross two cross-sections, one upstream and one downstream of the entry, were recorded.

Hummer et al. (2014) developed a simple macroscopic model based on the HCM equations and validated it using VISSIM. This microscopic software allows an accurate implementation of the roundabout geometry. The validation was set to replicate the roundabout capacity relationship of the HCM, and as a result the car-following parameter and speeds in reduced area were modified. Default values of critical gap and follow-up headway were considered. Analytical delays were computed for one cycle length and metering signal location, proving the benefits of metering. Criteria for signalized intersections were used (delay over 80 seconds) to indicate operational benefits. Both single-lane and two-lane roundabouts were analyzed.

Polus and Shmueli (1999) further examined and evaluated the capacity model previously developed in their 1997 study. In addition, the study estimated a gap size above which gaps are not relevant to the gap acceptance process and evaluated the gap acceptance behaviour of drivers entering roundabouts as their waiting time on the approach leg increased. Al-Masaeid and Faddah developed an empirical model for estimating entry capacity as a function of circulating traffic and geometric characteristics in 1997. Ten roundabouts located throughout Jordan were studied. Regression analysis was used to develop the entry-capacity model and its performance was then compared with results of German, Danish, and French capacity models.

III. TANNER MODEL

Tanner models use the gap-acceptance theory (or critical headway) to simulate the behavior of entering vehicles and vehicles circulating within the rotary. This method is not sensitive to rotary geometric parameters such as inscribed circle diameter, entry angle, etc. Critical headway and follow-up headway are two important parameters to perform operational analysis of rotary. Several rotary capacity models exist and can be classified into two broad categories - theoretical and empirical. The Tanner model is based on gap- acceptance theory with gap-acceptance parameters. The Highway Capacity Manual (HCM 2010) rotary tanner capacity model is an analytical (exponential regression) model with clear basis in gap-acceptance theory. In most typical cases, delay is generally evenly distributed among all approaches to a rotary, in contrast to cross-intersections, where minor road vehicles experience significantly greater delay than major road vehicles. The yield control on rotary approaches does not require that all vehicles come to a complete stop and therefore eliminates unnecessary stops made at stop signs when there are no conflicting vehicles. Additionally, minor road vehicles receive an “equal opportunity” to enter the intersection and so delays are typically reduced. This more efficient operation generally results in increased capacity and decreased overall delay. It is often reported that rotary offer additional advantages over other intersection types.

IV. IRC METHOD

In the IRC Method the practical capacity of a roundabout is considered as similar to that of the capacity of the weaving

$$\frac{280w(1+\frac{e}{w})(1-\frac{p}{3})}{1+\frac{w}{l}}$$

section of the rotary which is as follows. $Q_p =$. where Q_p is the practical capacity of the weaving section in pcu/h, w is the width of weaving section in meters (within the range of 6–18 m), $w = (e_1+e_2)/2 + 3.5$, e is the average entry width in meters ($e = (e_1+e_2)/2$), e/w to be within the range of 0.4-1, l is the length in meters of the weaving section between the ends of the channelizing islands (w/l to be within the range of 0.12–0.4), p is the proportion of weaving traffic, i.e., ratio of sum of crossing streams to the total traffic on the weaving section, given by $p = (b+c)/(a+b+c+d)$, the range of p being 0.4-1. The parameters a, b, c, d for a weaving section between two legs of a rotary are given in Table 1, where W_{ij} represents weaving section between leg i and leg j and T_{ij} represents vehicle turning movement counts from leg i to leg j . Legs are numbered in clock-wise direction as shown in table-1 below.

Table-1 Parameters of weaving traffic

Weaving Section	a	b	c	d
W_{12}	T_{12}	$T_{13}+T_{14}$	$T_{42}+T_{32}$	T_{43}
W_{23}	T_{23}	$T_{24}+T_{21}$	$T_{13}+T_{43}$	T_{14}
W_{34}	T_{34}	$T_{31}+T_{32}$	$T_{14}+T_{24}$	T_{21}
W_{41}	T_{41}	$T_{42}+T_{43}$	$T_{21}+T_{31}$	T_{32}

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