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Traffic Feasibility Study for a Grade Separator at a Busy Intersection in Vellore

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Abstract. One of the byproduct of urbanization is traffic congestion and before suggesting any solutions to reduce congestion, understanding the present context becomes very important. Study of traffic volumes at busy intersections to find the percentage composition of different vehicle types, directional distribution and peak hour traffic volume is a first step towards understanding the present context of traffic. Hence in the present study, one of the busy intersections in Vellore, namely, Gandhi nagar intersection in Vellore-Katpadi road was selected and traffic flow data was collected using video surveys. It was found that at the selected intersection, the two wheelers and three wheelers alone share 80% of the total traffic when compared to other vehicle types. Nearly 700 trucks and multi axle trailers were observed to pass through the intersection during the analysis period of five hours. That is, on an average 2 trucks/multi axle trailers were passing through the intersection in each minute. As like in other major cities, entry of trucks and other heavy vehicles such as multi axle trailers into the city needs to be banned during peak hours for smooth flow of traffic within city limits. A highest hourly volume of 6939 PCU's was observed between 4 and 5 pm at the selected intersection. By assuming a 10% uniform traffic growth every year, it was found that after about 4 years, i.e., in 2019, the traffic volume at the intersection may reach 10,000 PCU's and may warrant for a grade separator or interchange at the intersection.

1. Introduction

The increase in urban population due to economic growth in recent decades in India resulted in severe traffic congestion in most of the metropolitan cities of our country. It is said that, between 2010 and 2050, the number of people living in the world's urban areas is expected to grow by 80 percent, i.e., from 3.5 billion in 2010 to 6.3 billion in 2050 [1]. This twofold rise may lead to many urban related problems in world's cities and India is no exception to this. Next to Maharashtra and Gujarat, in Tamilnadu, 50% of the total population of the state was living in major cities of the state, which is one of the highest in the country. Availability of cars at affordable prices encourages personal vehicle usage for office and recreational trips thus resulting in lesser use of public transport which leads to congestion on city roads. For example, the total private vehicle population in Chennai has increased from 10 lakhs in 1999 to almost 37 lakhs in 2012. The situation is more or less similar in other cities of Tamilnadu also. For example, in recent years, the cities like Coimbatore, Madurai, Vellore, etc. are also witnessing rapid urbanization associated with increasing vehicular growth. Vellore being close to Chennai and having well connected road and railway network, it experiences a fast and tremendous urban growth after it has been declared as a city corporation in 2008. Vellore is one of the most preferred educational destinations in our country in both engineering and medicine due to the presence of world class institutions like VIT University and Christian Medical College and Hospital (CMC). In

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CMC, nearly 5,000 outpatients are visiting the hospital from various parts of our country and because of its close proximity to Vellore old bus stand and the market area, traffic congestion on all the surrounding roads becomes a daily phenomenon during peak hours. In VIT University, around 30,000 students are using the campus and in order to cater the accommodation needs of students and faculty, new residential areas have been developed recently by Katpadi co-operative housing society near VIT. As more and more new residential areas have come up, increase in vehicular volume becomes inevitable.

One of the major problems related to traffic congestion in Vellore is the proportion of share autos using the roads. For example, in Vellore city alone, around 9000 share autos were running every day in addition to the regular cars, two-wheelers and buses. These share autos were mainly running on the highway which connects the Vellore old bus stand, CMC, New bus stand and Katpadi railway station. Unauthorized parking at midblock and near intersections, frequent stops at passenger convenient locations, carrying passengers more than the permissible limit are some of the traffic and safety related problems caused by share autos in Vellore. As there is no ring road in Vellore which can connect the national highway (NH) number 46 (Chennai – Bangalore (east west corridor)) and state highway (SH) number 9 (Chittor-Cuddalore (North south corridor)), all the bypassable traffic such as trucks and large multi axle trailers are using only the city roads thus causing severe traffic chaos during peak hours in Vellore-Katpadi road. During Sabarimala season, more tourist vans and buses proceeding towards Vellore fort and Golden temple at Sripuram can be seen in addition to regular traffic on roads. Before suggesting various solutions to reduce congestion, understanding the present context becomes very important. Study of traffic volumes at busy intersection(s) is one of the primary survey a traffic engineer would be interested to do as it gives an idea of percentage composition of different vehicle types, directional distribution and peak hour traffic volume. The study of traffic volumes also helps to check whether a signal or a grade separator warrants at the selected intersection. Hence in the present study, one of the busy intersections in Vellore, namely, Gandhi nagar intersection in Vellore-Katpadi road was selected and traffic flow data was collected using video surveys. The collected traffic flow data was thoroughly examined to identify the percentage composition of various vehicle types, directional distribution and peak hour traffic volume. As per Indian Roads Congress (IRC) guidelines, warrant for constructing a grade separator was also examined using the collected traffic flow data. The details of the selected intersection are provided in the following section.

