

# Performance Evaluation and Safety Analysis of Pedestrians at Vytilla Junction, Kochi, Kerala

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**ABSTRACT:** Pedestrians are extremely vulnerable in crashes with the faster moving and much more massive motor vehicles. Circulation of pedestrian is of vital importance's to the modern metropolis, but the paradox here is that though meant for human travel, these roads hardly provide any quality space for those who are without vehicles (well known as pedestrian). Due to the ambiguous position of non-motorized travel in an urban transportation system, the transportation conditions for non-motorized travel are getting worse in cities, which illustrate the urgent need for the improvement for same. A proper of understanding of pedestrian needs and characteristics and factors that contribute to pedestrian crashes is essential for the proper design and operation of roadways and pedestrian facilities. The study is confined in identifying the pedestrian and vehicular conflict at the Vytilla junction and the problems faced by the pedestrians in the concerned area. The safety analysis of the pedestrians at the junction is done by PV<sup>2</sup> analysis and by determining the Level of Service (LOS).

**KEYWORDS:** Peak hours, Pedestrian flow, Pedestrian LOS, Pedestrian safety, PV<sup>2</sup> analysis.

## I. INTRODUCTION

Walking is a basic human activity and pedestrians are a part of every roadway environment. Everybody is a pedestrian at one point or another. A large segment of road users consisting of persons walking on road, operating hand carts, pushing cycle, carrying load on head or shoulder etc are all termed as pedestrians. They consist of persons of different age groups, socio-economic background and educational level. As a road user group, pedestrians formed the second largest group of road traffic fatalities, behind vehicular traffic. In spite of the importance and benefits of walking, road facilities in urban areas are still a significant source of harm to pedestrians. Every year, a large number of pedestrians are killed or seriously injured in crashes involving motor vehicles. Pedestrian safety is an issue in many urbanized areas throughout the world. While this is recognized by policy makers many tend to focus more on traffic congestion and finding solutions to improve traffic flow. Many countries have their own design specifications and standards for pedestrian facilities. The first document dealt with pedestrians was published by Indian Road Congress (IRC) in 1988. Since then, adequate research work has not been undertaken in understanding the pedestrian needs, planning and integrating pedestrian friendly features in transportation system and creating a safe environment for pedestrians. This neglect is now resulting in 25,000 deaths and more than one lakh injuries every year in India. The worst aspect is that children, elderly persons and physically handicapped persons are put to a great accident risk on roads. In the absence of any specific law to protect the rights of pedestrians, the motor vehicles act of 1988 is the only source of legislation that provides limited protections.[3]

## II. RELATED WORK

Every traveler is a pedestrian at some stage of his or her travel and hence pedestrian facilities are very significant in urban transportation. In view of the paradigm shift from 'moving the vehicles' to 'moving the persons' while

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planning for pedestrian facilities in cities, provision of integrated and barrier free pedestrian facilities is essential to ensure inclusive mobility, also to encourage more people into a greener mode of transportation. Pedestrian's characteristics can be divided into various groups such as it can be divided according to physical space required, walking ability, walking speed depending on age, gender, physical condition etc. Where complete segregation of pedestrians from vehicular traffic is not possible, some form of planned roads sharing principle must be applied. Being the most vulnerable road user, pedestrian should increasingly be given the place and time to legally claim the right to cross the road. Pedestrian crossings need to be provided where they will be well used. Integration of pedestrian with public transport enhances share of non-motorized modes and reduces use of personalized vehicles. Hence, pedestrian safety is an integral part of overall transport system.

### III. OBJECTIVES

The main aim of the study is to evaluate the efficiency of existing pedestrian facilities based on the pedestrian traffic demand. The major objectives of the study will cover the following aspects.

- To identify major travel corridor with high pedestrian movements.
- To assess the efficiency of existing pedestrian cross movement facilities and walk ways.
- To study the safety issues faced by the pedestrians in the area.

### IV. METHODOLOGY

1. Identification of junction
2. Data collection - Conduct survey on both traffic and pedestrian flow in the concerned junction. In order to collect frequency data, a traffic observation study is the suitable method.
3. Data extraction – Extraction of collected data and represent it in the form of tables, graphs etc.
4. Data analysis – Analyze the data collected. The pedestrian cross movement analysis is done using the  $PV^2$  method, where P is the number of pedestrians crossing and V is the volume of traffic flow and lateral movement analysis is done using pedestrian Level of Service (LOS) as per IRC (Indian Road Congress) recommendations.

