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Evaluation of Main Roundabouts of Kurukshetra

G. Veerababu[1] and S N Sachdeva[2]

[1]P.G Student, NIT Kurukshetra
[2]NIT Kurukshetra
E-mail: [1]veeru.guntaboyina2299@gmail.com, [2]snsachdeva@yahoo.co.in

Abstract—*Roundabouts are special form of channelized circular intersection in which traffic moves in one direction around a central island before exits to various intersecting roads. The roundabouts are provided to eliminate the necessity of stopping even for crossing streams of vehicles and to reduce the area of conflict. This paper presents capacity estimation models of roundabouts as followed across the world. The aim of the paper is to compare these capacity estimation models with the model suggested by IRC and to determine the capacity of main roundabouts of Kurukshetra. This paper also aims to evaluate the roundabouts based upon capacity and actual traffic volume during peak hour and finally to suggest measures for improving these roundabouts.*

Keywords*: Roundabout, Intersection, traffic, Capacity*

1. INTRODUCTION

Roundabout is a special form of channelized circular intersection in which traffic moves in one direction around a central island before exits to various interesting roads. With rapid growth of traffic it is experienced that widening of roads and providing flyovers have become imperative to overcome major conflicts at intersections such as collision between through and right turn movements. In this way, major conflicts are converted into milder conflicts like merging and diverging. The vehicles entering the rotary are gently forced to move in a clockwise direction. Roundabouts are the efficient intersection design over the signalized intersections depending upon traffic and site data. Depending on the size of circular traffic intersections it may be classified as Rotary, Roundabout and Mini-roundabout. Rotaries are suitable when there are more approaches and no separate lanes are available for right turn traffic thus making the intersection geometry complex. Rotaries were designed in the 1940's or earlier and work well at low volumes, but very poorly under heavy traffic conditions. Under low traffic conditions, a roundabout offers higher capacity as compared to a two-way stopped control or an all-way stop-controlled intersection. Roundabouts were developed in the 1960's and able to handle heavy traffic. Mini-roundabouts are best suited to areas with low speeds and there is no feasibility to use roundabout with a raised central island. Mini-roundabouts are common in United Kingdom (U.K.), France, United State and Germany since their introduction in the early 1970's.

2. LITERATURE REVIEW

The researchers have focused on the relationship between geometric design and traffic conditions for achieving the required operational performance of roundabout. IRC:65-1976(Recommended practice for traffic rotaries) lays down the guiding principles governing the design of traffic rotaries. S.K. Mahajan, et al. (2013) A new geometric concept is discussed to design rotaries at intersection of roads and a software package is developed to be used in road works. Design manual for Roads and Bridges(TD 16/07) sets out the design standards and advice for the design of roundabouts. Satish Chandra and Rajat Rastogi(2012) proposed a simple empirical method to determine the entry capacity from the flow conditions alone after comparing the results of UK model, US method, German Model, Swiss model and Indian model. S.Vasantha Kumar1, et al.(2014) Attempt to find the capacity of complex intersection with many one way approaches . R.AKCELIC (2003) This paper presents a single lane roundabout case study from the US to compare capacity estimates from the analytical models. BRUCE W. ROBINSON et al. a comprehensive discussion of roundabout planning, Performance analysis and design. Ramu Arroju1,et al. (2015) The capacity of the roundabout is determined using various capacity formulae. Serhan Tanyel1, et al.(2005) In this study, the applicability of the *Highway Capacity Manual 2000* HCM 2000 Procedure for roundabouts in Turkey is discussed. Mark Lenters et al. july (2010) an alternative techniques to adapt the U.K. empirical model to the design implications of the recent U.S. data.

3. 3. CAPACITY MODELS OF ROUNDABOUT

3.1 INDIAN CAPACITY MODEL (IRC: 65-1976)

$$Q_p = \frac{280\, w\left(1+\frac{e}{w}\right)\left(1-\frac{p}{3}\right)}{\left(1+\frac{w}{l}\right)}$$