2. Study area

The Gandhi nagar intersection in Vellore-Katpadi road is one of the busy intersections in Vellore and is located close to Katpadi railway station (1 km) and VIT University (2 km). Fig.1 shows the Google map view of this intersection along with prominent landmarks in Vellore such as old and new bus stand, railway station, VIT University and CMC hospital. As seen in Fig.1, SH-9 (Connecting Chittor in Andhra Pradesh and Cuddalore in Tamil Nadu) and NH-234 (connecting Mangalore in Karnataka and Villupuram in Tamilnadu) are passes through the selected intersection. As there is no bypass or ring road connecting SH-9 with NH-46, all the bypassable traffic such as cars, trucks and multi-axle trailers from NH-46 to SH-9 or vice versa, are using the same intersection and hence during peak hours, the traffic is heavy at the intersection. In addition to the bypassable traffic, all the regular traffic proceeding from Vellore town and adjoining residential areas such as Sathuvachari towards VIT and Katpadi railway station has to pass through this intersection only. The proposal to construct a bridge across Palar river connecting Sathuvachari with Kangeyanallur has not yet been materialized and hence all the traffic from Vellore town and adjoining areas has to pass through this intersection only to reach Katpadi and VIT university. Currently the traffic at the intersection is controlled manually by traffic police personnel during morning and evening peak hours. The details of video data collection to study the traffic flow at the selected intersection have been discussed in the following section.

Figure 1. Google map view of the intersection along with prominent landmarks in Vellore

3. Data collection and extraction

The traditional way of traffic volume data collection is to employ traffic enumerators (number of people to be hired depends on the vehicle classes, number of lanes, approaches, etc.) who can stand on roadsides and can manually note down the vehicles that crosses them. The problem with the manual data collection is that the daily wage has to be paid for the enumerators and sometimes, especially when the volume level is high, there can be chances that the enumerators may miss some of the vehicles. In order to overcome these drawbacks in manual data collection system, video recording of the traffic was done without much considerable cost and labour. With the recorded video, the traffic flow data can be easily obtained at the desired time interval. For example, every 5 minutes, the number of vehicles (class-wise) passing through the each arm of the intersection can be easily counted from the video. The main advantage of video data collection is that, if at a later date the traffic flow data is required at a different time interval, the same video can again be reanalysed and the required particulars can easily be extracted which is not possible in manual data collection system. As there are many advantages with the video data collection, the same has been adopted in the present study also. A commercial complex near the intersection was selected as it is having wide area coverage and power supply for continuous video recording using handycam. Five hours of video recording from 9.30 am to 12.30 pm and 4 pm to 6 pm was carried out on a typical working day. A snapshot of the video is shown in Fig.2.

Before data extraction, six directions of traffic were considered, namely, Vellore to Katpadi (direction-1 in Fig.3), Vellore to Gandhi nagar (direction-2 in Fig.3), Katpadi to Vellore (direction-3), Katpadi to Gandhi nagar (direction-4), Gandhi nagar to Vellore (direction-5) and Gandhi nagar to Katpadi (direction-6). In order to take into account the heterogeneous traffic conditions as existing in India, eight vehicle classes were considered, namely, bicycle, two-wheeler, three-wheeler (autos),

passenger car, light commercial vehicle (LCV), bus, trucks and multi axle trailers. Each 5 minute traffic volume in all the six directions of traffic for all vehicle classes was manually extracted using the collected video data. The observed class-wise traffic volume was converted to equivalent passenger car units (PCU) using the PCU factors suggested in IRC-106, 1990 [2]. The PCU factors used were 0.4, 0.75, 2, 1, 1.4, 2.2, 4 for bicycle, two-wheeler, three-wheeler (autos), passenger car, LCV, bus/trucks and trailers respectively. In IRC-106, 1990 [2], two sets of PCU values were given according to the percentage composition of different vehicle types in the traffic stream. For the present case, since the proportion of two-wheelers and autos were more than 10%, PCU values of 0.75 and 2 were used for two-wheelers and autos respectively instead of 0.5 and 1.2. The class-wise and PCU converted traffic volumes were analyzed to study the traffic flow in the selected intersection, the details of which are explained in the following section.

