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Identification of Accident Spots and Their Control Measures

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Abstract*: Road accidents are one of the main causes of death worldwide. About half a million people are killed in road related crashes every year throughout the world. Road intersections are often accident black spots. In areas with no prior experience of accident remedial work, many highway authorities in industrialized countries has found black spot treatment as an effective and straightforward measure before moving on to mass and route action plans. Accident analysis studies aim at the identification of high rate accident locations and safety deficient areas. In this study, effort has been made to identify the accident prone zones in and around Vizhinjam. For this purpose, the road accident data for the year 2013 pertaining to Trivandrum district, and of Vzhinjam for six years from 2008 to 2012 have been used. Accident particulars like date, location, type of vehicle involved, number of persons injured or died were collected. The road geometry was measured in the accident prone locations to find out the causes for the accident. Based on the result, suggestions are made to reduce occurrence of accidents in the future.
***Keywords:* accident analysis, road markings, road signs and traffic signalling**

I. INTRODUCTION

Worldwide, the transportation problems faced by various nations have increased manifold, necessitating search for methods or alternatives that ensure efficient, safe, feasible and faster means of transport. According to statistics released by the State police, 4,286 people were killed in accidents in the State in 2012. The previous year, 4,145 persons were killed in accidents. The highest number of accidents in 2012 was in Ernakulum district, 5,718, followed by Thiruvananthapuram district, 4,618. Wayanad accounted for the lowest with 579 accidents. Of the 25 black spots, eleven are in Thiruvananthapuram (6 in city and 5 in rural limits), three in Kollam district, one in Pathanamthitta and 10 in Alappuzha district. Hence, traffic safety has become a major area of concern for the authorities. The development of urban transport system has not kept pace with the traffic demand both in terms of quality and quantity. As a result the use of personalized transport mainly two wheelers and intermediate public transport is growing at a rapid speed. The disproportionate growth in the traffic with growth in road length along with unauthorized encroachments on road space, lack of traffic and lane discipline and deficiencies in traffic control have contributed to the increasing problem of congestion.

According to the accident data collected Vizhinjam was identified as the third in place among the cities of Trivandrum. Vizhinjam is the study area where four spots, Vizhinjam junction, Thennoorkonam, Mukkola and Uchakkada are selected for study. Figure1 gives a route map of the selected spots. Vizhinjam harbour is one of the most emerging projects that the government has undertaken. This predicts increase of traffic at the selected spots which lie close to the harbour. Therefore identification of accident spot and their control measures is essential at Vizhinjam.

The probability of an accident occurring is influenced by numerous factors like roadway geometric characteristics, traffic characteristics, driver characteristics, vehicle characteristics, pavement conditions and weather conditions. Traffic volume, speed and surface roughness has been identified as the factors causing accidents at the selected spots. Hence measures like signalling, provision of speed breakers, provision of sign boards and road roughening are suggested.

The Olympic Region Planning office in cooperation with Mason County (2001) studied about the accident history of a selected area. Road characteristics, the land use, population, traffic volume, future traffic volumes, speed and travel time was determined. Analysis of the accidents was done. Then evaluation of the alternative solution for these problems was undertaken. They put forward ideas for installation of a traffic signal in the selected area. [2]

Staff from Hennepin County, Minneapolis Public Works, Minneapolis Parks and Recreation, (2002) conducted a study on the Franklin Avenue (CSAH 5) and East River Parkway Intersection Study In this report they found out the vehicular traffic, pedestrian volume etc. The study team developed a recommended design concept to improve the operation of the intersection in the short term. [3]

K. Geurts, G. Wets (2003) studied about black spot analysis taking 5 year accident data. The road characteristics of the place were noted. Targeting and ranking of black spots were done. The factors affecting the cause of accidents were analyzed and counter measures were adopted. [4]

Michael Sørensen, Rune Elvik (2005) studied about Black Spot Management and Safety Analysis of Road Networks. Detailed analysis of accident spots were carried out. The road characteristics of the place were noted. Then analyzing the reasons for these accidents and finally treatment for these problems was done in this report. Accident model was made to minimize the accidents. [5]

Cheng, D., Tian, Z., and Messer, C. (2005) studied on the Development of an Improved Cycle Length Model over the Highway Capacity Manual Quick Estimation Method .This report deals with the development of an Improved Cycle Length Model over the Highway Capacity Manual 2000 Quick Estimation Method. [6]

