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Pedestrian Flow under the Influence of Obstacles

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Abstract : Coimbatore, one of the main cities in Tamil Nadu has grown to an unimaginable population of around 35 lakhs (2017). With the increase of population, a range of individuals walking on Coimbatore's footpath also increased. It was observed that pedestrian effective walkways gets reduced due to the presence of obstacles like sign boards, trees, dust bin, manholes, electric pole, etc. Pedestrians show some shyness and variation in speed at this location. This paper aims to review the result of obstacles on the pedestrian flow characteristics by Video graphical analysis, so that extra provision of width would be suggested within the design. Five locations in and around Coimbatore are selected and a trap of 40m is marked on the footpath to estimate the speed of pedestrian.
Key Words : Pedestrian flow, Obstacles, Videography.

1.0 Introduction

With the emerging population in Coimbatore, the footpaths also get increased. But the pedestrians walking over it have been facing difficulties due to the presence of obstacles such as dust bin, side tree, electric pole, sign boards, manholes, etc., on the walkways. They show shyness and uncomfortableness while crossing them. The normal speed of the pedestrians, walking on the pavement gets reduced due to the presence of obstacles. The speed reduced due to these obstacles is called obstruction speed. The walking speed is classified based on the pedestrian characteristics such as gender (male and female) and age (young, middle and old). With respect to the age classification, the people below 20 are considered as young, people between 20 and 50 are middle age peoples and the peoples above 50 are considered as old. Buffer is the clearance in distance between the pedestrian and the obstacles. The buffer adopted by the pedestrian is estimated regarding which the graphs are plotted against the width and frequency for each obstacle.To overcome this problem, either the width of the pavement has to be increased or the obstacles have to be placed without interfering the pedestrian walkway. This will help the people to use the pedestal pavement effectively, which in turn helps to reduce the accidents of the foot passengers. This also shows its direct effect in increasing the speed of the pedestrians which reduces the traffic.

2.0 Literature Review

Carey [2005] [2] conducted a study to establish the walking speeds of different age group of pedestrians to understand their crossings characteristics. He found that the average walking speed and the 15th walking speed were greater for the young pedestrian than the older ones. He also found that when the pedestrians are crossing in groups their walking speeds tend to be slower.

Fruin[1971] [3] studied 1000 non – baggage – carrying pedestrians inside the port Authority Bus Terminal and Penns and Station in New York city. He observed that the males walk faster than the females and the walking speed mostly declines after the age of 65. Empirical observations were made in various corridors of the San Francisco International Airport, and Cleveland Hopkins International Airport. At San Francisco International Airport, data were collected by following randomly selected parties of passengers through a corridor. For each observation, the approximate age (to the nearest decade), gender, and travel type (business or leisure) for each pedestrian in the party was recorded. The party size, number of bags carried, and direction of travel was recorded as well.

Koushki[1988] [4] observed pedestrian speeds in the central area of Riyadh, SaudhiArania, and compared them with pedestrian speeds observed in other countries or cities.

O'Flaherty [1997] [5] has indicated the road crossing speed at busy crossings for a mix of pedestrian age groups in the range of 1.2 m/s to 1.35 m/s. In case the crossings are less busy the average walking speed approximates to the free flow to the walking speed of 1.6 m/s. For disabled persons, 0.5 m/s is defined as the most approximate value.

Poluset al. [1983] [6] analyzed properties and characteristics of pedestrian flow on sidewalks, in Haifa (Israel). They found the walking speeds of men were significantly greater than those of women. Speeds were found inversely proportional to densities.

Seth B. Young et al. [1999] [8] proposed a methodology for estimating the travel time of pedestrians on moving walkways under various traffic flow conditions is derived. Application of the methodology using empirical collected date reveals investing results about the movement of pedestrian through corridors with moving walkway. The analysis presented may be use to estimate expected travel time in airport corridor and to estimate the effects of potential infrastructure investments. The goal of such an analysis is to improve the quality of services at the airport terminal particularly for the pedestrians who travel its corridors.

Tanaboriboon and Haw [1986] [9] observed walking rates on sidewalks and found that maximum flow rate obtained in Singapore is higher than that in western countries.