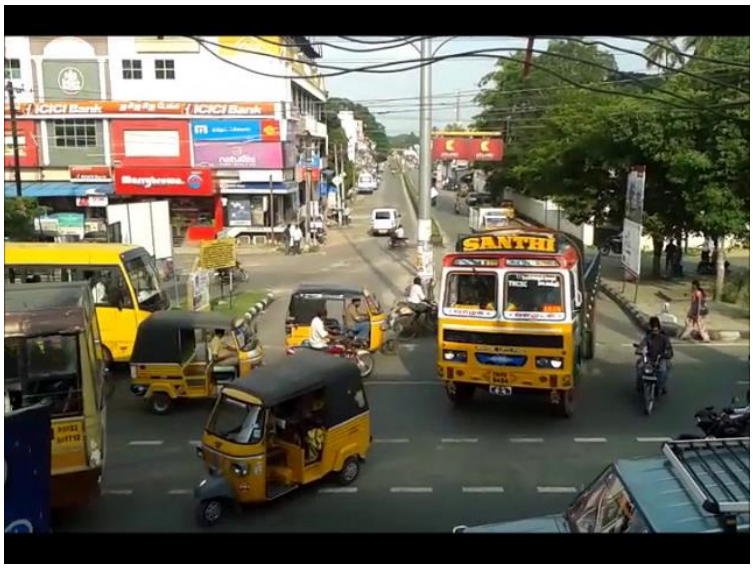

Figure 2. Snapshot of the video collected at the study location

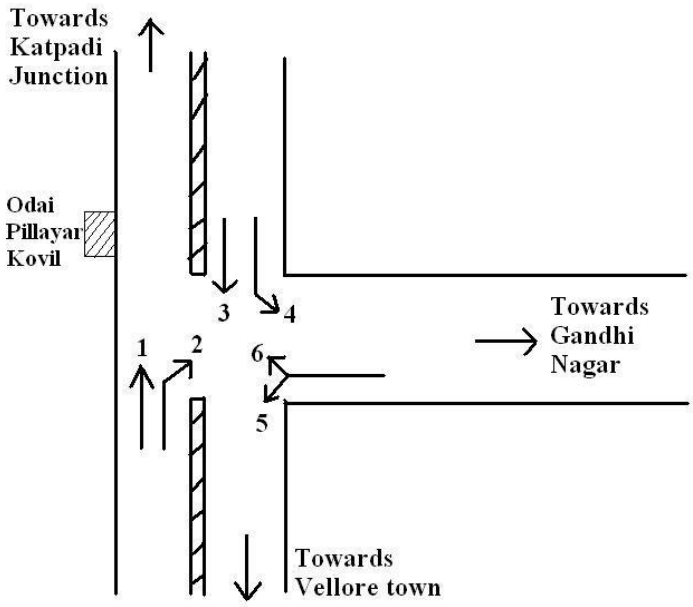

Figure 3. Traffic movement diagram at Gandhi nagar intersection

4. Mode composition and direction-wise flow of traffic

The percentage composition of various vehicle types in all the six directions of traffic during the analysis period is shown in Fig.4. It was found that 17601 two-wheelers were observed during the five hour period in all the six directions of traffic, which accounts for about nearly 62% of the total traffic. It was interesting to see that, next to two wheelers, 4993 share autos were observed, which accounts for about 18% of the total traffic. Thus, at the selected intersection, two wheelers and three wheelers alone share 80% of the total traffic when compared to other vehicle types. The possible reason for such a high number is that, for office and educational trips, most of the commuters were using their own two-wheelers or depend on intermediate public transport systems such as share autos. A study on the analysis of traffic flow in one of the major arterials in Chennai revealed that, two-wheelers constitute 45%, three-wheelers constitute 6%, passenger cars constitute 47% and heavy motor vehicles counts to 2% [3]. That is, the proportion of cars itself reaches almost 50% of the total traffic as the trip lengths are comparatively high in the range of 20-40 km in major metropolitan cities like Chennai, Bangalore, etc and hence people prefer using cars for such longer trips. But in the present case, the proportion of cars passing through the intersection is only 10% of the total traffic. The probable reason might be that, for office and educational trips people prefer using mostly two-wheelers than cars as the trip lengths are comparatively small in the range of only 5-10 km only in cities like Vellore. But as the town grows, the trip lengths may increase considerably and people may prefer using cars than two-wheelers. The analysis of traffic data revealed that the LCV, buses and trucks constitute about 8% of the total traffic. Nearly 700 trucks and multi axle trailers were observed to pass through the intersection during the analysis period of five hours. That is, on an average 2 trucks/multi axle trailers were passing through the intersection in each minute. As like in other major cities like Chennai, Hyderabad, entry of trucks/trailers and other heavy vehicles into the city needs to be banned during peak hours for smooth flow of traffic within city limits. Unless the ring road is formed in Vellore, it is not possible to implement this restriction as there is no alternative route available for heavy vehicles to move from NH-46 to SH-9 or vice versa.