The Kentucky Transportation Cabinet Division of Planning (2006) studied about Murray Five-Points Intersection to improve the traffic flow and delays at the Five-Point intersection. Road characteristics, traffic volume, population and accident rate was determined. Studies were done and signal timings were worked out. Control measures were taken keeping 5 legs in the intersection and using a roundabout for traffic control. It was selected because the operations and cost were best of the alternates. [7]

Dominique Huffman, et.al (2006) studied about Traffic Conflict at Intersection of 87th and Canyon. Various control measures were considered. The best feasible method they adopted is traffic signalling considering the cost and also the space requirements. [8]

Sandra Vieira Gomes (2008) studied about Low-cost engineering measures for casualty reduction. The LCEM include rumble strips traffic signs, road side improvement, anti-skidding pavement surface layer application, improvement of sight condition, traffic signals etc. [9]

Sharma, A et.al (2012) studied about the Impact of Signal Timing Information on Safety and Efficiency of Signalized Intersections. .Results in the journal showed that the information provided at the start of green (end of red) enhances efficiency, the start-up lost time is reduced, and there is an increase in RLVs. The information provided at the end of green (start of red) was found to reduce the incidence of RLVs. [10]

II. METHODOLOGY

A. Study Area

Many accident prone areas were identified as per police records for the year 2013. From the identified black spots of Trivandrum city Vizhinjam was selected as the study area. Four spots, Vizhinjam junction, Thennorkonam, Mukkola and Uchakkada were identified as the accident prone areas from the FIR data from Vizhinjam police station. Site reconnaissance at the selected spots showed absence traffic control measures warning signs, foot path, zebra crossing etc. A study of physical features at the study area was done. Five roads from Kovalam, Poovar, Pallichal and two roads from harbour meet at Vizhinjam junction. Bus terminal, school, offices, banks and shops are situated along these roads. Thennorkonam is a Y-intersection joining roads from Vizhinjam, Mukkola and Kottapuram whereas the Mukkola junction joins roads from Vizhinjam, Uchakkada and Poovar. Uchakkada is also a Y intersection that joins roads from Vizhinjam, Chapath and Balaramapuram.

B. Data Collection

The various data collected for the study stretch include accident data, road geometric data, and speed of vehicles (kmph), pedestrian volume (no: of pedestrians per hour) and traffic volume (pcu/hr).

1) *Accident data:* The accident data for six years from 2008 to 2013 of Vizhinjam and one year (2013) data covering Trivandrum City as a whole was collected. The data was obtained from FIR's (First Information Report) of the District Commissioner of Police, Pattom Traffic police station and Vizhinjam police station for each year. The accident data included location, involvement of vehicle/pedestrian, and type of accident. The number, type of accidents and pedestrian accident statistics during the period 2008 to 2013 is shown in Table 1. According to the nature of injury accidents are classified into fatal, grievous, minor and non injury accidents respectively.

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TABLE 1
ACCIDENT STATISTICS OF THE STUDY AREA [FIR]

Name of the Place	Pedestrian accident	Vehicle accident	Others	Total accidents	Fatal	Grievous	Minor	Non injury
Vizhinjam junction	29	42	3	74	7	45	21	1
Thennorkonam	5	27	2	34	7	17	10	
Mukkola	14	20		34	4	20	10	
Uchakkada	14	13	3	30	3	19	8	
Vengannoor	10	17	2	29	3	23	3	
Mulloor	11	14	1	26	1	16	7	2
Aazhimala	13	10	2	25	2	11	12	
Mullumukku	4	10		14		12	2	
Chappath	5	6	1	12	1	9	2	
Chovara	1	9		10		9	1	
Pullannimukku	3	7		10	1	7	2	
Nettathanni	4	2	1	7	1		2	4
Kottappuram	5	1		6		5	1	
Nellikunnu	3	3		6			3	3
Panavila	4	1	1	6		4	1	1
Punnakulam		6		6	1	4	1	
Chirazhikodu	3	2		5		2	3	
Muryathottam	2	3		5	1	2	1	1
Karikuzhi	1	3		4		1	3	
Chirathalavilakam	2	1		3		1		2
Kattachalkuzhi	2	1		3	1	2		
Nr.Abad company		3		3	1	2		
Vattavila	2	1		3		2	1	
Nr. Azad export company	2			2		2		
Vzh. Old bridge	1	1		2		1	1	
Idi vezhunnavila		1		1		1		
Karimpallikara	1			1		1		
Nr.Vzh.Federal bank	1			1		1		
Ocean investigation centre,Vizhinjam		1		1	1			
Panavillacode		1		1				1
Thalakodu		1		1			1	
Vzh.New bridge	1			1		1		

2) Road geometric data: Various geometric data like the width of the road; alignment of the road, gradient and number of side roads present, within 100m from the junction on each road was recorded. It is a known fact that the width of the road plays an important role in accident causation. The alignment of the road is also an important parameter which affects the accident rate. Alignment of the road affects sight distance available which is essential for the safe traffic operations. The following table 2 shows the observations from the study of geometric features at the selected spots, based on which CAD drawings were prepared.

