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Sustainable Traffic Improvement forUrban Road Intersections of Developing Countries: A Case Study of Ettumanoor, India

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Abstract

The spectacular increase of number of motor vehicles on the road is mainly attributed ingeneration oftraffic problems like accidents, congestions, delays etc., especially in the urban premises of developing countries. This paper examines the traffic problems and sustainable improvement ofroadintersection at Ettumanoor, India. The spacial and temporal constitutions of the vehicle as well as pedestrian traffic at the intersections were examined and the characteristics of the junction indoctrinating the delay problems are identified. Data regarding the traffic volume, land use and pedestrian movement activities are collected through direct field surveys. Analysis of the collected data revealed that the improper planning of the junctions, lack of traffic signals and unauthorised parking are the major factors contributing to the traffic congestions. Various remedial measures are also proposed, focusing on junction improvement, alternative operation plan and junction signalisation.

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*Keywords:*Traffic congestion; intersections; traffic volume; traffic delay; junction signalisation.

1. Introduction

India is urbanising in a rapid rate and the absolute increase of population is more in the urban areas (9.1%) than in the rural areas [1] during the period 2001-2011. The urban population of India is estimated to be 37.7 crore. The quick urbanisation has resulted in enhanced travel demands and thereby an increase inurban transport problems.The urban traffic problems are attested with traffic congestions, accidents, unauthorised parking, poor land use, inadequate transport planning as well as poorly maintained road networks. Accounting for the colligationof social

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and economic regimes, traffic systems are perceived to be the nervure of an urban area [2]. Productivity and development is highly pendant with the transport systems and the problems related to the mobility adversely affect the urban life and system [3].Moreover, acute traffic congestions and associated problems potentially induce psychological and environmental issues.

Many researchers have performed studies that address the traffic flow issues in urban areas worldwide and are reported in the literature [4-9]. Ruskin and Wang [7] studied traffic flow in an urban unsignalised intersection using cellular automata (CA) models. Artificial neural networks were employed by Murat and Baskan [8] to model and address vehicle delays at signalised junctions. Kidwai et al. [9] attempted traffic flow analysis of a signalised intersection at Kuala Lumpur, Malaysia. As the traffic scenarios vary considerably compared to the developed countries, a special attention to the traffic problems in developing countries is demanded. A number of researchers have studied and suggested solutions for urban transportation issues subsumed with developing countries [10-19]. Patel [10] studied traffic congestion and delays at Thaltej rotary intersection, India. The traffic delay problems and related studies at Ilorin – a Nigerian city, were carried out by Aderamo and Salau [3], Atomode [11] and Adeleke and Jimoh [12]. Maitra et al. [13] took effort to evaluate the troubles encountered at road intersections of Kolkata, India. Research on safety and efficiency of a signalised intersection at Chennai, India were carried out by Sharma et al. [14].The impact of a flyover on transportation problems at an intersection was studied by Maitra et al. [15].Researches on pedestrian traffic and safety in Delhi, India were attempted by Mittal [16].Rubayat and Sultana [17] examined the reasons behind road accidents at Dhaka, Bangladesh. The traffic congestions and related problems at a railway crossing at Gandhinagar, India were studied by Modi and Podar [18]. Gomasta et al. [19] contributed to the literature by reporting traffic issues and possible solutions at two intersections of an Indian city – Bhopal.

Even though a handful of studies have been reported regarding the traffic problems related to urban environment, traffic delays and related issues at the urban road intersections still demands contemplation, taking local issues into consideration. Moreover, idealised models to solve traffic issues that can be implemented in growing urban areas of developing countries are still lacking in the literature. In this paper, the traffic issues at a burgeoning prominent urban intersection - Ettumanoor, Kerala State, India is studied. Field studies on traffic volume count, pedestrian traffic and public transport bus traffic within the study area were performed to establish the spatial model of commutation at the intersection. Past accident data were collected from local governing bodies and are critically analysed. Ailment in operational plans and unscientific land use pattern are identified to be the critical issues pertaining the area. An attempt is also made to suggest remedial measures by modification of traffic, alternative operational and routing strategies as well as junction signalisation.