### V. LOCATION OF STUDY

Vytilla is an intersection in the city of Kochi, in the state of Kerala. It is one of the largest as well as the busiest intersections in Kerala. This node intersects the main North-South artery of the state, namely NH-47. Vytilla hosts the Kochi Mobility Hub, which converges different ways of surface transport to the city onto a single node.

Figure 1 (a) and (b) shows a schematic and google map image of the junction while Figure 2 shows a photograph of the study area.



Fig. 1. (a) A schematic map of the Vytilla junction (b) Google map image of the Vytilla junction

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Fig. 2. Vytilla junction

## VI. DATA COLLECTION

### 6.1 Pedestrian volume survey for lateral and cross movements

Manual method was adopted for passenger count. Collection of data was conducted on week days mainly on Monday (26-9-2016) and Saturday (18-9-2016) as traffic is more these days. Counts were taken in the morning and evening periods as suggested by the traffic police of the city. The time was selected around an assumed peak hour based upon the working hours.

### 6.2 Vehicular volume survey

Vehicular count was also done manually and then was converted to PCU (passenger car unit) equivalent. It is rather difficult to estimate the traffic volume under mixed traffic flow unless the different vehicle classes are converted to one common standard unit. It is a common practise to consider the passenger car as standard vehicle unit to convert the other vehicle classes and this unit is called PCU. Passenger car unit (PCU) is the metric used to assess traffic-flow rate or volume on a heterogeneous traffic highway. PCU currently used in the design and analysis of signalized intersections in Kerala as well as in India are based on the values given in the Indian Road Congress code, IRC SP 41. PCU values given in IRC SP 41 are shown in Table1.

Table 1. PCU values of different vehicles

Type of Vehicle	PCU Values
Car	1
Motor Cycle	0.5
Auto Rickshaw	1
Tempo	1
Truck	4.5
Light Commercial Vehicles	1.5
Bus	3

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## VII. ANALYSIS OF DATA

All the data collected from various sources were compiled and were processed for the further analysis. The analysis included the availability of existing facilities, pedestrian demands, their adequacy and necessity of additional facilities. For cross movements of pedestrians, the value of PV2 was computed to identify necessary pedestrian facilities. For lateral movements, the level of service (LOS) concept was used for analysis. The standards for LOS were obtained from relevant IRC codes.

### 7.1 Determination of Peak hour of flow

From the pedestrian volume data collected, the morning peak hour of pedestrian flow in the junction was from 9.00 am-10.00 am and evening peak hour was from 5.00 pm- 6.00 pm during both working and non-working day. The corridors of NH-47 Kundanoor stretch and NH-47 Palarivattom stretch were having large number of pedestrians crossing the road and pedestrians using sidewalk facilities. The peak time for vehicular flow was at 9.00am-10.00am at morning and 5.00pm-6.00pm at evening. The Ernakulam stretch indicated the heavy traffic followed by the NH-47 stretch to Palarivattom and Kundanoor. There is comparatively less variation in morning and evening peak vehicular flow during working hours in each stretch. From the collected data we found that the volumes of pedestrian and vehicular traffic are so large that junction. The issues of pedestrian-vehicular collision are increasing day by day in the area.

### 7.2 Road Inventory Data

The road inventory data were collected from The National Highway Authority of India, Cochin. The collected data are shown in Table 2 below:

Table 2. Road inventory data of the Vytilla junction

1	Name of the road	NH - 47 KUNDANOOR	NH - 47 PALARIVATTOM	S-A ROAD (ERNAKULAM)	VYTILLA – THIRPUNITURA ROAD
2	Type of the road	PWD	PWD	PWD	PWD
3	Width of the road	8.5 m	8.5m	7m	7m
4	Median	1.2m	1.2m	1m	1m
5	Footpath	1.5m	1.5m	1.5m	1.5m
6	Shoulder	1m	1m	1m	1m
7	Conditions of the footpath	Poor, unauthorized encroachments.	Very poor, interruption to flow.	Obstructions are present, not well conditioned.	Absence of hand rail, poor.
8	Bus stops: Left Right	0	1	1	1
		1	0	1	0
9	Remarks	Heavy pedestrian and traffic flow.	Heavy pedestrian and traffic flow.	High vehicular flow and moderately high pedestrian flow	Moderately high vehicle and pedestrian flow

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## 7.3 Pedestrian Level of Service for cross movement analysis

Pedestrian level of service indicates the environmental qualities of a pedestrian space and serves as a guide for development of standards for pedestrian facilities. The planning and design methods for pedestrian suggested by many researchers are based primarily on vehicular traffic flow theory. Additional environmental factors that contribute to the walking experience and therefore to the perceived level of service, such as comfort, convenience, safety, security and attractiveness, should also be considered.

