

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 7, July 2017

Comparative Study for Estimation of Capacity of RoundABOUTS

B. Prasanna Kumari¹, Nandini²

P.G. Student, Department of Highway Engineering, Bheema Institute of Technology and Science,
Andhra Pradesh, India¹

Associate Professor, Department of Highway Engineering, Bheema Institute of Technology and Science, Andhra
Pradesh, India²

ABSTRACT: Modern Roundabouts were first introduced in the early 1960s in England. These facilities were introduced in order to solve the problems of the existing rotaries and traffic circles. Using the principal that entering traffic yields to circulating traffic, or the “give way” rule, roundabouts proved to be a much more efficient intersection than the rotaries, and in many cases, signalized intersections. Roundabout is a junction with a central island where the conflicting traffic streams are separated in time by the priority rules, i.e. the entry vehicles should give way to the circulating vehicles. Roundabout intersections are the most common intersections found in developed countries. Their capacities are more than other intersection types. They do play an important part in the control of traffic in a network. Capacity of roundabout intersections is either analysed by the empirical regression method, which is mainly applied in the context of British Research results or by the so called gap-acceptance procedures (GAP).

In this study, capacities of roundabout are calculated from the U.K. method, German method and the HCM 2000 method.

KEYWORDS: Roundabouts, Rotaries, Intersection, Empirical regression method, Gap-acceptance procedures

I. INTRODUCTION

Roundabouts are intersections of two or more roads that are made up of a one-way circulating roadway that has priority over approaching traffic. The approaching traffic is controlled by yield signs, and can only make a right turn onto the circulating roadway. Roundabouts are often confused with rotaries. Rotaries are often stopping or signal controlled, and gives priority to traffic entering the intersection. Roundabouts have three main characteristics that identify them when compared to rotaries. Roundabouts give vehicles in the circulating roadway the right of way. This is different than other uncontrolled, yield controlled or multi-way-stop controlled intersections that give priority to vehicles approaching from the left. Most roundabout approaches flare out at the entries and allow more vehicles to enter the circulating roadway at a more obtuse angle. This improves capacity, and allows entering vehicles to enter at similar speeds as the circulating vehicles unless a queue has developed at the entry. The size and angle of the flare is generally controlled by a raised splitter island that separates the entering and exiting traffic at an approach. In addition to these three primary requirements, there are other attributes common to roundabouts. Unlike traffic circles, where there can be pedestrian access to the centre island, crosswalks for roundabouts are located on the approach legs, behind the yield lines. Also, parking is not allowed within the circulating roadway or at the entries of the approach legs, and all entering traffic is required to proceed around the roundabout in a clockwise direction.

In most cases roundabouts have been found to be much safer than other intersections. There are several reasons for this. First, roundabout design requires that vehicles to be slowed to speed of 15-30 miles per hour in order to make over the facility. Second, since all entering vehicles turn left, there is a great reduction in the number of points of conflict

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 7, July 2017

compared to a conventional intersection. The reduction from 32 to 8 points of conflict lessens the chance for crashes, and when combined with the reduced speed, crash severity is further reduced.

The capacity of each entry to a roundabout is the maximum rate at which vehicles can reasonably be expected to enter the roundabout from an approach during a time period under prevailing traffic and roadway (Geometric) conditions. The maximum flow rate that can be accommodated at a roundabout entry depends on two factors; the circulating flow on the roundabout that conflicts with the entry flow, and the geometric elements of the roundabout. When the circulating flow is low, drivers at the entry are able to enter the roundabout without significant delay. The large gaps in the circulating flow are more useful to the entering drivers and more than one vehicle may enter each gap. As the circulating flow increases, the size of the gaps in the circulating flow decrease and the rate at which vehicles can enter also decreases. The geometric elements of the roundabout also affect the rate of entry flow. The most important geometric element is the width of the entry and circulatory roadways, or the number of lanes at the entry and on the roundabout. Two entry lanes permit nearly twice the rate of entry flow as does one lane. Wider circulating roadways allow vehicles to travel alongside or follow, each other in tighter bunches and so provide longer gaps between bunches of vehicles. The flare length also affects the capacity. The inscribed circle diameter and the entry angle have minor effects on capacity.

As at other forms of unsignalized intersection, when traffic flows on an approach exceed approximately 85 percent of capacity, delays and queue lengths vary significantly about their mean values (with standard deviations of similar magnitude as the means). For this reason, the analysis procedures in some countries recommend that roundabouts be designed to operate at no more than 85 percent of their estimated capacity.

