Design of a rotary for an uncontrolled multi-leg intersection in Chennai, India

IOP Conf. Series: Materials Science and Engineering **263** (2017) 032030 doi:10.1088/1757-899X/263/3/032030

Design of a rotary for an uncontrolled multi-leg intersection in Chennai, India

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Abstract. One way to control the traffic at busy intersections is to construct a roundabout or rotary intersection, which is a special type of at-grade intersection, where all converging vehicles are forced to move round a central island in clock-wise direction. The present study aims to design a rotary for an uncontrolled multi leg intersection located in Royapetah in Chennai, India. The intersection has five approach roads with two-way traffic in all the approach roads and there is no signal or traffic police to control the traffic at present and hence experiences traffic chaos during peak hours. In order to design the rotary, it is essential to have the information on traffic volumes coming from the approach roads. For this, a video data collection was carried out for a duration of eight hours from 7.30 am to 11.30 am and from 2.30 pm to 6.30 pm on a typical working day using a handycam from the terrace of an apartment building located near the intersection. During data extraction stage, each 5 min. traffic volume was extracted for all the five classes of vehicles considered and were converted to passenger car units (PCU). The analysis of traffic data showed that during peak hour from 4.45 pm to 5.45 pm, the proportion of weaving traffic, i.e., ratio of sum of crossing streams to the total traffic on the weaving section was found to be 0.81. According to Indian road congress (IRC) guidelines, this proportion can take any value between 0.4 and 1 and in the present study, the calculated value is found to be within the prescribed range. Using the calculated values of average entry width of the rotary and width & length of weaving section, the practical capacity of the rotary was found to be 3020 PCUs which is well above the observed traffic volume of 2665 PCUs.

1. Introduction

The problem of traffic congestion and ways to tackle needs to be addressed urgently in major urban areas of India. The exponential growth of personal vehicles, combined with increase in trips and trip lengths are the major reasons for traffic congestion in India. In Chennai, the total personal vehicle population has increased from 10 lakhs in 1999 to almost 32 lakhs in 2011. This accounts for about 220 percent rise in the last 12 years. The increase of personal vehicles on urban roads not only causes traffic congestion, but also leads to safety issues. The anticipated average journey speed on major corridors in cities with population more than 80 lakhs (category-1a) will be 9 kmph and in cities with population 40-80 lakhs (category-1b) will be 10 kmph in the year 2021 [1]. In 2031, the situation will be even worse with anticipated speeds of 6 and 7 kmph, respectively. The master plan for Chennai for the year 2026 is aiming for a modal split of 70:30 (Public transit: Personal vehicles) against the modal split of 35:65 in 2009 [2]. The decreasing use of public transport further exacerbates the congestion situation.

According to Indian Road Congress (IRC) guidelines (IRC-65, 1976), a rotary can be of either circular, elliptical, oval, rectangular shape with four approach roads/legs or it can be of complex intersection with many approaches [3]. Most of the existing studies [4-7] on design of a new rotary or capacity analysis of an existing rotary are mainly concentrated on intersections having only four legs that intersect at nearly equal angles. The procedure for design of such rotaries having only four legs intersecting at right angles is simple and straightforward as given in IRC guidelines [3]. However studies on design of a complex rotary intersection with many approach roads have not been reported in India. Hence the present study aims to design a rotary for an uncontrolled multi leg intersection located in Royapettah in Chennai, India. The selected intersection has five approach roads as shown in Fig.1. The Royapettah high road, Lloyd's road and Masilamani road are intersecting at the junction and two-way traffic exists in all the approach roads. Currently there is no signal or traffic police to control the traffic and hence experiences traffic congestion during peak hours. In order to design the rotary, it is essential to have the information on traffic volumes coming from the approach roads. For this, a video data collection was carried out, the details of which are presented in the following section.