Where

Q_p = Practical capacity of the weaving section of the rotary in passenger car units (PCU) per hour

w = Width of weaving section in metres(within the range of 6-18m)

e = Average entry width in metres (i.e., average of 'e_1' and 'e_2'), $\frac{e}{w}$ to be within a range of 0.4 to 1.00

l = Length in metres of the weaving section between the ends of channelizing islands($\frac{w}{l}$ to be within the range of 0.12 and 0.40)

p = Proportion of weaving traffic , i.e., ratio of sum of crossing streams to the total traffic on the weaving section (p = $\frac{b+c}{a+b+c+d}$), range of p being 0.4 to 1.0

a = left turning traffic moving along left extreme lane

b = crossing/weaving traffic turning towards right while entering the rotary

c = crossing/weaving traffic turning towards left while leaving the rotary

d = right turning traffic moving along right extreme lane

3.2 UK CAPACITY MODEL (Kimber, 1980)

$$q_{e,max} = k(F - f_c q_c)$$

Where,

$q_{e,max}$ = entry capacity (veh/h)

q_c = circulating flow (veh/h)

F = 303 x_2

f_c = 0.21 T_D (1 + 0.2 x_2)

k = 1 – 0.00347(Φ – 30) – 0.978(1/r – 0.05)

$T_D = 1 + \frac{0.5}{1+\exp\left(\frac{D-60}{10}\right)}$

x_2 = entry adjustment factor = $v + \frac{e-v}{1+2S}$

$S = \frac{e-v}{l}$

e = entry width(m) ranging from 3.6 to 16.5

v = approach half-width(m) ranging from 1.9 to 12.5

l = effective flare length(m) ranging from 1 to ∞

r = entry radius(m) ranging from 3.4 to ∞

Φ = entry angle (°) ranging from 0 to 77°

S = measure of the degree of flaring ranging from 0 to 2.9

D = inscribed circle diameter(m) ranging from 13.5 to 171.6

3.3 US METHOD (HCM 2000):

$$C = \frac{Q_C e^{-Q_C T_C/3600}}{1-e^{-Q_C T_f/3600}}$$

C = approach capacity (veh/h)

Q_c = conflicting circulating traffic (veh/h)

T_c = critical gap(s)

T_f = follow up time(s)

3.4 Proposed Capacity Model 1 (PM 1):

The model depends upon the width of weaving section, proportion of vehicle and number of vehicles entering into the road in consideration as given in Equation (4.10). The model is developed considering the IRC:65-1976 capacity formula. Passenger Car Unit (PCU) value of different type of vehicles are taken according to IRC:65-1976.

$$Q_P = 300W - (V_P \times E_R)$$

Where,

Q_P = Capacity of Roundabout (pcu/h)

W = Circulating Carriageway Width (m)

V_P = Vehicle Proportion = $\frac{No.of\ Vehicles\ entering\ from\ the\ road\ in\ consideration}{Total\ no.of\ vehicles\ entering\ from\ all\ roads\ to\ the\ intersection}$

E_R = No. of vehicles entering from the road in consideration (pcu/h)

3.5 Proposed Capacity Model 2 (PM 2):

The model depends upon the width of weaving section, entry width and inscribed circle diameter. The model is developed considering the IRC:65-1976 capacity formula as explained in Equation (4.11).

$$Q_P = 215(e + w)\log\left(\frac{2D}{e + w}\right)$$

Where,

Q_P = Capacity of Roundabout (pcu/h)

e = Average Entry Width (m)

w = Width of Weaving Section (m)

D = Inscribed Circle Diameter (m)

4. CAPACITY CALCULATION

Table 4.1: Geometric Details of Selected Roundabouts of Kurukshetra

Geometric parameters	1.Ambedkar Chowk	2.visvkarma chowk	3.3rd Gate KUK
Central Island (m)	12	12	-
Inscribed circle Diameter (m)	33	33	-
Entry Width (m)	8	8	6
Exit width (m)	8	8	6
Approach width (m)	7.5	7.5	7.5

Departure width (m)	7.5	7.5	7.5
Circulating road width (m)	8	8	-
Entry radius (m)	30	30	25
Exit radius (m)	30	30	25

Table 4.2: Volume Data Collected for different Roundabouts

Roundabout	Direction	Entry Volume (vph)			Total Volume (vph)
		LT	ST	RT	
1.Ambedkar Chowk	AB	14	324	86	**424**
	BC	130	1188	90	**1408**
	CD	180	438	174	**792**
	DA	268	1326	138	**1732**
2.visvkarma chowk	AB	598	762	0	**1360**
	BC	538	0	1102	**1640**
	CA	0	966	238	**1204**
3.3rd Gate KUK	AB	1144	0	96	**1240**
	BC	0	536	600	**1136**
	CA	72	824	0	**896**

