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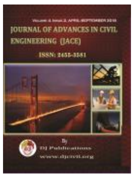

RESEARCH ARTICLE

Enhancing the Two-Wheeler Traffic Movement at Junctions

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ABSTRACT

To attempt a proposal with an ideology for enhancing an urban traffic junction, an isolated subway to by-pass the two wheeler traffic is presented. At the particular intersection of the three or more roads, subways from all the sides meet at a roundabout below the existing road level, so that the two-wheelers can descend through the inlet subway, choose their respective road at the roundabout and ascend ahead in the decided direction through the outlet subway.

Keywords: Junction enhancement, Two-wheeler traffic flow, Two-wheeler subway, Traffic reduction, Two-wheeler free flow.

1. INTRODUCTION

In today's world, with the growing population, problems faced by the society have outnumbered themselves. In India, one major issue which needs to be solved is traffic regulation and congestion control. The metropolitan cities are facing difficulty to accommodate this increase in traffic intensity with the existing infrastructure and proposed design elements. Such increase in traffic volume is unavoidable. Simultaneously it is almost impossible to develop an infrastructure by expanding the space for vehicular movement in an urban junction as it needs massive procurement of private land. Similarly constructing a flyover or subway with 5.5m of height clearance at every junction is expensive and not feasible in the present scenario.

As a figurative explanation, we chose to conduct our case study on the Lakshman Shruthi Signal at Vadapalani, a part of a prime road at Chennai called the Inner Ring Road (IRR). The traffic survey statement of IRR at Vadapalani by the highways department of Tamil Nadu government has concluded that 52.42% of the total vehicular volume is two-wheeler traffic. During our survey at the signal during peak hours, we are aware that the vital traffic causing factor is the 'two-wheeler' which acts as a filler component filling the voids between the lanes, interrupting the movement of other vehicles. Regulating the lane violators has been a tiresome task, as they are huge in number and difficult to control. Controlling and isolating two-wheelers will enhance the traffic flow. Our proposal in this study is to redirect their traffic by constructing an underground pathway. It is designed exclusively for two-wheelers with one lane each for inward and outward traffic.

The proposal is extended beneath all the four roads at the junction point. In the centre of the junction, where the subways from all the four directions meet, a suitable roundabout has to be placed to regulate the underground two-wheeler traffic without signal to avoid collisions. We have also attempted to predict the time, fuel and cost saved in this study. The present work is an effective substitute to reduce traffic at junctions rather than building flyovers.

2. RELEVANT WORKS

The reasons for the rush-hour traffic are analogous in every urban region. [1] has studied the causes of congestion at Bangkok. It mentions that the traffic chaos causing factors are not just inadequate road spaces, but

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also failure to control traffic demands, ineffective usage of roads, improper planning of road networks, misappropriate knowledge of road users, inefficient law enforcement, deficient public transport services and incapability to co-ordinate between various transit modes. To overcome these deterrents, it recommends demand management concept and improved transit services. [2] has assessed the severity of the existing traffic system engulfed by tremendous traffic congestion in the Sylhet city. [3] has discussed the possible causes and solutions of traffic jam in Dhaka city. It describes the environmental and economic benefits that will be bestowed upon the city if the traffic congestion is relieved.

[4] has mentioned about the economic theory of traffic congestion with the assigned variables such as road capacity, traffic flow, cost per PCU (Passenger Car Unit)-mile, and road demand. [5] has categorised the factors causing congestion as micro-level factors. It gives an overview and presents the possible ways for identifying and measuring metrics for urban arterial congestion with a systematic review based on certain factors. They have also discussed about the existing practices and different methodologies for measuring congestion in various countries, including India.

[6] has conducted traffic analysis at the Medavakkam Y-shaped intersection in Chennai where the congestion is calculated as PCUs/hr, and the estimated future traffic is predicted based on pessimistic, optimistic and most likely conditions. Further, it also includes a proposal of constructing a flyover to elicit the difference at the locality. [7] has carried out a classified volume count survey and analysis, checking the capacity of existing roundabout at the Thaltej rotary intersection (NH147). Various alternatives like redesigned roundabout, traffic signal, flyover, underpass, cloverleaf and uplifted roundabout are proposed, designed and checked for their suitability in the proposed site.