TABLE 2
GEOMETRIC FEATURES OF VIZHINJAM JUNCTION

Name of stretch	Presence of Foot path	Width (m)	Alignment	Gradient	Gradient	No of side roads	Speed (km/hr)
Kovalam	No	7.5	Straight	None		none	29.8
Pallichal	No	6	Curved	Rising	01:21	none	27.83
Poovar	No	8.6	Straight	None		none	26.44
Harbour 2	No	6	Straight	Falling	01:30	none	24.3
Harbour 1	No	7	Curved	Falling	01:43	none	25.615

3) Traffic data: The number of vehicles entering and leaving the junction was noted. Volume was directly obtained by counting the number of vehicles in both directions and converting them into passenger cars. The traffic data is shown in table 3.

Table 3
Traffic Characteristics Of Vizhinjam-Poovar Road

Time	Kovalam		Pallichal		Poovar		Harbour 1		Harbour 2	
	Lateral entry+ exit	Towards crossing	Lateral entry+ exit	Towards crossing	Lateral entry+ exit	Towards crossing	Lateral entry+ exit	Towards crossing	Lateral entry+ exit	Towards crossing
8.30-8.45 am	52	23	17	16	32	28	5	4	50	19
8.45-9.00 am	45	20	24	20	39	26	10	7	63	21
9.00-9.15 am	58	26	20	15	30	33	6	6	75	28
9.15-9.30 am	87	33	30	21	44	35	16	10	90	35
9.30-9.45 am	125	36	63	33	45	65	17	13	95	36
9.45-10.00 am	117	43	60	49	40	40	25	11	70	20
10.00-10.15 am	104	21	72	30	50	48	16	7	79	18
10.15-10.30 am	125	39	50	29	48	33	20	16	75	23

4) Speed: Spot speed studies were used to determine the speed distribution of a traffic stream at a specific location. When the front wheels of a vehicle cross the mark at the beginning of the predetermined study length, the observer starts the stopwatch. The watch is stopped when the vehicle's front wheels pass the other reference line. The time interval was noticed. From the known distance and the measured time intervals, speeds were calculated and the average value was taken. The speed values obtained are shown in table 2.

5) *Pedestrian volume:* Pedestrian volumes were obtained by conducting pedestrian surveys synchronous with traffic surveys. One hour count was taken during peak time. The sum of pedestrian volume on both directions was assumed as the total pedestrian volume at that location. Pedestrian volume is shown in table 4.

Table 4
Pedestrian Volume Count Data

POOVAR									
Time	Direction	Car/van jeep/	Two-wheeler	Cycle	Three-wheeler	Bus	Lorry/ truck	PCU	PCU/hr
8:30-8:45	Kovalam	35	98		5		4	79.34	
	Pallichal	4	10					7.3	
	Harbour2	3	13		2			9.29	
	Harbour1	1		1	1			2.2	
8:45-9:00	Kovalam	39	86		5		3	77.63	
	Pallichal	2	7		1			5.31	
	Harbour2	3	2		2			5.66	
	Harbour1		1		1			1.33	
9:00-9:15	Kovalam	44	119		8		8	105.27	
	Pallichal	1	6		2			4.98	
	Harbour2	0	10					3.3	
	Harbour1	1	4		1		1	5.07	
9:15-9:30	Kovalam	66	152		12	1	5	139.16	401.4
	Pallichal	1	7	1				3.51	21.1
	Harbour2	1	6		1			3.98	22.23
	Harbour1				3			3	11.6
9:30-9:45	Kovalam	74	142		15	6	9	165.11	487.17
	Pallichal	1	7					3.31	17.11
	Harbour2		8		1			3.64	16.58
	Harbour1	4	6		9			14.98	24.38

III. RESULT AND ANALYSIS

A. Provision Of Traffic Signals

Traffic signalling is chosen as a control measure at Vizhinjam junction to control the conflicting streams of vehicular and pedestrian traffic (table 3, 4), as they satisfy the warrant formulated by IRC:93-1985[11]. The warrants for provision of traffic signals are the minimum vehicular volume warrant, interruption of continuous traffic warrant, minimum pedestrian volume warrant, accident experience warrant and the combination of warrants. Fixed time signal is designed at Vizhinjam junction using Webster's method and HCM method, where the cycle time obtained from Webster's method and HCM method are 123 seconds and 120 seconds respectively.