3.0 Pedestrian Walking Scenaria

A Pedestrian is a person travelling on foot, whether walking or running. In some communities, those travelling using roller skates or skateboards are also considered to be pedestrians. In the present, the term principally refers to somebody walking on the road or pathway; however this was not the case traditionally.

Pedestrians have been grouped into three categories:Pedestrians on foot, Pedestrianson small wheels andMobility impaired Pedestrians.

Pedestrians on foot can be sub grouped asRunner /jogger, Pedestrian with a guide dog, Pedestrian with a cane and Sensory impaired pedestrian.

Pedestrians on small wheels can be sub grouped asKick scooters, Pedestrian with a pram and Skateboards.Mobility impaired Pedestrians can be sub grouped as Manual wheelchairs, Electrical wheelchairs and Pedestrian with a walking frame.

3.1 Walking speed

The speed which a pedestrian walks freely in the road is called as walking speed. This is affected by pedestrian characteristics (age, gender and physical condition), trip characteristics (walking purpose, route familiarity, trip length and encumbrances), route characteristics (width, gradient, surfacing, shelter, attractiveness, pedestrian density and crossing delays) and environmental characteristics (weather conditions).

The vast majority of people walk at speeds between 0.8 m/s and 1.8 m/s. A fit, healthy adult will generally travel at a mean speed of 1.5 m/s and the aged and those with mobility impairments travel more slowly, at around 1.2 m/s. Mobility scooters can travel faster than most pedestrian, but may take time to maneuver between different and footpath levels.

3.2 Deterrents to walking

Shortfalls in the physical environment are the most obvious deterrent to walking.Reasons often mentioned include:

- Missing footpaths or sections of footpath
- Poor quality (cracked, uneven or slippery) walking surfaces
- Obstacles on the footpath, including poorly placed street furniture
- Lack of footpath maintenance (litter, dog fouling)
- Increased distances imposed by road layouts, barriers, footbridges and subways
- Poor-quality lighting
- Lack of continuous pedestrian routes

3.3 Pedestrian characteristics

Based on the observations, it was determined that the Gender, Age, Person size, Group size (if a pedestrian is walking in a group) and Trip purpose (business, non-business, tourist, etc.) were important pedestrian characteristics which should be considered for this study.

4.0 Data Collection

For any traffic analysis the most important is data collection. Pedestrian data are usually collected by three methods: Hand Counting, Videography and Laser-Sensor. In the present study the data are collected by videography.

4.1 Videography

The video measuring system analyzes the captured videopicture for pedestrians by algorithms, but pedestrians can't be analyzed by computer.

4.2 Details of study locations

The data were collected from various sidewalks, having obstructions like electric pole, side tree, sign board, manhole cover and dust bin.

Electric pole is located onthe cross cut road in Gandhipuram, Coimbatore. Electric pole hasa perimeter of 50 cm. Footpath width at the location was 1.8 m and width was strip marked is 10 cm. Trap lengths at and before the obstacle marked was 4 m.

Side tree is located opposite to Krishna Mills PvtLtd., Coimbatore. Side tree hasa perimeter of 45 cm. Footpath width at the location was 2.4 m and width was strip marked is 10 cm. Trap lengths at and before the obstacle marked was 4 m.

The Sign board is located in the Sai Baba Colony,Mettupalayam road in Coimbatore. Sign board has a perimeter of 50 cm. Footpath width at the location was 1.8 m and width was strip marked is 10 cm. Trap lengths at and before the obstacle marked was 4 m.

Manhole cover is located on the cross cut road near Joy Alukkas in Coimbatore. Electric pole has a perimeter of 2.82 m. Footpath width at the location was 2.2 m and width was strip marked is 10 cm. Trap lengths at and before the obstacle marked was 4 m.

Dustbin is located at an Avinashi road in Coimbatore. Dustbin hasa perimeter of 500 cm. Footpath width at the location was 2.7 m and width was strip marked is 10 cm. Trap lengths at and before the obstacle marked was 4 m.

4.3 Advantages of videography

The installation of video cameras can replace several counters. It can collect data of any size of an area efficiently and economically within a short time. This type of data collection is inconspicuous and therefore

more representative. The main advantage of videography is that the evaluation can be repeated at each time and at each possible place. This method shows only a small error rate. It is also possible to analyze problems of road safety and reproduction of situation pictures.