[8] has mentioned about accommodating the vulnerable road users like pedestrians and cyclists in a roundabout design. The improved efficiency of roundabouts compared to that of intersections has been proved mathematically in [9]. It also demonstrates the critical arrival rates to separate the three mentioned modes to decrease the congestion at intersection points. [10] has investigated the complications in the construction of subways. [11] has concluded that the speed of motorcycles and scooters are 10% faster than the remaining vehicles and also has higher tendency to break speed limits and violate lanes leading to more number of two-wheeler accidents.

3. CONCEPT METHODOLOGY

Traffic flow is generally categorized into free flow, merged flow and crossing. The free flow is in a single stream of traffic where the traffic keeps flowing without any intrusion. Merged flow has the traffic streams from two or three roads that merge into a single stream in a road. A crossing is an intersection of four or more roads at a junction, where a traffic signal is used to regulate the traffic due to the inter collision at that point. The travel time of free flow is minimum, merged flow is slightly more and crossing is maximum, since it includes the time delay at signals.

If this delay is reduced, then the total travel time, fuel consumption and environmental impacts can be reduced significantly. To enhance the traffic movement in an urban area, the infrastructure at the junctions must be developed. Excessive congestion and high PCU of bikes and cycles are the factors for this underpass proposal at any intersection of three or more roads. The two wheelers will be diverted to the corner of the road just few metres ahead of a junction, where they are lowered into an underpass with 2.5m height clearance. This process is followed for all the roads meeting at the junction with an apt alignment. The subways from all the directions meet at the junction where a rotary island is being placed, specially designed for the two-wheelers. Figure 1 shows the rough alignment of road junctions.

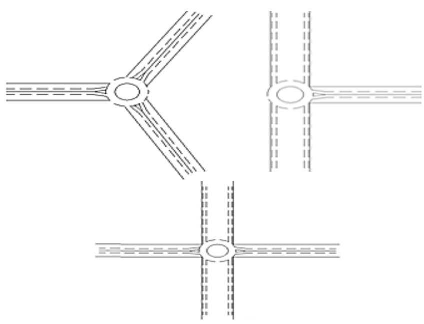

Figure 1.Rough alignment for 3 and 4 road junctions

This concept can be implemented in all the junctions, which encounter an immense traffic volume due to lack of space and infrastructure. In a major arterial road, instead of having junctions at frequent intervals, underpass can be designed as a tunnel spanning along the complete stretch of the road. This system of enhancing traffic flow will lead to uninterrupted flow of two-wheeler volume, i.e. the two-wheelers can reach their destination on time. It considerably reduces the signal time for the remaining vehicles.

4. STUDY AREA

A prime region of congestion in Chennai which influenced us was the portion of IRR between Ashok Pillar and Vadapalani. The Lakshman Shruthi junction in Ashok Nagar and the Arcot road junction in Vadapalani, parellel to each other were the busiest junctions in IRR. But in the latter, a flyover was constructed by the highways department of Tamil Nadu government elevating the movement of vehicles in IRR. However, in the Lakshman Shruthi junction, no measure has been proposed yet, which inspired us to conduct this study.

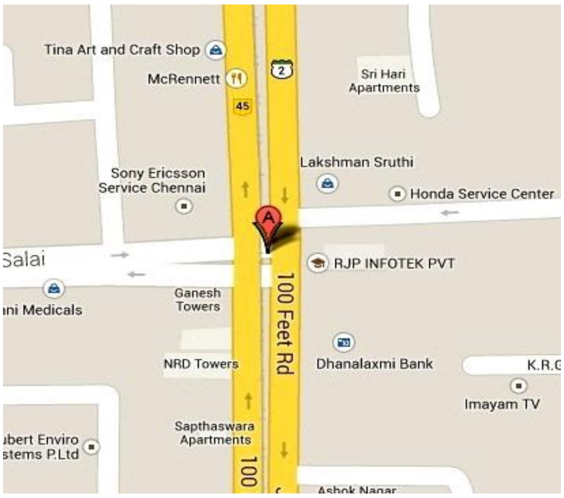

Figure 2.Location map of signal

IRR towards north leads to Koyambedu, and south leads to Guindy through Ashok pillar. In the west, P.T.Rajan Salai from Vadapalani Sivan park comes in to join with IRR, and from east comes the Ashok Nagar II Avenue road from Kodambakkam to merge with IRR. It is to be mentioned that II Avenue road carries only one way traffic travelling towards the junction. The location of the existing junction considered in this study is shown in figure 2, where the arrows denote the directions of traffic flow.