II RELATED WORK

According to Thaweesak Taekratok, 1998, which has been accepted around the world since the introduction of the off-side priority rule, Prior to the rule, conventional roundabouts performed as a weaving section between two streams circulating and entering flows. With the new rule, entering traffic now has to give way to circulating traffic and enter when accepted gaps are available. The operational basis is measured by the number of vehicles entering the roundabout. Capacity is measured in terms of the entry capacity, rather than of weaving section capacity

Because drivers enter the roundabout only when the gap in the circulating traffic is large enough, the capacity of the roundabout will depend primarily on the circulating flow and the availability of gaps. Consequently, the entry capacity decreases if the circulating flow increases, since there are fewer gaps for entering drivers. The dependence of entry capacity on circulating flow is known as the entry/circulating flow relationship, and depends on the drivers' interaction and roundabout geometry.

Fundamentally, two methodologies can be used to assess the entry/circulating flow relationship. The first is a regression analysis and the second is the gap acceptance theory. Most countries have adopted their capacity formula based on either one of these two methodologies. Earlier attempts for development of capacity norms for roundabouts are summarized below.

III. METHODOLOGY

The study is carried out to estimate the capacity of roundabout. The present study involves collection of the data through field studies. Traffic volume count survey according to movement wise and roundabout inventory survey is conducted.

a. Selection of Location

Before collecting the data, intersections that represent the objectives of the study are chosen after reconnaissance survey to fulfil the specified objectives of the study two roundabouts have been chosen.

1. Kaman Junction
2. Gitabhawan Junction

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 7, July 2017

Typical maps of the roundabout are shown in the figure 1 and figure 2 respectively.



Figure 1 Typical Layout of Kurnool Junction in Kurnool City

Figure 1 shows the aerial view of Kaman junction at Kurnool City; Surveys were carried out to get the reliable data at this intersection consisting of heterogeneous traffic. Different modes of traffic such as Buses, Trucks, cars, auto rickshaws, cycles and low commercial vehicles etc ply on these roads.



Figure 2 Typical Layout of Gitabhavan Junction in Kurnool City

Traffic volume survey according to direction wise will be carried out on the selected roundabout locations. Inventory data is a collection of the physical characteristics of the roundabout. The inventory details of the roundabout are collected by the team of enumerators.

IV. SURVEY AND DATA COLLECTION

Surveys will be carried out to get the reliable data at the chosen intersection consisting of heterogeneous traffic. Different modes of traffic such as Buses, Trucks, cars, auto rickshaws, cycles and low commercial vehicles etc ply on these roads. The following surveys will be conducted.

- Roundabout Inventory survey
- Traffic Volume Count Survey

a. Roundabout inventory survey:

Inventory data is a collection of the physical characteristics of the roundabout. The inventory details of the roundabout are collected by the team of enumerators. The inventory details constitute the following parameters.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 7, July 2017

1. Entry width
2. Approach half width
3. Effective flare length
4. Inscribed circle diameter
5. Entry angle
6. Entry radius
7. Sharpness of flare

b. Traffic Volume Count Survey:

Traffic volume survey according to direction wise will be carried out on the selected roundabout locations. The traffic volume survey will be conducted for duration of 4 hours on both locations.

c. Data Analysis:

Detailed analysis of the survey data will be undertaken to assess the traffic and transportation characteristics of the roundabout. The data collected from the field on the data sheets will be analysed to study variation of traffic, peak hour, and traffic composition. The traffic at intersection consists of various modes of vehicles, and predominant among them include autos and two-wheelers. The traffic volume for each hour will be analysed.

d. Capacity Estimation by Various Methods

Generally the capacity of the roundabout has been estimated by using the empirical approach and gap acceptance approach. In the present study the capacity will be estimated by two empirical methods namely:

- The U.K. capacity method
- Germany's method

V. TRAFFIC ANALYSIS

The study of traffic behavior is useful for traffic engineer to design intersections, for developing traffic control warrants, timing traffic signals, to design vehicle storage lanes etc. A principal objective of capacity analysis is the estimation of the maximum number of persons or vehicles that can be accommodated by a given facility in reasonable safety within a specified time period. However, because facilities generally operate poorly at or near capacity, they are rarely planned to operate in this range. Accordingly, capacity analysis also provides a means of estimating the maximum amount of traffic that can be accommodated by a facility while maintaining prescribed operational qualities. Capacity analysis at intersections depends upon a clear description and understanding of the interaction of drivers. Capacity is either analyzed by the empirical regression method, which is mainly applied in the context of British research results, or by the so called gap-acceptance procedures (GAP). In this study the capacity is calculated by using Empirical regression method as U.K. Capacity Formula and Germany's Formula and by using the gap acceptance method as HCM 2000 formula.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 7, July 2017

Table 1 Traffic Volume Data For Movement 1

| Time Period | 2-Wheeler | Auto-Rickshaw | Jeep/Taxi/Van/Car | Bus/Truck | LCV | Cycle | Total Vehicles | Total PCU |
|-------------|-----------|---------------|-------------------|-----------|-----|-------|----------------|-----------|
| 3:00-3:15 | 22 | 16 | 3 | 11 | 1 | 3 | 56 | 61 |
| 3:15-3:30 | 20 | 19 | 2 | 13 | 1 | 4 | 59 | 68 |
| 3:30-3:45 | 24 | 22 | 5 | 14 | 0 | 9 | 74 | 78 |
| 3:45-4:00 | 30 | 25 | 8 | 13 | 2 | 5 | 83 | 85 |
| 4:00-4:15 | 26 | 20 | 4 | 15 | 1 | 7 | 73 | 81 |
| 4:15-4:30 | 32 | 22 | 3 | 15 | 0 | 8 | 80 | 83 |
| 4:30-4:45 | 24 | 17 | 5 | 16 | 1 | 3 | 66 | 80 |
| 4:45-5:00 | 41 | 22 | 4 | 14 | 2 | 4 | 87 | 87 |
| 5:00-5:15 | 29 | 19 | 3 | 10 | 0 | 8 | 69 | 64 |
| 5:15-5:30 | 36 | 23 | 7 | 11 | 1 | 7 | 85 | 79 |
| 5:30-5:45 | 30 | 19 | 5 | 10 | 3 | 6 | 73 | 71 |
| 5:45-6:00 | 25 | 17 | 6 | 12 | 2 | 5 | 67 | 72 |
| 6:00-6:15 | 44 | 16 | 7 | 10 | 2 | 5 | 84 | 76 |
| 6:15-6:30 | 42 | 21 | 4 | 13 | 1 | 6 | 87 | 83 |
| 6:30-6:45 | 35 | 18 | 3 | 11 | 0 | 2 | 69 | 68 |
| 6:45-7:00 | 33 | 15 | 5 | 10 | 2 | 3 | 68 | 67 |
| PCU | 0.5 | 0.75 | 1 | 3 | 1.5 | 0.3 | | |

Table 1 shows the number of vehicles moving at the Kaman junction, it can be observed from the table that the number of vehicles moving at this junction is not uniform and they are most at 4:45 to 5:00. The above data is collected and stored for the comparison.

Table 2 Traffic Volume Data For Movement 2

| Time Period | 2-Wheeler | Auto-Rickshaw | Jeep/Taxi/Van/Car | Bus/Truck | LCV | Cycle | Total Vehicles | Total PCU |
|-------------|-----------|---------------|-------------------|-----------|-----|-------|----------------|-----------|
| 3:00-3:15 | 22 | 12 | 7 | 0 | 0 | 5 | 46 | 29 |
| 3:15-3:30 | 26 | 23 | 5 | 0 | 1 | 4 | 59 | 38 |
| 3:30-3:45 | 35 | 21 | 11 | 0 | 1 | 6 | 74 | 48 |
| 3:45-4:00 | 32 | 14 | 14 | 0 | 0 | 2 | 62 | 41 |
| 4:00-4:15 | 36 | 10 | 7 | 0 | 2 | 6 | 61 | 37 |
| 4:15-4:30 | 37 | 9 | 7 | 0 | 1 | 8 | 62 | 36 |
| 4:30-4:45 | 35 | 14 | 11 | 0 | 2 | 4 | 66 | 43 |
| 4:45-5:00 | 28 | 11 | 13 | 0 | 1 | 6 | 59 | 39 |
| 5:00-5:15 | 40 | 13 | 13 | 0 | 1 | 2 | 69 | 45 |
| 5:15-5:30 | 37 | 17 | 18 | 0 | 3 | 6 | 81 | 56 |
| 5:30-5:45 | 33 | 19 | 16 | 1 | 2 | 9 | 80 | 55 |
| 5:45-6:00 | 41 | 15 | 14 | 0 | 5 | 7 | 82 | 55 |
| 6:00-6:15 | 37 | 18 | 11 | 0 | 2 | 5 | 73 | 48 |
| 6:15-6:30 | 28 | 16 | 13 | 0 | 1 | 8 | 66 | 43 |
| 6:30-6:45 | 22 | 9 | 15 | 0 | 1 | 4 | 51 | 35 |
| 6:45-7:00 | 32 | 13 | 12 | 0 | 2 | 4 | 63 | 42 |
| PCU | 0.5 | 0.75 | 1 | 3 | 1.5 | 0.3 | | |