4.4 Disadvantages of videography

The main disadvantage of videography is that it is difficult to find a suitable place for the assembly of the camera. It needs concerning four meters, or better nevertheless, even six meters higher than street level. There may be problems at night and during cold weather. Regular control and access is needed for exchanging the batteries and video tapes which causes a gap during the changing of battery and tape. The behavior in traffic can change if the location of the video camera is recognized.

5.0 Methodology

In kinematics, the speed of an object is the magnitude of its velocity; it is a scalar quantity. The average speed of an object in a period of time is the distance travelled by the object divided by the duration of the interval; the instant speed is the limit of the typical speed because the period of measure approaches zero.

5.1 Speed Analysis

The speed is defined as the magnitude of the velocity that is the derivative of the position with respect to time:

$$\mathbf{v} = |\mathbf{V}| = |\mathbf{r}| = \left|\frac{\mathbf{dr}}{\mathbf{dt}}\right|$$

Where,

v - Speed of the object
V - Velocity of the object
r - Position of the object
t - Time travelled

If s is the length of the path travelled until time t, the speed equals the time derivative of s:

$$\mathbf{v} = \frac{\mathbf{ds}}{\mathbf{dt}}$$

5.2 Average Speeds

The table 1 shows the percentage reduction in speed such as normal speed (V1) and obstruction speed (V2) for different types of obstacles. Normal speed (V1) is the speed a pedestrian walk with when it is not hindered by obstacles. Obstruction speed (V2) is the speed of a pedestrian at the obstacle. The least percentage reduction in speed is 7.63%, which occur when the obstacle is electric pole. The higher percentage reduction in speed is 18.66 %, which occur when the obstacle is dust bin.

Table 1 Percentage reduction between avg. normal speed &avg. obstruction speed

Types of obstacles	Average speed-V1	Average speed-V2	Percentage Reduction
Electric pole	1.18	1.09	7.63%
Side Tree	1.24	1.11	10.48%
Sign Board	1.30	1.08	16.92%
Manhole	1.16	1.05	9.48%
Dust Bin	1.34	1.09	18.66%

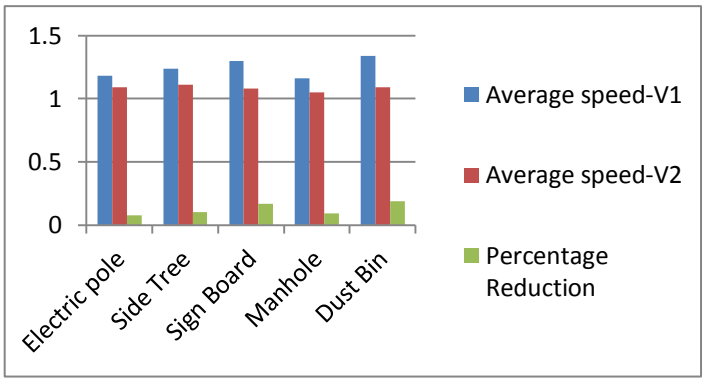

Fig. 1 Comparison of avg. normal speed, avg. obstruction speed &Percentage reduction of various obstacles

5.3 Buffer Analysis

Clearance in distance between the pedestrian and obstacles is called a buffer. The data below were extracted from the cumulative distance plotted between the width and frequency in each obstacle.

In order to be effective, aspect - walks ought to be provided on either side of the road and higher than the amount of the roadway separated by non -mountable kerbs. Height of the edge at the sting ought to, however, not exceeds the peak of non-mountable kerbs, as this may otherwise trim down pedestrians from older to the side-walks.

The dimension of side-walks depends upon the expected pedestrian flows and will be mounted with the help of guide lines given in table 1 (IRC 103- 1998) [1], subject to a minimum dimension of 1.5 m.

5.3.1 Buffer Analysis for electric pole

Table 2 shows that the frequency increases as the width increases. Y, M, O and F represent young, medium, old and frequency respectively. A graph is plotted between width and the frequency by taking the width in x-axis and frequency in the y-axis.

From the graph 2, it has been found that the frequency becomes linear at a certain width above 80 cm.