5. TRAFFIC ASSESSMENT

Traffic survey is conducted at the selected signal with the support and guidance of the highways department. The results are promising providing a better scope for executing this concept.

Table 1.Traffic survey details

Vehicle type	PCU switch factor	Maximum value per day		Average value per day	
		Number	PCU	Number	PCU
Car, van, jeep	1	61920	61920	48689	48689
Mini truck, Mini bus	2	13602	27204	10722	21444
Two axle, Three axle	3	3564	10692	2809	8427
Multi axle	4.5	124	558	98	441
Bus	3	7829	23487	6171	18513
3-wheelers	1	8013	8013	6301	6301
Cycles	0.5	1575	787.5	1328	664
2-wheelers	0.5	105260	52630	91082	45541
% of 2-wheelers (including cycles)		52.92	28.83	55.27	30.8

To estimate the percentage of PCU that will be diverted into the subway, a count is performed on the number of two-wheelers and it is compared to the existing data collected by the highways department. The volume of two-wheeler traffic on the busiest day of the week and in the busiest hour of the corresponding day has been considered.

Table 1 shows the details on the highest number of vehicles in the busiest day of the week and the average number of vehicles per day (considering 24 hours) in a week, along with their corresponding PCU. It also emphasizes the percentage of two wheelers including cycles for these two parameters.

It is noted that the peak value of two-wheelers is 106835 per day and the peak value is 8813 (7pm to 8pm). During this hour, 61.91% of the whole traffic comprise of two-wheelers which is approximately 45.3% of the total 9727.5 PCU. Thus, if the subway proposal is accomplished, this 45.3% PCU will be diverted into the subway and the remaining 54.7% (5320 PCU) will pass the junction at the ground level with reduced traffic intensity. Upon implementation, the number and PCU of two-wheelers will boost as a considerable percentage of car users will switch to motorcycles due to uninterrupted flow of vehicle at that junction.

6. PROPOSAL UNDERPASS

The topographical map of the existing junction is collected from the highways department, and various alignment calculations are made to implement the proposed method. Parameter such as turning radius, width of existing road, the area of land that has to be encroached, capacity of the underpass, diameter of roundabout, volume of two-wheelers with their PCU, design speed, sight distance and the corresponding alignment are considered for designing the underpass. Above IRR, the metro rail bridge work is in progress. The piers of this bridge are placed in the median of IRR at regular intervals. Hence, the underpass has to be positioned at the extreme ends, to avoid hindrance to the footing and pile cap of the metro rail piers. But in the P.T.Rajan Salai, the underpass has been shifted to the center of the road for convenience of construction. In the II Avenue road allowing only one way traffic, the underpass is positioned at the right extreme of the road to evacuate the two wheelers. The slope of the ramp diminishing into the subway is kept as 1 in 30 as per IRC 86: 1983 [12] code for urban roads design. To provide a vertical height of 2.5m (plus 0.5m for road and slab depth), the bike must travel a horizontal distance of 90m, until which the area occupied by the underpass on the existing ground level is retarded from use by other vehicles.

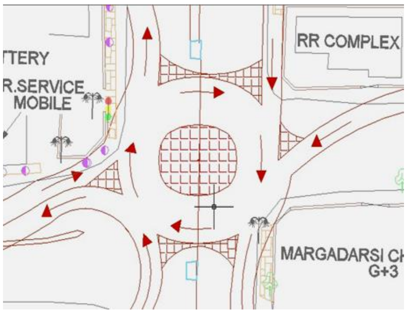

Figure 3.Proposed central rotary

Figure 3 shows the proposed central rotary. The carriageway adjacent to the underpass is extended to a maximum extent in order to neutralize the space occupied by the underpass. There is no particular IRC code available for the rotary of two wheelers. Thus we have compared the IRC code 11: 1962 [13] for cycle tracks and IRC 65: 1976 [14] of traffic rotaries to devise the following elements. It is an attempt to use the existing codes for designing our underpass; if it does not satisfy the requirements, a new code has to be developed exclusively for two-wheelers considering separate values formulated for the capacity required.