Table 3. Pedestrian Level of service at road crossing (IRC 103-2012)

Level of service	Waiting time in seconds
A	$\leq 3$
B	$>3$ and $13 \leq$
C	$>13$ and $38 \leq$
D	$>38$ and $64 \leq$
E	$>64$ and $90 \leq$
F	$>=90$

The Pedestrian Level of service at road crossings in the area considered was found to be LOS E as per the above table.3, as the average waiting time of pedestrians were found to be 65 seconds (The waiting time may slightly vary due to daily traffic variations at the junction).

## 7.4 Pedestrian-Vehicular volume<sup>2</sup> (PV<sup>2</sup>) analysis for cross movement analysis

For cross movement analysis of pedestrians, the value of PV<sup>2</sup> has to be computed so as to identify the necessary pedestrian facilities.

P = Number of pedestrians crossing

V = Vehicular traffic volume in PCU (Passenger Car Unit) per lane per hour

From the data collected we determined the peak hour volumes of vehicles for each road (V).

The PV<sup>2</sup> analysis was conducted for each stretch of road joining the junction.

Table 4. PV<sup>2</sup> values obtained on Monday

MONDAY	P	V	PV <sup>2</sup> x 10 <sup>8</sup>
NH 47(Kundanoor stretch)			
Morning	2395	7762.5	1443
Evening	2992	8256	2039
NH 47(Palarivattom stretch)			
Morning	2813	7867.5	1741
Evening	3114	7401	1705
S-A Road			
Morning	1456	8857.5	1142
Evening	1650	8950.5	1321
Vytilla-Petta Road			
Morning	1390	7554	793
Evening	1669	7264.5	880

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Table 5.  $PV^2$  value obtained on Saturday

SATURDAY	P	V	$PV^2 \times 10^8$
NH 47(Kundanoor stretch)			
Morning	2487	6643.5	1097
Evening	1804	6688.5	807
NH 47(Palarivattom stretch)			
Morning	2510	6424.5	1035
Evening	1852	5955	656
S-A Road			
Morning	1121	6592.5	487
Evening	846	7725	504
Vytila-Petta Road			
Morning	1040	6789	479
Evening	873	7026	430

The permissible  $PV^2$  value is  $1 \times 10^8 - 2 \times 10^8$  in general cases. From table 4 and table 5, it is evident that the obtained value is much higher than the permissible limit confirming that the junction is not safe for pedestrian cross movement.

## 7.5 Pedestrian Level of Service for lateral movement analysis

Level of Service (LOS) in transportation engineering is a term used which describes existing operating conditions (or suitability) for a mode of travel in a transportation system. Motor vehicle LOS is primarily based on speed, travel time, and intersection delay. Calculation of Pedestrian LOS is more complex, which represents the operating condition of pedestrian facility and level of comfort pedestrians experience in using these facilities. The definition of Pedestrian LOS does not include anything about mobility or safety. This is an inherent bias of the LOS that strongly favours automobiles over pedestrians. As per IRC 103-1988 :

1. LOS A is a pedestrian environment where ideal pedestrian conditions exist and the factors that negatively affect pedestrian LOS are minimal.
2. LOS B indicates that reasonable pedestrian conditions exist but a small number of factors impact on pedestrian safety and comfort. As LOS A is the ideal, LOS B is an acceptable standard.
3. LOS C indicates that basic pedestrian conditions exist but a significant number of factors impact on pedestrian safety and comfort.
4. LOS D indicates that the poor pedestrian conditions exist and the factors that negatively affect the pedestrian LOS are wide ranging or individually severe. Pedestrian comfort is minimal and safety concerns within the pedestrian environment are evident.
5. LOS E indicates that the pedestrian environment is unsuitable. This situation occurs when all or almost all of the factors affecting pedestrian LOS are below acceptable standards.
6. LOS F, all walking speeds are severely restricted, and forward progress is made only by shuffling. There is frequent, unavoidable contact with other pedestrian. Cross and reverse flow movements are virtually impossible. Flow is sporadic and unstable. Space is more characteristic of queued pedestrian than of moving pedestrian streams. Pedestrian characteristics are represented by their flow, speed, space, and density. They are determined from the observation of the 15- minute peak volume and width of the segment using the equations :