2. Field Survey and Data Collection

Ettumanoor is one of the developing urban areas in Kottayam district, Kerala, India. Three major roads meet at the Ettumanoor Central junction: the Main Central (MC) road (State Highway 1), Ettumanoor – Poonjar road (State Highway 32) and Ettumanoor – Athirampuzha road. Ettumanoor en route to major destinations like Ernakulum (Kochi), Vagamon, Sabarimala, Kottayam etc. The proximity of a University, few colleges and a number of schools together with important religious in situations are also keyed out with Ettumanoor. Two bus stations (one private owned and other the State owned) and taxi stands are in propinquity with the junction. Inadequacy of road width, unsignalised junctions, deficiency of parking space, unauthorised trading along the road sides and lack of pedestrian amenities are also identified within the area under consideration. The especial nature of Ettumanoor with regard to the abovementioned reasons are attributed to the initiation and the outgrowth of traffic issues, especially during the peak hours of a day. In order to characterise the problems owing to the traffic issues in the Ettumanoor junction, direct field survey was performed to collect relevant data. Accident data were collected from the Ettumanoor Police

Station for three years (2012, 2013 and 2014). Peak hour volume count of the vehicles in all the directions was exercised to quantify the vehicular movement. In order to avoid the complexity of data ascribed to the interaction of various kinds of vehicles in mixed traffic condition, a common Passenger Car Unit (PCU) was adopted for all the vehicular volume counts. Turning movements of vehicles at the intersection with respect to 12 identified directions were reckoned during morning and evening peak hours. Entry and exit of public transport buses to the bus stations were also counted during both the peak periods. Pedestrian movement characteristics in the lateral and cross movement directions with respect to the roads were also enumerated. A simple hand counter was employed for pedestrian and vehicle volume counts.

3. Data Analysis and Synthesis

In order to identify the crucial issues that give rise to the traffic troubles in the Ettumanoor junction, the collected field data are analysed and deductive reasoning is carried out. In the following sections, the results of the analysis are presented.

3.1. Accident Analysis

The collected accident data during the three year period are examined and the number of victims dead, grieved and injured during the accidents is depicted in Fig. 1. From the figure, it is identified that the number of victims has considerable growth rate for the year 2012 to 2014, an exception can be seen in the grieved category. Fatal accidents are identified to be less in number, whereas, grieved category with heavy personal casualty is reckoned to be very high. Moreover, from the detailed analysis of the accident data, it is found that the pedestrians are more affected during the accidents.

3.2. Intersection Turning Manoeuvre

The turning movements of vehicles at the Ettumanoor intersections at 12 different locations are analysed and the results are presented in Fig. 2. It is identified that, the turning manoeuvres on location named Ettumanoor-Kottayam is identified to be burdened with huge traffic volume. The route towards and from Ernakulum as well as Pala is also observed to be having high traffic density. Lack of road markings, proper medians, traffic signs and signals reason out to the increased volume of traffic and congestion during the turning manoeuvre.

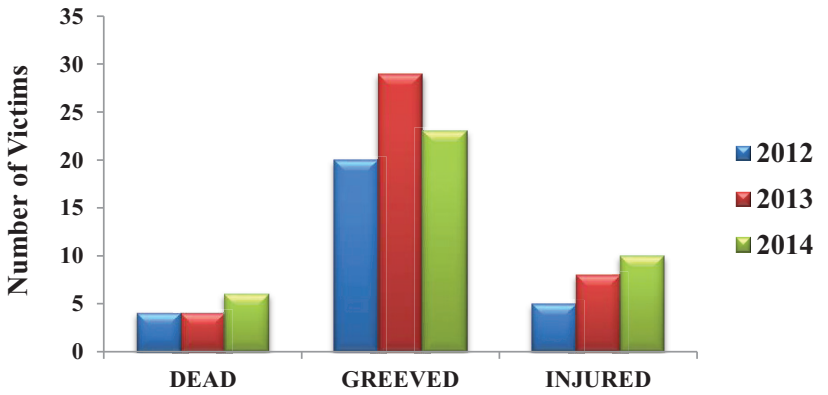

Fig. 1. Results of accident analysis.