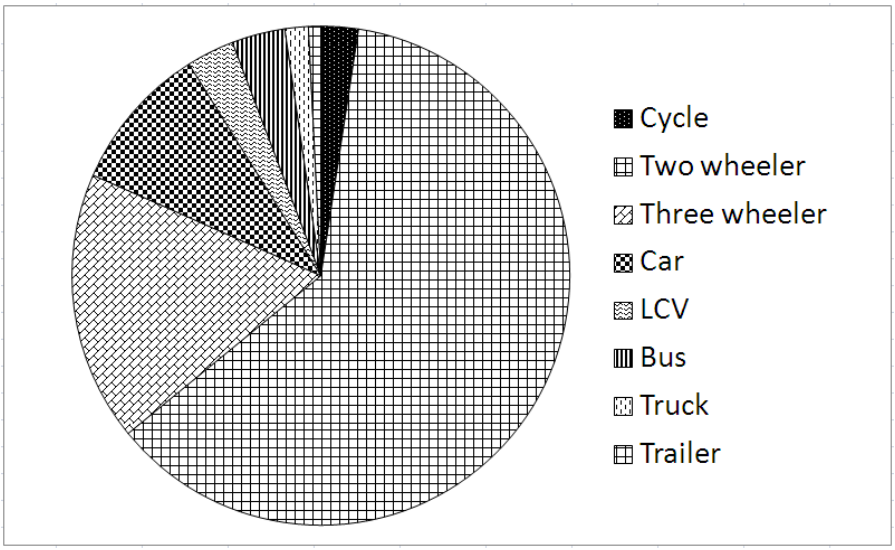

Figure 4. Percentage composition of various vehicle types

The direction-wise traffic flow in terms of PCU's for morning and evening hours are shown in Fig.5 and Fig.6 respectively. It was found that the directions-1 and 3 (Vellore to Katpadi and vice versa) were showing higher traffic flow when compared to other directional movements as it mainly comprises the through traffic which flows between Vellore and Katpadi. It can be seen from Fig.5 and 6 that during morning hours, the direction-1 shows comparatively higher flow than direction-3, whereas during evening hours, the traffic flow is reversed, i.e., direction-3 is greater than that of

direction-1. The reason for this is that during morning hours the office and educational trips are oriented towards Katpadi, where educational institutions such as VIT University, Kingston Engineering College, Sunbeam higher secondary school and Shrishti Vidyashram are located. During evening hours, traffic flow is reversed, i.e., the trips are oriented towards their home in Vellore.