$$Q = \frac{v_{15}}{15W_E}$$

$$S = \frac{V_s}{Q} = \frac{1}{D}$$

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where,

Q = Flow of pedestrian (p/m/minute)

$v_{15}$  = Peak 15-minute volume (p/15 minute)

$W_E$  = Effective width of footpath (m)

$V_s$  = Space mean speed (m/minute) (assumed as 1 m/s)

D = Density ( $p/m^2$ )

S = Space ( $m^2/p$ )

The pedestrian LOS was calculated for each stretch of roads. It was determined on the basis of flow of pedestrians (Q) and pedestrian space (S) as mentioned in below tables :

Table 6. Pedestrian LOS at Vytilla junction on Monday

MONDAY	V15	E m	Q p/min/m	LOS	SPEED m/min	SPACE $m^2/p$	LOS
<b>NH 47(Kundanoor stretch)</b>							
Morning	599	1.5	26.62	D	60	2.25	C
Evening	748	1.5	33.24	E	60	1.8	D
<b>NH 47(Palarivattom stretch)</b>							
Morning	704	1.5	31.28	E	60	1.91	C
Evening	779	1.5	34.62	E	60	1.73	D
<b>S-A Road</b>							
Morning	364	1.5	16.17	C	60	3.71	B
Evening	413	1.5	18.35	C	60	3.26	C
<b>Vytilla-Petta Road</b>							
Morning	348	1.5	15.46	C	60	3.88	B
Evening	418	1.5	18.57	C	60	3.23	C

Table 7. Pedestrian LOS at Vytilla junction on Saturday

SATURDAY	V15	E m	Q p/min/m	LOS	SPEED m/min	SPACE $m^2/p$	LOS
<b>NH 47(Kundanoor stretch)</b>							
Morning	622	1.5	27.64	E	60	2.17	C
Evening	451	1.5	20.04	C	60	2.99	C
<b>NH 47(Palarivattom stretch)</b>							
Morning	628	1.5	27.91	E	60	2.14	C
Evening	463	1.5	20.57	C	60	2.91	C
<b>S-A Road</b>							
Morning	281	1.5	12.48	B	60	4.8	B
Evening	212	1.5	9.42	A	60	6.36	A
<b>Vytilla-Petta Road</b>							
Morning	260	1.5	11.5	A	60	5.19	A
Evening	219	1.5	9.73	A	60	6.16	A

The quantitative level of service of the study area when measured was found to be varying from LOS A-LOS E as per table 6 and table 7. The pedestrian space (S) and the flow rate (Q) were found to be varying for each stretch of roads at

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the junction during the morning and evening peak hours of flow. The LOS of the NH 47 stretch (both Kundanoor and Palarivattom) was the worst among the roads meeting the junction (LOS C - LOS E). This may be due to the lack of adequate space so as to accommodate heavy pedestrian flow during peak hours.

## VIII. SUMMARY AND CONCLUSION

Based on preliminary studies conducted, the NH-47 stretch was found as the major travel corridor for pedestrian movement and the junction has a poor condition of foot. From the results of safety analysis it was evident that the pedestrians in the junction are not safe. The  $PV^2$  values obtained are much higher than the permissible value for each stretch and so is the LOS of cross movement. The LOS for cross movement was found to be LOS-E, since the average waiting time for the pedestrians to cross the road was 65 sec. The LOS for lateral movement was found to be ranging from LOS E – A. Hence it can be concluded that the pedestrians crossing the junction is unsafe. The lateral movement is mostly unsafe at the NH-47 stretch. Owing to the growing financial capacities of the common man, more and more vehicles are coming out on the roads. And thus, there is a need to increase the road infrastructure with necessary steps to protect pedestrians of the area. The project work was confined to Vytilla junction, Kochi, Kerala.

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