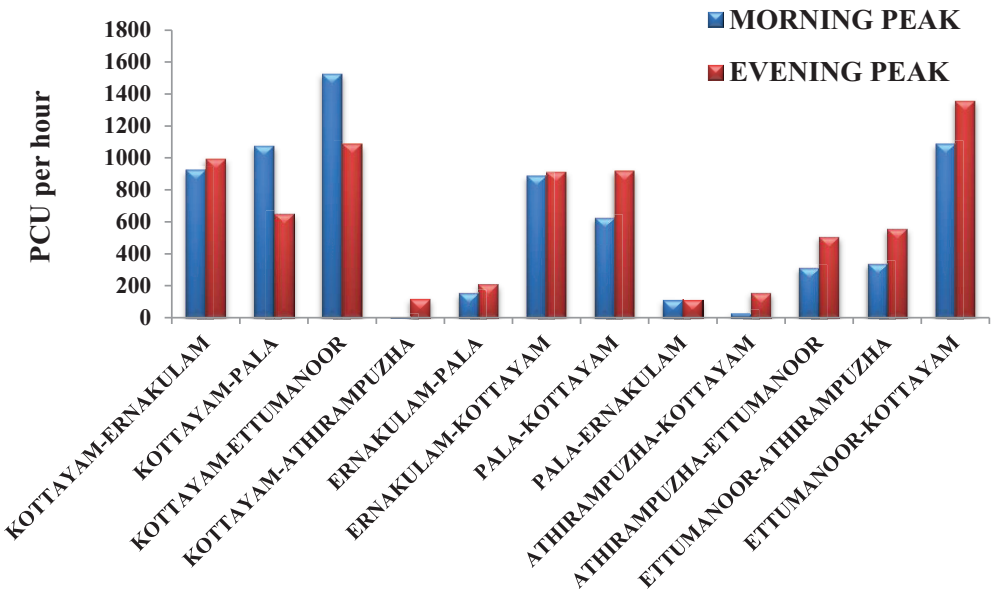

Fig. 2. Turning manoeuvres at different routes during the peak hours.

3.3. Entry and Exit of Buses to Bus Station

The volume of buses entering and exiting both the private as well as public bus stations during the peak hours are presented in Table 1. By analysing the location of bus stations and entry and exit of buses, it is identified that, the volume of buses plays a major role in the traffic congestion at Ettumanoor. It is noticeable that, there is a minor discrepancy concerning entry and exit volumes of a particular bus station, which can be attributed to the existence of an internal road connecting both the stations, which is in turn misused by the bus drivers for illegal manoeuvres. Furthermore, it was evident that, the smooth flow of traffic is adversely affected at the entry and exit points of buses at the highway. The other vehicles other than also identified to find their way to the nearby market through the entry and exit routes of the bus stations, violating the directional rules and hence resulting in mess and traffic blocks.

Table 1. Entry and exit of buses to two bus stations

Bus Station 1 (Private owned)			
Location		From Kottayam	From Ettumanoor
Morning peak	Entry	110	101
	Exit	99	114
Evening peak	Entry	48	155
	Exit	49	100
Bus Station 2 (Kerala State owned)			
Morning peak	Entry	131	48
	Exit	91	0
Evening peak	Entry	131	83
	Exit	85	88

3.4. Pedestrian Survey

The most vulnerable road users are pedestrians and the pedestrian survey analysis is performed based on the cross and lateral movements. The approximate mean speed of the pedestrians varied from 1 to 1.5 ms^{-1}. The hourly cross and lateral movements of pedestrians at the junction towards four routes are identified and furnished in Figs. 3 and 4 respectively, during the morning and evening peak hours. It can be identified from both the graphs that the pedestrian movement is more in the Kottayam route. One of the major reasons for high volume of pedestrians in Kottayam route is identified to be the proximity of bus stations. On the Kottayam route, the hourly volume of pedestrian movement is discovered to be exceeding the permissible limit of 500 [20] in the Kottayam route during the peak hours. Moreover, the pedestrian volume has little variance along the cross and lateral directions. Furthermore, it is identified from the field that there exists no pedestrian crossing or footpath in the Kottayam route.

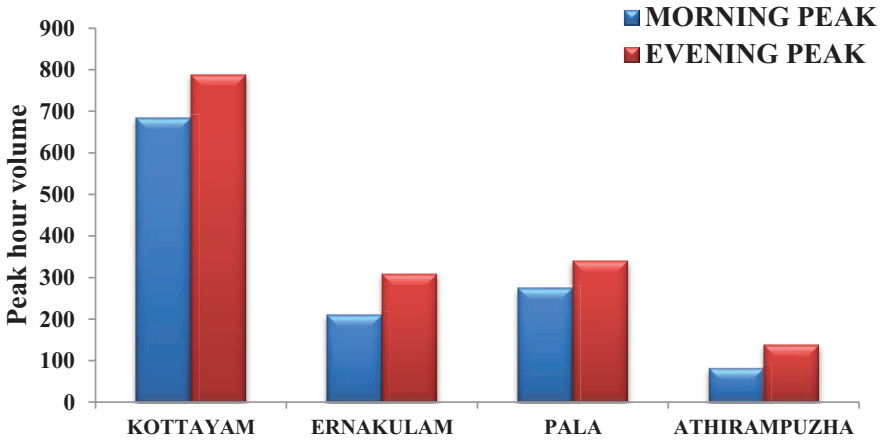

Fig. 3. Cross movements of pedestrians.