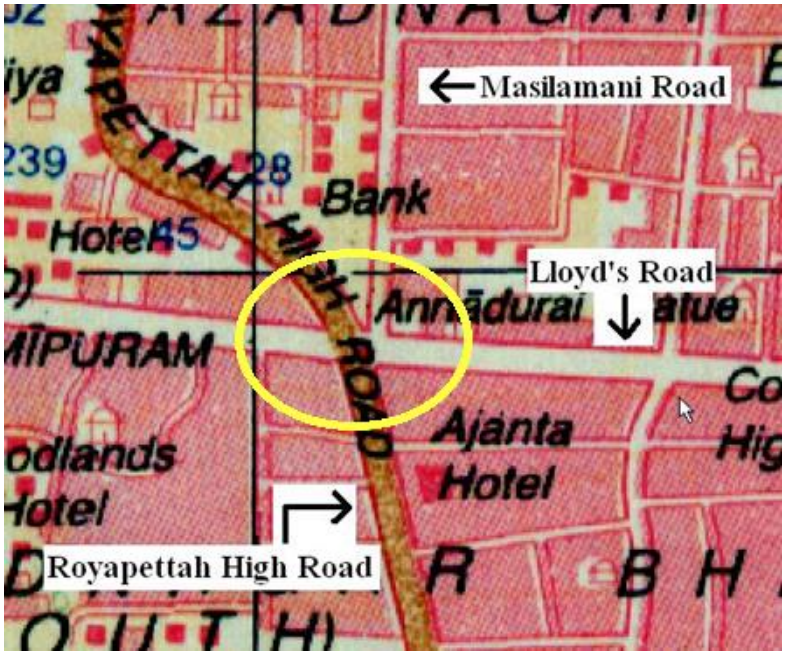

Figure 1. Map showing the study location

2. Data collection and extraction

The video data collection was carried out to obtain the current traffic volumes, which is the main input in design of a rotary. The data collection was carried out for a duration of eight hours from 7.30 am to 11.30 am in the morning and from 2.30 pm to 6.30 pm in the evening on a typical working day using a handycam from the terrace of an apartment building located near the intersection. A snapshot of the video collected is shown in Fig.2. As there is no signal or traffic police to control the traffic, the intersection experiences traffic chaos during peak hours. During data extraction stage, each 5 min. traffic volume was extracted for all the five classes of vehicles considered, namely, two-wheeler, three-wheeler, passenger cars, light commercial vehicles (LCV) and heavy commercial vehicles (HCV). A total of 20 directions of traffic movements were considered while extracting the 5 min. traffic volume data. The directions considered are shown in Table 1. The class-wise traffic volumes observed from video were converted to passenger car units (PCU) using the PCU factors suggested in IRC guidelines [3]. The PCU factors used were 0.75 for two-wheeler, 1 for three-wheeler, passenger cars, LCV and 2.8 for HCVs. The number of PCUs in each of the one hour duration, i.e., 7.30 to 8.30 am, 7.35 to 8.35 am, etc. was calculated till 11.30 am to find out the morning peak hour volume. In the

same way, each one hour traffic volume from 2.30 pm onwards was calculated to identify the peak hour volume in evening hours. Since it is difficult to identify the vehicles from video after 6.30 pm, the evening data was restricted upto 6.30 pm. The observed peak hour volumes were used for design of the rotary, the details of which are explained in the following section.

Figure 2. Snapshot of the video showing vehicles coming from different approach roads at the selected intersection

Table 1. Observed traffic movements at the selected intersection.

Sl. No.	From	To
1	Royapetah High Road (south)	Lloyd's road (west)
2		Royapetah High Road (north)
3		Masilamani road
4		Lloyd's road (east)
5	Lloyd's road (east)	Royapetah High Road (south)
6		Lloyd's road (west)
7		Royapetah High Road (north)
8		Masilamani road
9	Masilamani road	Lloyd's road (east)
10		Royapetah High Road (south)
11		Lloyd's road (west)
12		Royapetah High Road (north)
13	Royapetah High Road (north)	Lloyd's road (west)
14		Royapetah High Road (south)
15		Lloyd's road (east)
16		Masilamani road
17	Lloyd's road (west)	Royapetah High Road (south)
18		Lloyd's road (east)
19		Masilamani road
20		Royapetah High Road (north)

3. Identification of peak hour traffic volume

The hourly traffic volumes from 7.30 am to 11.30 am and 2.30 pm to 6.30 pm are shown in Fig.3 and 4 for morning and evening hours respectively.