Table 4.3: Capacity Estimated by Different Methods for Roundabouts

Roundabout	Direction	Entry Capacity(pcu/h) by			
		UK Method	IRC Method	PM1	PM2
1.Ambedkar Chowk	AB	1202	2622	2973	2209
	BC	2105	2685	2529	
	CD	1394	2685	2908	
	DA	2015	2749	2314	
2.visvkarma chowk	AB	2062	3337	2615	2209
	BC	1721	3453	2401	
	CA	1438	2745	2705	
3.3rd Gate KUK	AB	Can't apply any formula			
	BC				
	CA				

5. COMPARISON OF CAPACITY MODELS

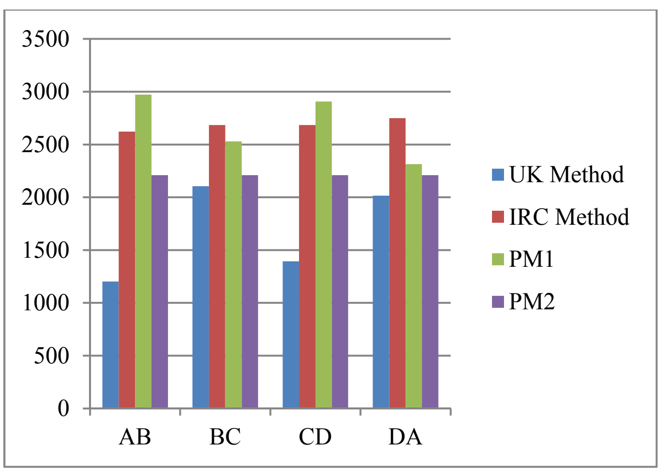

Fig. 5.1: Comparison of Capacity Models(Ambedkar chowk)

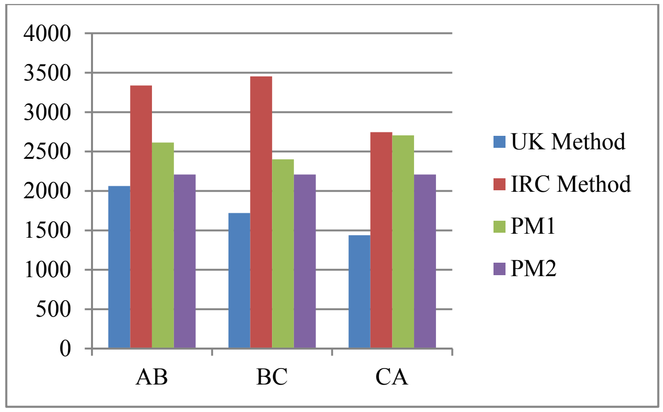

Fig. 5.2: Comparison of Capacity Models(Visvkarma chowk)

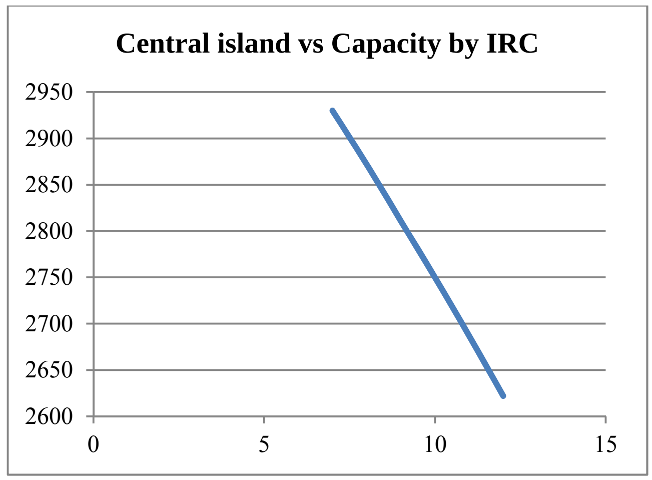

Fig. 5.3: Variation of Capacity with respect to Central Island Diameter

6. CONCLUSION

Several design factors and capacity models are discussed for the design of roundabouts. Out of different capacity models, UK method is purely empirical and is based on the geometry of the intersection. The US method considers only the circulating flow at the intersection and is based on the gap acceptance process of entering vehicles. The Indian method (IRC: 65-1976) considers both geometrical as well as traffic data. From the capacity calculation of roundabouts by different methods, the IRC method gives maximum capacity of a roundabout whereas UK method gives the least capacity.

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