The lane width of the underpass for the single directional traffic movement is provided as 3.5m. Approaching the rotary, the average entry width is maintained as 3.5m (e_1), and impeded with speed breakers for the deceleration of the bikes before entering the rotary weaving section. The average exit width is maintained as 4m to stimulate the vehicular speed of the bikes exiting the rotary. The width of the non-weaving section has been maintained as 5.5m (e_2), and that of the corresponding weaving section is computed as in (6.1) and (6.2).

$$w = \frac{(e_1+e_2)}{2} + 3.5 \tag{6.1}$$

$$w = \frac{(3.5+5.5)}{2} + 3.5 = 8m \tag{6.2}$$

The shape of the central rotary island is drafted as an oval shape to even up the space constraint in between the piers of the metro rail. The maximum and the minimum radii of the oval are maintained as 9m and 7.5m respectively. To prevent collision and to impart proper movement of traffic, a channelizing island is provided in the aisle of P.T.Rajan Salai. Curbs are provided at every sharp edge with appropriate heights to improve the sight distance for the motorists. The capacity of the roundabout for the specified dimensions has been defined in (6.3).

$$\text{Rotary capacity } Qw = \frac{280w\left[1+\frac{e}{w}\right]\left[1-\frac{p}{3}\right]}{1+\frac{w}{l}} \tag{6.3}$$

where,
e is the entry and exit width average = 3.75m
w is the weaving width = 8m

l is the weaving length ≃ 15m
p is the ratio of weaving to non-weaving traffic calculated to be 0.941 as shown in figure 4.

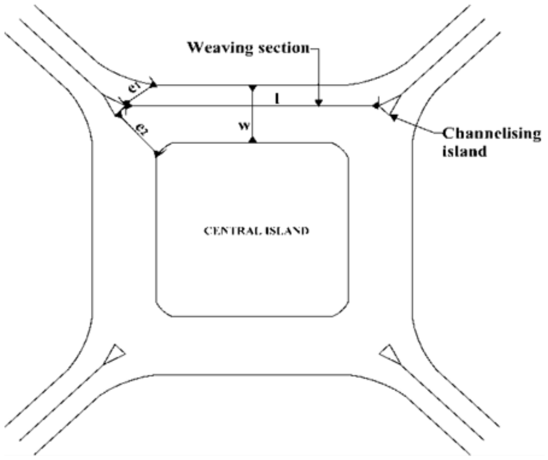

Figure 4.Capacity calculation elements

The capacity of the rotary calculated by using this formula is 1482 PCU per hour, i.e. 1976 motorcycles per hour as per IRC 65: 1976. Though the capacity attained for the rotary is much less compared to the capacity required, we have to commemorate the fact that the formula used in general code is for all the vehicles. We need a specific code for designing the rotary of two-wheelers. In spite of this hurdle, for a general satisfaction, the weaving and the non-weaving width may be extended to 10m and 7.5m respectively by shrinking the oval island to a radius ranging between 9m and 5.5m. Figure A1 shows the complete subway alignment.

7. FEASIBILITY AND ECONOMIC VIABILITY

A four directional over-bridge similar to the Tambaram over-bridge adjacent to the railway station and bus terminus with two lanes instead of four, which can be constructed for the same purpose is postulated for comparison with this proposal of particular subway for two wheelers. Evidently, we have found out promising results with significant reduction in land use, construction cost and period. The parameters taken into consideration are explained below in detail.

Framing an over-bridge for the same traffic flow has to be initiated with a longitudinal gradient (along the positive direction), much higher than the value of the longitudinal gradient (along the negative direction) corresponding to the two wheeler subway to provide the 5.0m of average height clearance below the over-bridge for the traffic flow of its non-users. This over-bridge would include abutments, piers, retaining or reinforced earthen walls and longitudinally span about 200m (in the horizontal axis) into all the four roads of the intersection from the centre of the junction. But the ramp of the subway is only 90m from the centre.

The cost of such an over-bridge with a common roundabout at its acme will definitely range between 35 and 45 crores with regard to previous similar projects. The subway of two-wheelers on the same line of comparison has been designed effectively within 6 and 7 crores. The time period of the construction is also greatly reduced. The building of the over-bridge in such a congested area will consume 20 to 24 months with a major portion of the road being concealed with barricade causing more traffic chaos to the commuters. Interestingly, the construction of the two-wheelers subway can be accomplished within 6 to 8 months by just partially retarding the traffic flow of the area.

(Note: Factors considered in estimation of the subway for two-wheelers – 3.5m lanes with 3m height clearance, 90m ramp length for each lane, 300mm thick retaining walls, bottom and top slab of the underpass being 200mm deep, 4 numbers of 7m long and 1m diameter piles grouped by a pile cap foundation, a 3m diameter single pier at the centre island, 200mm of granular sub-base and 200mm of wet mix macadam under all ramps and centre circular lanes.)