B. Provision of Channelizing Island

At Thennorkonam, Mukkola and Uchakkada junctions, channelizing islands are provided to guide the traffic into proper channel through the intersection area. Centre or divisional islands are designed for the selected spots. The channelizing islands are provided as raised island outlined by kerbs as per IRC: SP 41 [12]

C. Provision of Speed Breakers for Control of Vehicular Speeds on Minor Roads

Speed breakers are provided at Thennorkonam, Mukkola and Uchakkada as these spots are justified under the following three circumstances or warrants as per IRC 99-1988 [13]:

1) T intersections of minor roads with rural trunk highways, characterized by relatively low traffic volumes on the minor roads but very high average operating speed and poor sight distances. Such locations having high records of fatal accidents speed breaker are recommended on minor roads.
2) Intersections of minor roads with major roads, and mid-block sections in urban areas where it is desirable to bring down speeds.
3) Selected local streets in residential areas, school, college or university campus, hospitals etc. Also in areas where traffic is observed to travel faster than the regulated or safe speed in the area.

The spots also comply with other conditions given below, for which speed breakers are recommended

4) Any situation where there is a consistent record of accidents primarily attributed to the speed of vehicles.
5) Approaches to temporary diversions.
6) On the minor arms of uncontrolled junctions.
7) Sharp curves with poor sight distance.

Hence speed breakers may be providing as rounded hump of 3.7m width and 0.1m height for the preferred advisory crossing speed of 25km/hr. For comfortable passage of larger and heavier vehicles humps may be modified with 1.5m long ramps at each edge.

D. Provision of Rumble Strips

Low surface roughness has been identified as one of the reasons for accidents at Mukkola. Hence rumble strips are suggested to make the roads rougher, thereby reducing accidents due to slippery road [14].

E. Road Markings

Road markings are provided as per IRC 35-1997[15] to perform an important function of guiding and controlling traffic at Thennorkonam, Mukkola and Uchakkada. The road markings are classified into various types, out of which the following markings are suggested for the selected spots.

1) *Centre line:* On undivided two way roads of the selected roads, centre line is provided to separate the opposing streams of traffic and facilitate their movements. Here they are provided as white single broken lines. The centre lines shall consist of simple broken lanes 100mm wide of 3m segments at 4.5m gaps on straight roads and 3m gap on intersections.
2) *Border or edge lines:* These indicate carriage way edges of rural roads which have no kerbs to delineate the limits up to which driver can safe venture. This continuous guideline makes night driving comfortable particularly during inclement weather. These shall be in the form of a single continuous white line placed on the carriage way 150mm from the edge and with a width of 150mm.
3) *Stop line*: Stop line indicates the position beyond which the vehicles should not proceed when required to stop by traffic police, traffic signals or other traffic control devices. Single stop lines are provided as solid white transverse line 300mm wide and supplemented by a stop sign in accordance with IRC: 67-1977 and word message "STOP" marking on the carriageway.

4) *Pedestrian crossing*: Crossing of the carriageway by pedestrians, only at the authorised places minimizes the confusion. As a result of this, the number of pedestrian casualties is reduced and the tendency to joy walk is curbed. At the intersections, the pedestrian crossings are preceded by a stop line at a distance of 3m and they are provided at a width of 3m. Marking for pedestrian crossing is provided using zebra pattern consisting of equally spaced white strips generally 500mm wide in accordance with IRC: 103-1988.
5) *Markings at traffic islands*: Kerbs of the central and channelizing islands should be painted with vertical black and yellow stripes, each 500 mm wide, to improve visibility.

F. Provision of Road Signs

Road Signs are also suggested at the selected spots to promote road safety and efficiency by providing for the orderly movement of all road users on all roads as per IRC 67- 2010[16]. The signs provided at the selected sites are mentioned here. NO PARKING signs are erected where the controlling authority has decided to prohibit parking, and are accompanied by suitable carriageway markings. Cautionary/warning signs are provided for school ahead, slippery road and speed breaker. These signs are posted 50m in advance of the speed breaker location. Informatory signs for police station, bus stop and auto-rickshaw stand are provided.