Table 2 shows the data collected at the Kaman junction the next day, here it can be noted that at 5:45-6:00 peak traffic is shown and also more or less similar traffic volume is recorded at 3:30-3:45. This data is collected and used for the purpose of comparison.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 7, July 2017

Table 3 Traffic Volume Data For Movement 3

| Time Period | 2-Wheeler | Auto-Rickshaw | Jeep/Taxi/Van/Car | Bus/Truck | LCV | Cycle | Total Vehicles | Total PCU |
|-------------|-----------|---------------|-------------------|-----------|-----|-------|----------------|-----------|
| 3:00-3:15 | 148 | 40 | 11 | 8 | 1 | 18 | 226 | 146 |
| 3:15-3:30 | 122 | 49 | 9 | 12 | 3 | 22 | 217 | 154 |
| 3:30-3:45 | 136 | 43 | 7 | 9 | 1 | 20 | 216 | 142 |
| 3:45-4:00 | 151 | 55 | 13 | 13 | 2 | 25 | 259 | 179 |
| 4:00-4:15 | 168 | 44 | 15 | 11 | 1 | 21 | 260 | 173 |
| 4:15-4:30 | 200 | 58 | 9 | 12 | 1 | 26 | 306 | 198 |
| 4:30-4:45 | 200 | 43 | 15 | 10 | 2 | 28 | 298 | 189 |
| 4:45-5:00 | 220 | 58 | 13 | 9 | 1 | 23 | 324 | 202 |
| 5:00-5:15 | 225 | 71 | 11 | 13 | 1 | 25 | 346 | 225 |
| 5:15-5:30 | 209 | 55 | 16 | 14 | 2 | 22 | 318 | 213 |
| 5:30-5:45 | 227 | 68 | 12 | 18 | 4 | 31 | 360 | 246 |
| 5:45-6:00 | 205 | 59 | 15 | 16 | 3 | 29 | 327 | 223 |
| 6:00-6:15 | 165 | 45 | 13 | 12 | 2 | 24 | 261 | 175 |
| 6:15-6:30 | 187 | 51 | 9 | 15 | 2 | 26 | 290 | 197 |
| 6:30-6:45 | 197 | 44 | 6 | 11 | 1 | 20 | 279 | 178 |
| 6:45-7:00 | 166 | 49 | 11 | 14 | 1 | 22 | 263 | 181 |
| PCU | 0.5 | 0.75 | 1 | 3 | 1.5 | 0.3 | | |

Table 3 shows the flow of traffic collected at the Gitabhavan junction, a very high flow of traffic has been observed at this junction as it is one of the most used junctions in the city. Here at 5:15-5:45 huge amount of flow has been recorded than the other time.