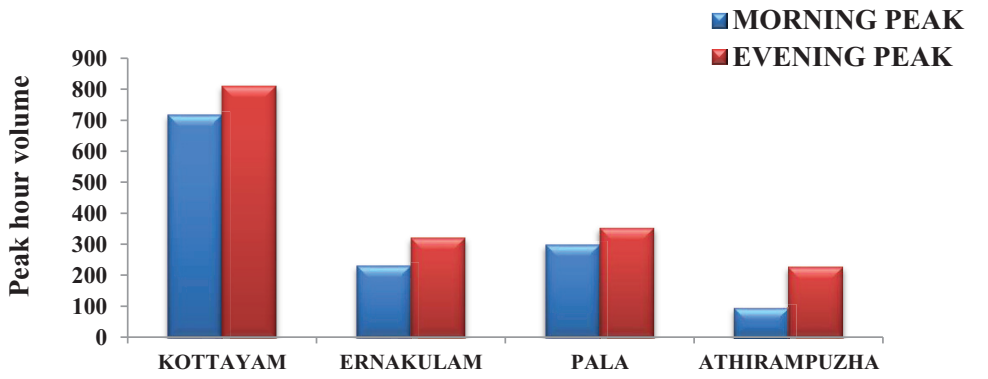

Fig. 4. Lateral movements of pedestrians.

4. Proposed Modifications and Improvements

Based on the collected data and synthesis, and after the identification of crucial problems, a few methodologies to modify the Ettumanoor urban intersection are proposed. The proposed modifications in different routes at the intersection are furnished in Table 2. It is also suggested to provide a footpath of width 1.5 m along with proper drainage and medians of 1 m width along all the routes. Furthermore, it is proposed to provide proper road markings, traffic signs and signals. Based on the collected traffic volume as well as following the standard procedures [21], traffic signals were designed for the two junctions of Ettumanoor intersection and the details of the same is tabulated in Table 3. It is suggested to provide 'no parking' boards at relevant spots and restrict unauthorised parking by charging heavy penalty. Hawking and trading along the road sides is evoked to be strictly restricted and proper measures need to be taken in proper rehabilitation of roadside traders.

Table 2. Proposed modifications along different routes at the intersection

Serial	Route	Proposed Modification
1	Kottayam	Channelising island, pedestrian path and traffic signal
2	Athirampuzha	Channelising island, turning radii improvement, pedestrian path and traffic signal
3	Pala	Channelising island, turning radii improvement, pedestrian path and traffic signal
4	Ernakulum	Channelising island, pedestrian path and traffic signal

Table 3. Proposed signal characteristics

Junction	Phase	Cycle length (s)	Green Time (s)	Amber Time (s)	Red Time (s)	Pedestrian crossing time (s)
Junction 1 (Kottayam – Pala – Ernakulum)	Phase I (Kottayam to Ernakulum & Kottayam to Pala)	90	30	4	4	12
	Phase II (Ernakulum to Kottayam & Ernakulum to Pala)		20	4	4	
	Phase III (Pala to Kottayam & Pala to Ernakulum		16	4	4	
Junction 2 (Kottayam – Ettumanoor – Athirampuzha)	Phase I (Kottayam to Ettumanoor & Kottayam to Athirampuzha)	90	24	4	4	12
	Phase II (Ettumanoor to Kottayam & Ettumanoor to Athirampuzha)		30	4	4	
	Phase III (Athirampuzha to Kottayam & Athirampuzha to Ettumanoor)		12	4	4	

5. Conclusions

Increase in population and rapid urbanisation of India have resulted in increased usage of vehicles and transportation facilities, which in turn result in traffic congestion and related problems. A case study of a prominent urban intersection – Ettumanoor was taken as a case study to propose the methodology to solve traffic congestion problems in developing countries. Field surveys were performed and relevant data regarding the commutation volume, land use activities, pedestrian movements and accident data were collected. Analysis of the collected data revealed that the improper planning; lack of road markings, signals, etc., as well as improper land uses pattern trigger and sustain the traffic problem at the Ettumanoor intersection. During the peak hours, it was observed that the pedestrian volume is exceeding the permissible limits at the roads. Improvements in the planning of the intersection, parking, traffic movements as well as proper signalisation were suggested. The proposed methodology can be further meliorated and utilised to develop standardised procedures for the sustainable betterment of urban intersections of developing countries.

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