8. CONCLUSIONS

This proposal completely saves signal time for two-wheelers and partially for remaining vehicles. With 45% PCU reduction at the signal, the signal time decreases drastically. Since the two-wheelers have an uninterrupted flow, fuel consumption and pollution at the signal reduces greatly by 20-30%. The environmental impact is not reduced, but their concentration is diversified. Suitable technologies have to be implied to make a favorable environment by avoiding suffocation due to air pollution. The project does not need excavation above 3m depth, unlike normal subway of 6m or more. Rather than building a flyover or a normal subway, the underpass designed particularly for the two-wheelers is preferred since it consumes less time and cost.

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APPENDIX

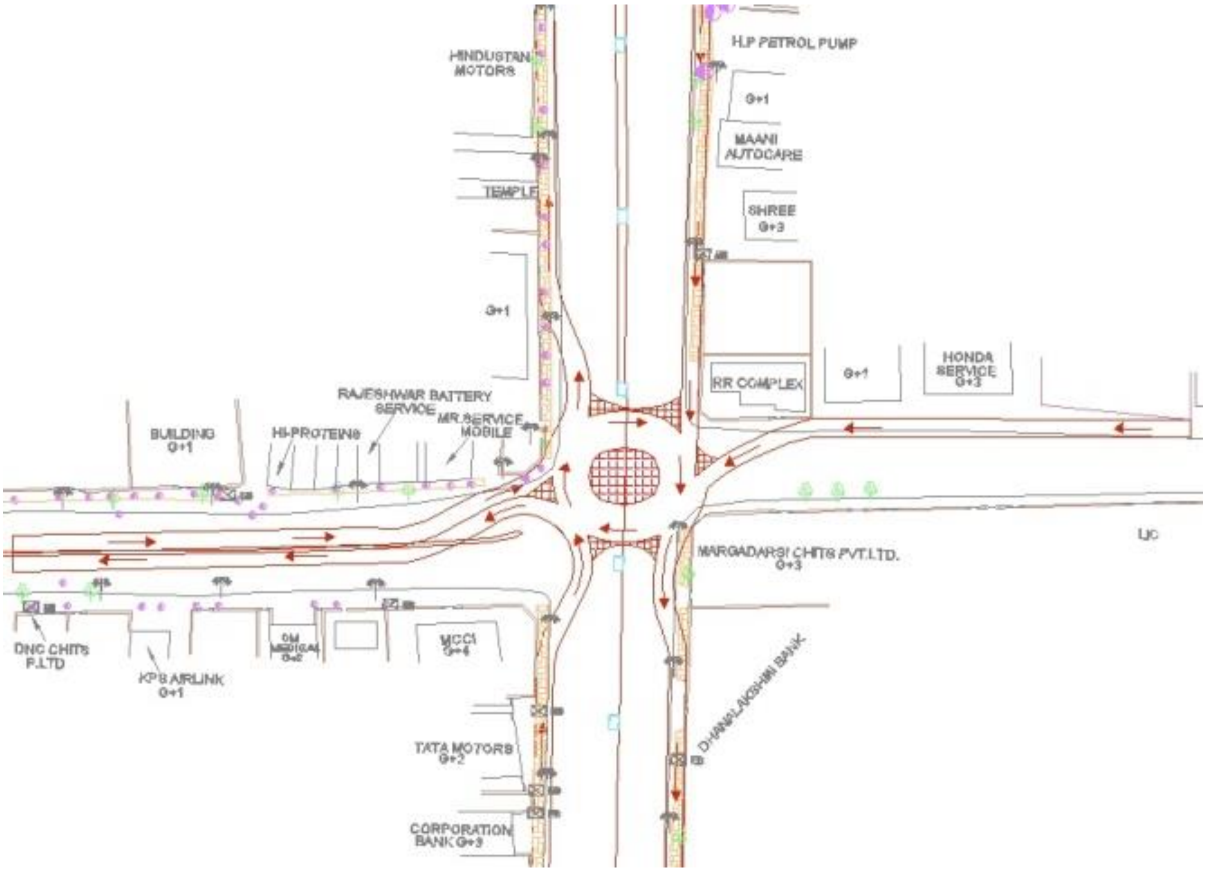

Figure A1.Complete subway alignment