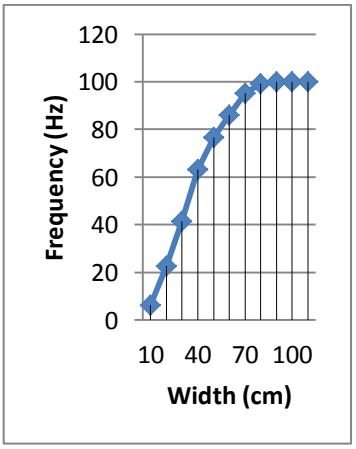

Fig. 2 Frequency width relation for electric pole

Table 2 Buffer analysis for electric pole

Width	Male			Female			Total	Group	F
	Y	M	O	Y	M	O			
10	1	3	2	1	1	0	8	7	6.25
20	3	11	2	1	2	2	21	3	22.65
30	1	12	3	2	4	2	24	4	41.4
40	2	13	4	2	3	4	28	5	63.28
50	1	5	2	3	5	2	17	2	76.56
60		5	1	3	2	1	12	2	85.93
70		4	4	1	2	1	12	1	95.31
80		2	1	1	1		5	2	99.21
90		1					1	1	100
100							0	1	100
110							0	1	100

5.3.2 Buffer Analysis for side tree

Table 3 shows that the frequency increases as the width increases. A graph is plotted between width and the frequency by taking the width in x-axis and frequency in the y-axis.

From the fig3, it has been found that the curve gradually increases with increasing width of sidewalk.

Table 3 Frequency width relation for side tree

Width	Male			Female			Total	Group	F
	Y	M	O	Y	M	O			
10							0	3	9.40
20	3	6	2				11	2	12.09
30		6	1	1	2		10	3	23.08
40	2	9	2	1	3	2	19	2	43.96
50	2	6	6		2		16	5	61.54
60	2	7	2		1		12	3	74.73
70	1	3	1		1	2	8	3	83.52
80	1	3	2		2	1	9	2	93.41
90	1	5	2			1	9	2	103.30
100	0	6	1		2		11	2	115.38
110	0	6	0				6	1	121.98
120	0	0	1				1	1	123.08
130	0	2	0				2	2	125.27
140	0	1	2				1	1	128.57

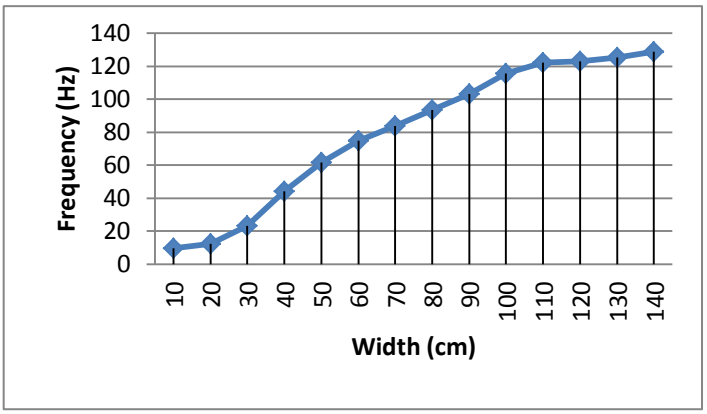

Fig. 3 Frequency width relation for side tree

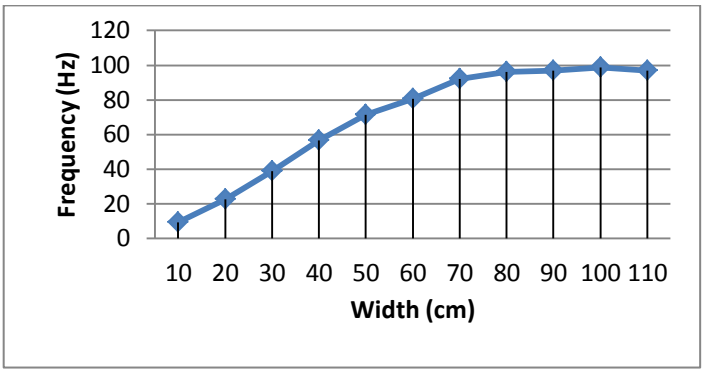

Fig.4 Frequency width relation for sign board

1.3.3 Buffer analysis for man hole

Table 5 Buffer analysis for man hole

Width	Male			Female			Total	Group	F
	Y	M	O	Y	M	O			
10	1	5	1			2	9	3	7.03
20	1	8	3	2	4	1	19	8	21.87
30	1	6	2		2	3	14	6	32.81
40		6	2	1	1		10	5	40.62
50	1	4	1		2		8	3	46.87
60			3		1		4	3	50.00
70							0	1	50
80			1				1	1	50.78
90							0	0	50.78
100							0	0	100