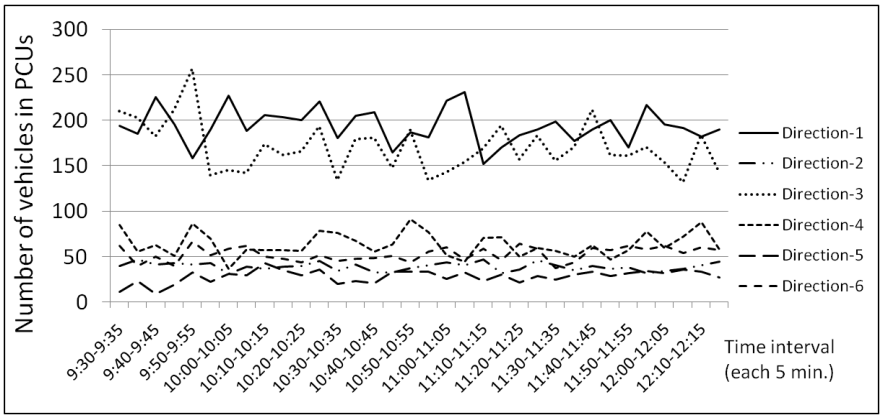

Figure 5. Direction-wise flow of traffic during morning hours

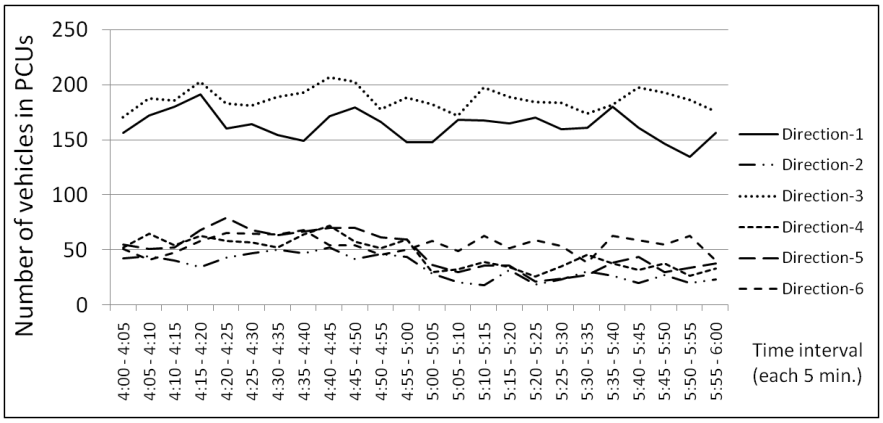

Figure 6. Direction-wise flow of traffic during evening hours

5. Peak hour volume and traffic feasibility for a grade separator

The total number of vehicles in PCU's from all the directions in each one hour duration with 5 min. increment is shown in Fig.7 and 8 for morning and evening hours respectively. It was found that, a highest hourly volume of 6939 PCU's was observed between 4 pm and 5 pm, which is the peak hour traffic volume at the selected intersection.

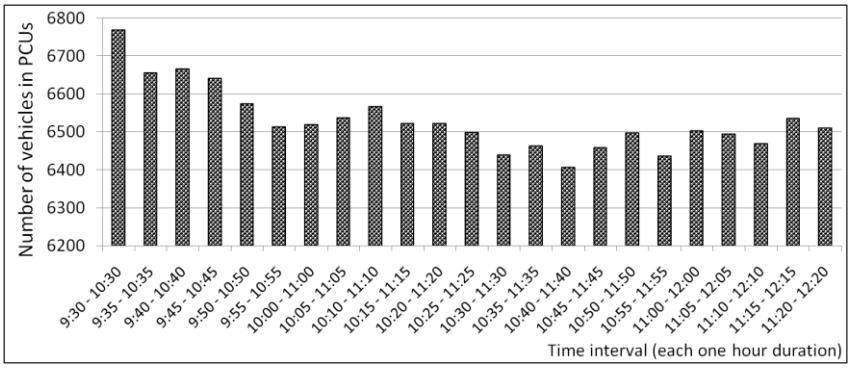

Figure 7. Hourly traffic volume in PCUs during morning hours

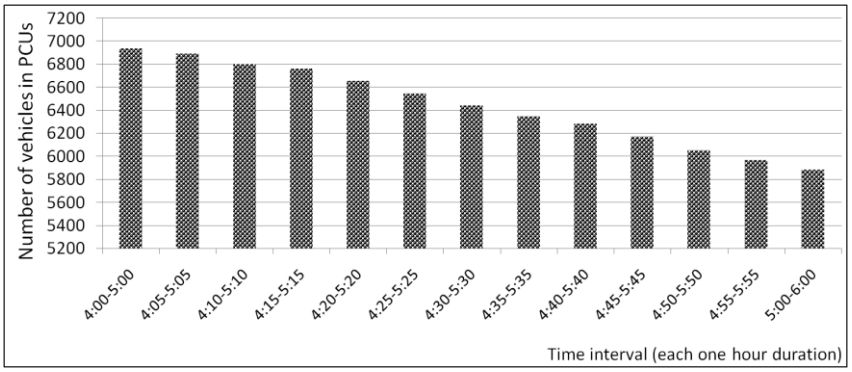

Figure 8. Hourly traffic volume in PCUs during evening hours

According to IRC-92, 1985 [4], when the total traffic of all the arms of the intersection is in excess of 10,000 PCU's per hour, then the interchange may be justified as the at-grade intersection fails to handle the given traffic volume. In the present case, for the selected intersection, the total volume of all the arms of the intersection is only 6939 PCU's, which is less than 10000 PCU's and hence an interchange may not be required at present. Due to non-availability of economic indicators such as gross domestic product (GNP), population record, a uniform annual growth rate of 10% was assumed to arrive at the future traffic volume at the selected intersection. The formula used to calculate the future traffic volume is given below in equation (1).