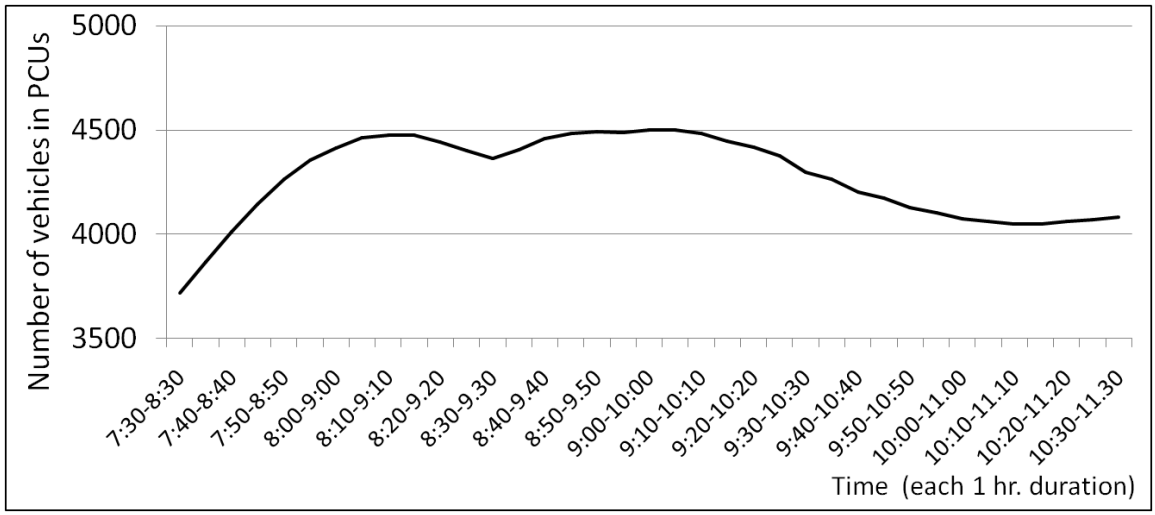

Figure 3. Hourly traffic volumes between 7.30 am and 11.30 am

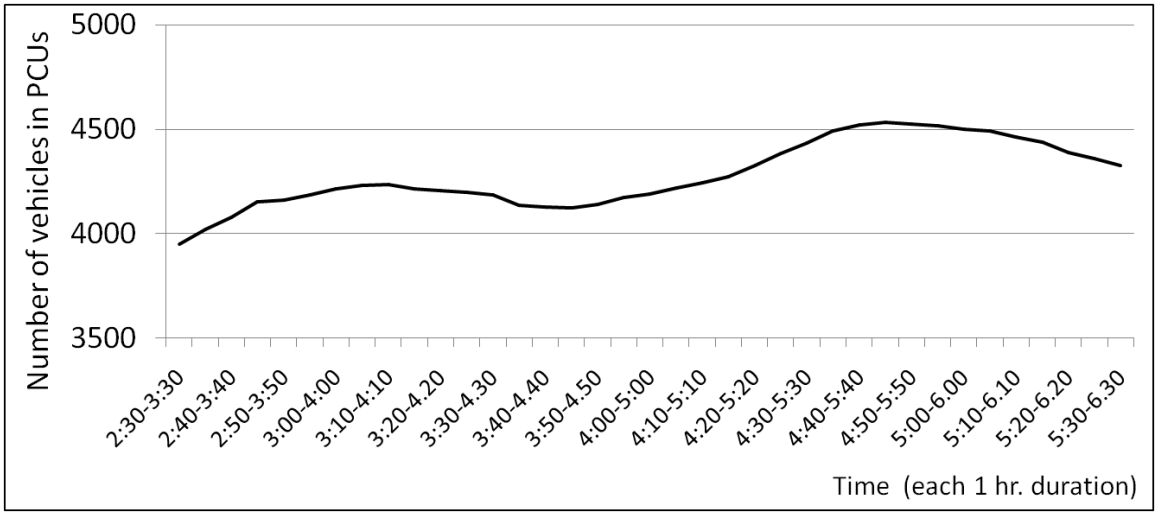

Figure 4. Hourly traffic volumes between 2.30 pm and 6.30 pm

It was found that, from 9 am to 10 am, the traffic volume was 4500 PCUs, which is the maximum when compared to other hourly volumes during morning hours. Similarly during evening hours, between 4.45 pm and 5.45 pm, a maximum traffic volume of 4535 PCUs was observed. Thus the results showed that the maximum traffic volume during the eight hours study period was 4535 PCUs and that has been used in the design of the rotary as explained in the following section.