Table 4 Traffic Volume Data For Movement 4

| Time Period | 2-Wheeler | Auto-Rickshaw | Jeep/Taxi/Van/Car | Bus/Truck | LCV | Cycle | Total Vehicles | Total PCU |
|-------------|-----------|---------------|-------------------|-----------|-----|-------|----------------|-----------|
| 3:00-3:15 | 133 | 55 | 16 | 8 | 3 | 22 | 237 | 159 |
| 3:15-3:30 | 127 | 43 | 18 | 6 | 3 | 17 | 214 | 141 |
| 3:30-3:45 | 106 | 57 | 17 | 8 | 2 | 23 | 213 | 147 |
| 3:45-4:00 | 117 | 53 | 20 | 11 | 4 | 16 | 221 | 162 |
| 4:00-4:15 | 115 | 58 | 22 | 10 | 6 | 29 | 240 | 171 |
| 4:15-4:30 | 129 | 66 | 26 | 12 | 8 | 25 | 266 | 196 |
| 4:30-4:45 | 122 | 77 | 22 | 9 | 4 | 27 | 261 | 182 |
| 4:45-5:00 | 159 | 69 | 27 | 8 | 4 | 34 | 301 | 198 |
| 5:00-5:15 | 173 | 73 | 19 | 9 | 3 | 31 | 308 | 201 |
| 5:15-5:30 | 167 | 62 | 15 | 7 | 6 | 33 | 290 | 185 |
| 5:30-5:45 | 175 | 70 | 17 | 9 | 3 | 29 | 303 | 197 |
| 5:45-6:00 | 187 | 61 | 21 | 10 | 5 | 27 | 311 | 206 |
| 6:00-6:15 | 189 | 80 | 25 | 8 | 4 | 30 | 336 | 219 |
| 6:15-6:30 | 148 | 66 | 27 | 9 | 4 | 18 | 272 | 189 |
| 6:30-6:45 | 159 | 61 | 22 | 7 | 2 | 21 | 272 | 178 |
| 6:45-7:00 | 170 | 59 | 26 | 8 | 3 | 20 | 286 | 190 |
| PCU | 0.5 | 0.75 | 1 | 3 | 1.5 | 0.3 | | |

The above table 4 is the recorded traffic volume flow at the Gitabhavan junction collected the next day, which also shows the heavy flow of traffic compared to the prior junction in the city. All the above data is recorded and saved for the purpose of comparison.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 7, July 2017

Table 5 Comparison of Capacity by Various Methods

| Junction Name | Legs | Capacities | | |
|---------------|-------|-------------|-----------------|---------------|
| | | U.K. Method | Germanys Method | H.C.M. Method |
| Kaman | Leg-1 | 1535 | 1022 | 867 |
| | Leg-2 | 1560 | 1040 | 889 |
| | Leg-3 | 491 | 249 | 298 |
| | Leg-4 | 442 | 247 | 959 |
| Gitabhawan | Leg-1 | 1314 | 859 | 696 |
| | Leg-2 | 1293 | 843 | 681 |
| | Leg-3 | 393 | 207 | 281 |
| | Leg-4 | 786 | 455 | 399 |

All the data collected from the tables is used in the three methods and the results for them are tabulated in table 5 And finally the comparison has been made between the capacities obtained by the various methods.

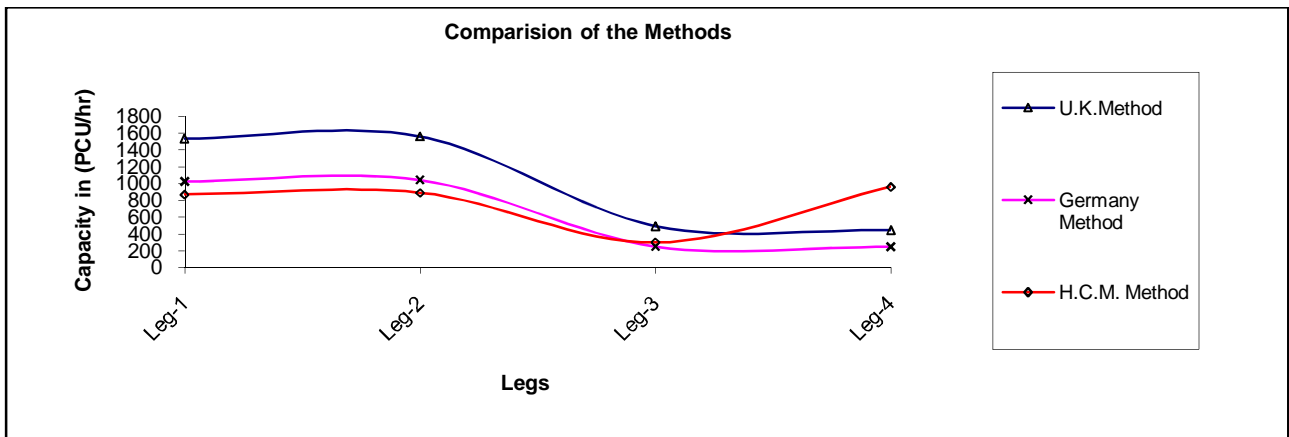


Figure 3 Comparison of Capacity by Various Methods for junction1

The above figure shows the comparison of the traffic volume with the three methods at the Kaman junction, from the above it can be stated that capacity of H.C.M Method is more than Germany Method and U.K Method.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 7, July 2017