$$P_n = P_o(1 + r)^n \tag{1}$$

Where, P_n is the traffic in n th year, P_o is traffic in the base year, r is the annual rate of growth of traffic expressed in decimals and n is the number of years. Fig.9 shows the predicted traffic volume in the next 10 years. It was found that after about 4 years, i.e., in 2019, the traffic volume at the intersection may reach 10,000 PCU's and may warrant for a grade separator or interchange at the intersection. As a short term measure, traffic signals can be erected at the intersection for orderly movement of traffic as the traffic volume on the major road (Vellore-Katpadi road) is greater than 800 PCUs per hour, which is the minimum traffic volume to justify for a signal [5].

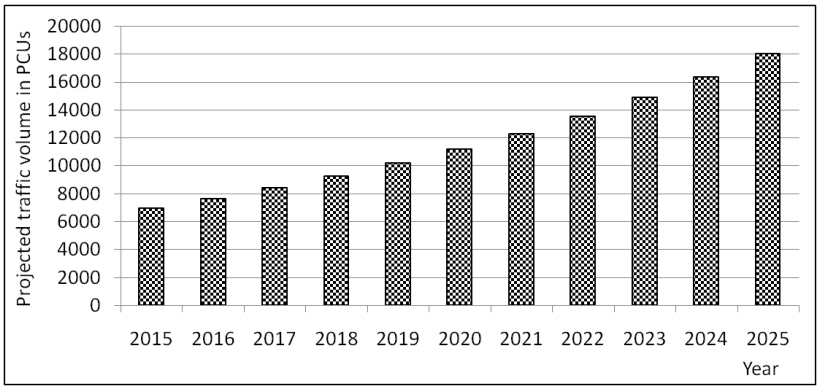

Figure 9. Predicted traffic volume in PCUs at the selected intersection

6. Conclusion

The uncontrolled growth of urban areas is a serious issue faced by most of the cities and towns in developing countries like 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. For example, in Chennai, over the last 13 years, there was about 300 percent rise in private vehicle population but the increase in road space in only 10%. The situation is more or less similar in other cities like Coimbatore, Salem, Madurai, Trichy and Vellore. As Vellore is on the main Chennai-Bangalore industrial corridor and being close to Chennai, the city had a tremendous growth especially in the last decade. The premier institutions like CMC and VIT attracts large number of students from various parts of the country and in recent years Vellore is facing a gradual transition from a medium sized town to a metropolitan city. Study of traffic volumes at busy intersection(s) to find the percentage composition of different vehicle types, directional distribution and peak hour traffic volume is a first step towards understanding the present context of traffic. Hence in the present study, one of the busy intersections namely Gandhi nagar intersection on Vellore-Katpadi road was selected and traffic flow data was collected using video surveys. The collected traffic flow data was thoroughly examined to identify the percentage composition of various vehicle types, directional distribution and peak hour traffic volume. It was found that at the selected intersection, the two wheelers and three wheelers alone share 80% of the total traffic when compared to other vehicle types. Nearly 700 trucks and multi axle trailers were observed to pass through the intersection during the analysis period of five hours. That is, on an average 2 trucks/multi axle trailers were passing through the intersection in each minute. As in other major cities like Chennai, Hyderabad, entry of lorries/trucks and other heavy vehicles into the city needs to be banned during peak hours for smooth flow of traffic within city limits. Unless the ring road is constructed in Vellore, it is not possible to implement this restriction as there is no alternative route available for heavy vehicles to move from NH-46 to SH-9 or vice versa. A highest hourly volume of 6939 PCU's was observed between 4 pm and 5 pm at the selected intersection. By assuming a 10% uniform traffic growth every year, it was found that after about 4 years, i.e., in 2019, the traffic volume at the intersection may reach 10,000 PCU's and may warrant for a grade separator or interchange at the intersection.

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