Table 5 shows that the frequency increases as the width increases. A graph is plotted between width and the frequency by taking the width in x-axis and frequency in the y-axis.

From the fig. 5, it is found that the frequency suddenly increases at a width above 90 cm.

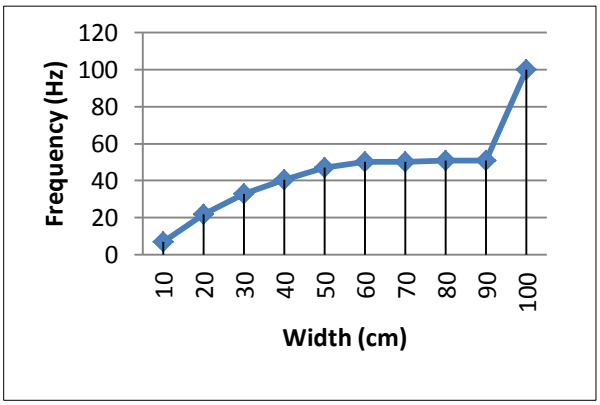

Fig.5 Frequency width relation for man hole

5.3.5 Buffer analysis for dust bin

Table 6 shows that the frequency increases as the width increases. A graph is plotted between width and the frequency by taking the width in x-axis and frequency in the y-axis.

The fig. 6 shows that the curve obtained is gradually increasing with the increase of width.

Table 6 Buffer analysis for dust bin

Width	Male			Female			Total	Group	F
	Y	M	O	Y	M	O			
10	1	2	2	1	1	0	7	4	6.73
20	3	5	2	1	2	2	15	3	21.15
30	1	5	3	2	2	2	15	4	35.57
40	2	4	2	2	3	4	17	6	51.92
50	1	3	2	3	2	2	13	3	64.42
60		3	1	3	2	1	10	2	74.03
70		3	2	1	2	1	9	3	82.69
80		2	1	1	1		5	2	87.5
90		1					1	3	88.46
100		1			1		2	2	90.38
110		1			1		2	1	92.30
120		2			2		4	2	96.15
130		1			1		2	1	98.07

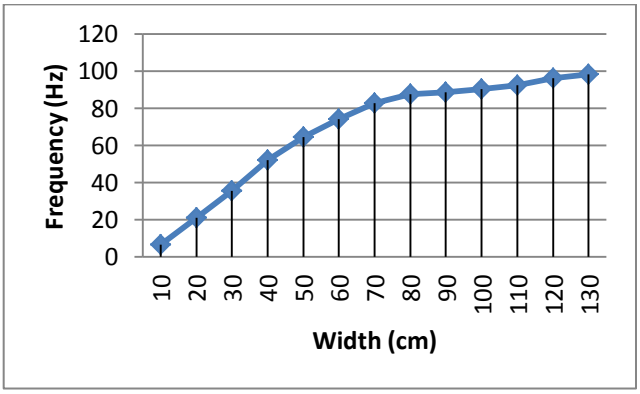

Fig.6 Frequency width relation for dust bin

6.0 Conclusion

A study of pedestrian flow in sidewalks having various types of obstacles like electric pole, dustbin,manhole cover, side trees,sign board was analyzed in and around Coimbatore city. The salient conclusions derived from the studyare as follows.

1. Male pedestrian speed was found to be higher than female pedestrian at all locations.
2. The percentage reduction in speed is more when the obstacle is dust bin.
3. The normal speed was found to be the maximum in obstacle of the dust bin.
4. The obstruction speed was found to be the minimum in the manhole cover.
5. Thus the pavement width has to be increased as mentioned above to reduce the pedestrian traffic flow.

7.0 References

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