4. Design of rotary intersection

The design of rotary for the selected intersection is performed following the IRC guidelines [3]. The first step in design is to identify the peak hour traffic volume and for the present case study intersection, it was found to be 4535 PCUs. The direction-wise traffic volume in PCUs is shown in Fig. 5. It can be seen that the number of vehicles travelling in Royapetah high road is very high, i.e., 936 PCUs from north to south and 611 PCUs from south to north. Similarly the number of vehicles proceeding towards Lloyd's road west from north of the Royapettah high road is high as seen in Fig. 5.

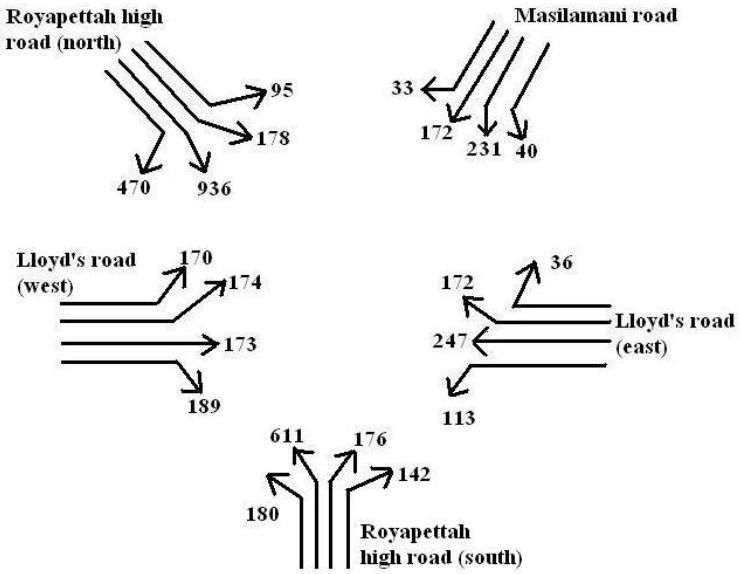

Figure 5. Direction-wise traffic volume in PCUs

The next step is to determine the inflow and outflow volumes in each of the approach roads. The results are shown in Fig.6. It can be seen that the sum of inflow and outflow was found to be maximum in the Royapettah high road (north), i.e., about 2665 PCUs. According to Kadiyali [8], the practical capacity of the rotary should be more than this value for the design to be satisfactory.

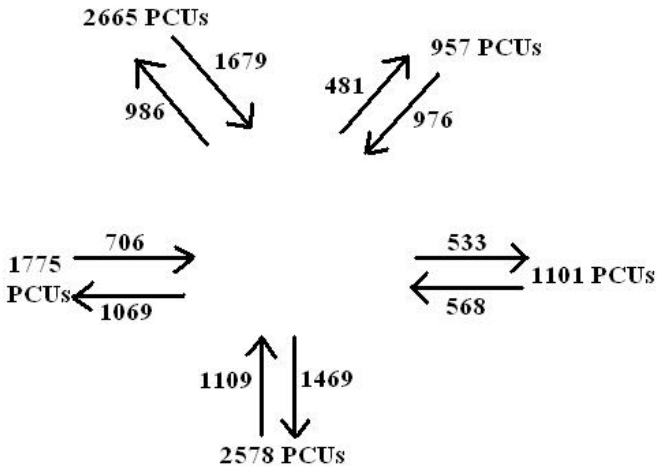

Figure 6. Inflow and outflow volumes in each approach road

The third step is to find out the diverging, merging and weaving traffic from each of the five approach roads as shown in Fig.7. This helps to find out the section where the proportion of the weaving traffic (p), i.e., ratio of sum of crossing streams $(b + c)$ to the total traffic $(a + b + c + d)$ is maximum. For the present intersection, the maximum proportion was found to occur between Royapettah high road (south) and Lloyd's road (west). That is,

$$p = \frac{(b+c)}{(a+b+c+d)} = \frac{(142+176+611)+(470+172+247)}{(180+929+889+241)} = 0.81$$

According to IRC guidelines [3], the proportion can take any value between 0.4 and 1 and in the present study, the calculated value is found to be within the prescribed range.