IV. CONCLUSION

This paper discusses various factors of accident causation. According to the accident statistics of Trivandrum city, selected study area Vizhinjam is the third most accident prone area in Trivandrum. From the accident data of Vizhinjam police station, Vizhinjam junction, Mukkola, Thenoorkonam and Uchakada were selected as the accident spots for study. The control measures suggested for these spots include traffic signalling at Vizhinjam junction for reducing accident rate and for control of traffic; traffic islands and speed breakers to reduce the accident rate at Mukkola, Uchakkada and Thenoorkonam. Suitable road markings and road signs are also suggested for the intersections. These control measures can be implemented effectively with proper road widening.

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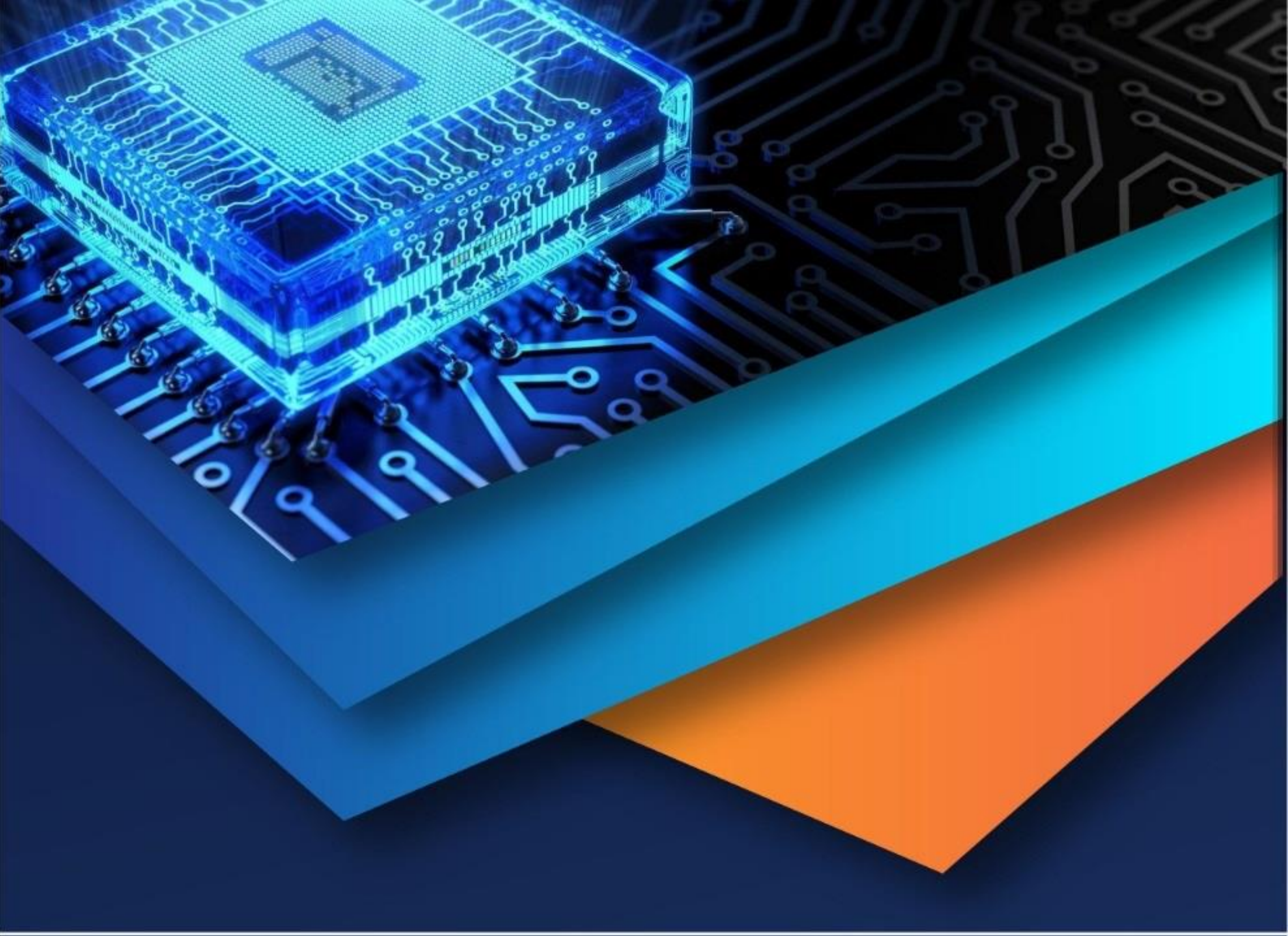

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