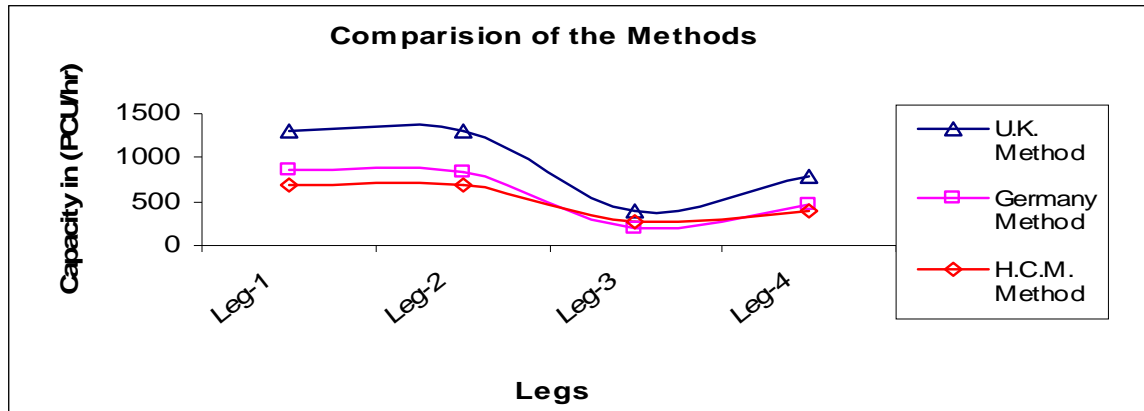


Figure 4: Comparison of Capacity by Various Methods for junction 2

Figure 4 shows the comparison of traffic volume at the junction Gitabhavan of the Kurnool City, using the three methods and it can be concluded that at this junction U.K Method has more volume capacity than the other two. It also has the higher volume capacity than the prior junction.

VI. CONCLUSION

Based on the study carried out the following conclusions have been made:

- The capacities estimated by the Germany's method and HCM 2000 method are nearly equal.
- The estimated capacity by the U.K. method is quite greater than the Germany's method and HCM 2000 method. Hence capacity estimated by U.K. method can be considered for the design purpose.

REFERENCES

- 1) Thaweesak Taekratok, A report on "Modern Roundabouts for Oregon" for Oregon Department of Transportation Research Unit 200 Hawthorne SE, Suite B-240 Salem, OR 97310 June 1998.
- 2) Hideki Nakamura and Koji Suzuki, "Performance Analysis of Roundabouts as an Alternative for Intersection Control in Japan". Journal of the Eastern Asia Society for Transportation Studies, Vol.5, October, 2003.
- 3) Leif Ourston, P.E., Santa Barbara, A paper on "Relative Safety of Modern Roundabouts and Signalized Cross Intersections", California (1996).
- 4) Aimee Flannery, "Modern Roundabouts and Traffic Crash Experience in the United States", Transportation Research Board, January 1996.
- 5) Amy L. Gamble, P.E., "Montpelier Roundabout Final Report Main Street/Spring Street Montpelier, Vermont", Vermont Agency of Transportation, Montpelier, Vermont, 1996.
- 6) Cassidy, Michael J., Samer M. Madanat, Mu-Han Wang, and Fan Yang, "Unsignalized Intersection Capacity and Level of Service: Revisiting Critical Gap", Transportation Research Record 1484. 1995.
- 7) Varhelyi A, "The effects of small roundabouts on emissions and fuel consumption", a case study, Elsevier Science Ltd, Sweden, 2002.
- 8) Jacquemart Georges National Cooperative Highway Research Program Synthesis of Highway Practice No. 264, "Modern Roundabout Practice in the United States", National Research Council, Transportation Research Board, Washington, DC 1998.
- 9) Hyden C, and Varhelyi A, "The effects on safety, time consumption and environment of large scale use of roundabouts in an urban area", a case study, Accident Analysis and Prevention, Sweden, 2000.
- 10) Sisiopiku P. Virginia and Heung-Un Oh, "Evaluation of Roundabout Performance Using SIDRA", Journal of Transportation Engineering, March/April 2001.
- 11) Federal Highway Administration, "A Sampling of Emissions Analysis Techniques for Transportation Control Measures", Final Report, Publication No. FHWA-EP-01-017, 2000.