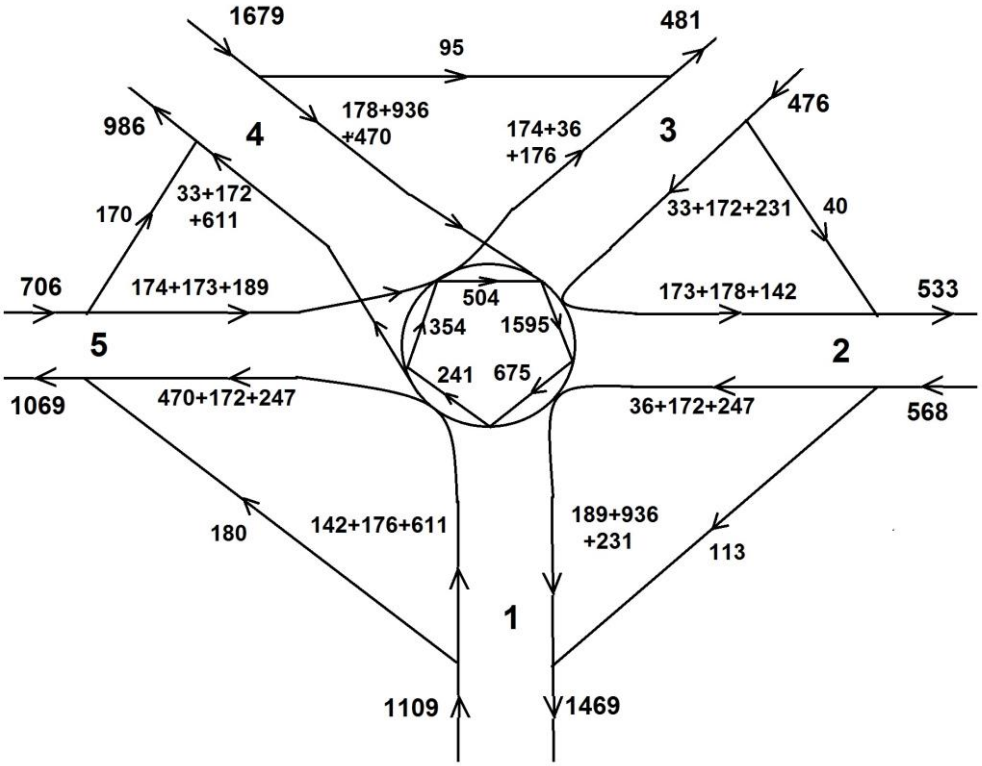

Figure 7. Diverging, merging and weaving traffic from each of the five approach roads

The next step is to calculate the practical capacity the rotary can handle for the given geometric conditions and proportion of weaving traffic to total traffic. The empirical formula to calculate the capacity of the rotary is given below [3].

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

Where, Q_p is the practical capacity of the weaving section of the rotary in PCUs/hr, w is the width of the weaving section, e is the average entry width of the rotary and l is the length of the weaving section and p is the proportion of the weaving traffic, i.e., ratio of sum of crossing streams (sum of b & c) to the total traffic (sum of a, b, c and d) on the weaving section. For the present case, the proportion of weaving traffic was calculated as 0.81. Using the maximum width of the approach road (10.36m), the average entry width of the rotary was found to be 7.48 m and width of the weaving section as 10.98 m. According to IRC-65:1976, the weaving length should be at least 4 times the width of the weaving section. Thus the weaving length for the present study was calculated as 44 m. Using the above values of average entry width of the rotary, width & length of weaving section, proportion of weaving traffic, the practical capacity of the rotary using equation (1) was calculated as 3020 PCUs which is well above the maximum value of sum of inflow and outflow volumes, i.e., 2665 PCUs. Hence the design can be considered adequate to handle the present approach traffic volumes. Finally, the drawing of the proposed rotary intersection was prepared using AutoCAD as shown Fig.8.

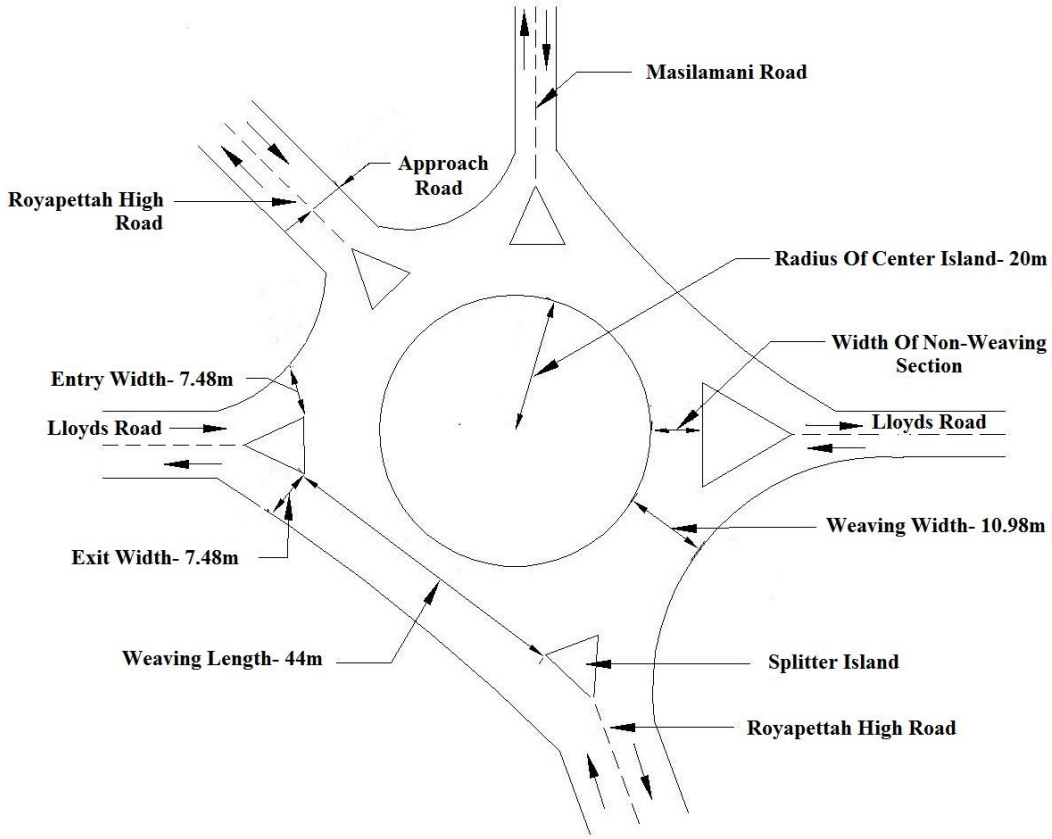

Figure 8. AutoCAD drawing showing the proposed rotary intersection

5. Conclusion

The Rapid urbanization is a serious issue faced by most of the metropolitan cities in India. Many people are migrating from rural to urban areas and this urbanization results in the increase in number of vehicles plying on the road. Though the vehicular growth follows an exponential trend, the infrastructure expansion does not commensurate at the same level, thus results in traffic congestion on city roads. Less usage of public transport further aggravates the congestion situation. One way to control the traffic at busy intersections is to construct a roundabout or rotary intersection. Most of the existing studies on design of a new rotary or capacity analysis of an existing rotary are mainly concentrated on intersections having only four legs that intersect at right angles. However studies on design of a complex rotary intersection with many approach roads have not been reported in India. Hence in the present study, design of a rotary for an uncontrolled multi leg intersection located in Royapettah, Chennai was attempted. Traffic volumes coming from different approach roads were collected using videographic techniques and analyzed for peak hour traffic volume. Using that, the design of the rotary following IRC guidelines was attempted and finally a drawing showing various design elements for the proposed rotary intersection was prepared using AutoCAD software. When compared to grade separators, constructing a rotary is a cheap and effective solution.

6. References

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