



iJRASET

International Journal For Research in
Applied Science and Engineering Technology



INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 7 Issue: III Month of publication: March 2019

DOI: <http://doi.org/10.22214/ijraset.2019.3095>

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Fundamental Relationship between Pedestrian Speed-Flow-Density

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Abstract: Pedestrian walking is significant way to transportation in world, and also in some Indian cities. Also some mode of transportation for long as well as short trips. Pedestrian walk different on different location and pedestrian walking speed generally depend upon its activity, age of pedestrian, gender of pedestrian, mobile phone using during the walking, carrying baggage and walking movement in group. For construction of new sidewalk and maintains exiting sidewalk, estimation of the pedestrian level of service (PLOS) is needed. Data will be collected by using video graphic survey. This paper is mainly describe characteristics of pedestrian in Nagpur cities from different location. Examine their relationship of pedestrian walking speed, flow, density.

Keyword: Pedestrian traffic, sidewalk, pedestrian characteristics (speed, flow, density), fundamental diagram.

I. INTRODUCTION

Walking is main mode of transportation, because of social and economic condition. Sidewalk is mainly provided safety for pedestrian during walking. Sidewalk is avoid dispute between pedestrian and motor vehicles. According to model split study MMRDA (Mumbai metropolitan region development authority) 2.85 million trips, 52.4% are walking trips in Mumbai. African cities have a greater walking mode as compare to Asian and Latin America cities. Montgomery (2006) average walking speed of African, Asian and Latin America cities are 57, 38, 22%. Many research have been done on male and female pedestrian walking speed. Frain (1971), Polus et al (1983), Tarawneh(2001), Montufar et al (2007) and Walton(2008) observed that male walking speed is more faster than female. Also some research has been done on pedestrian activity during walking and their effect on walking speed. Morrall et al (1991) observed that people whose carrying baggage during walking tend to walk slower than non-baggage carrying pedestrian.

As per New York pedestrian study(2006), pedestrian wearing headphone and using mobile phone during walking are slower than as compare to pedestrian whose does not including this activity.

Author	Year	Country	Average speed, m/min
Fruin	1971	United state	81
Bornstein	1976	France	90
Polus et al	1983	Israel	79
Tanaboriboon et al	1986	Singapore	74
Morrall	1991	Sri Lanka	75
Morrall	1991	Canada	84
Finis and Walton	2008	New Zealand	88
Kotkar et al	2010	India	72

Table 1. Average walking speed in different countries.

II. METHODOLOGY AND DATA

Data for this experiment were collecting from two different location from Nagpur cities. For the data collection video graphic survey was conducted video was recorded (iPhone 6s plus, 1334 x 750 pixel) and one camera tripod stand. Video will be recorded approximately 90min during morning peak hour (8-9.30) and evening peak hour (5-6.30) on typical working days. Video recorder was used for record the situation at the observation site.

Following step use for data collection

- 1) Select a random pedestrian about to enter the system and track them through the study area;
- 2) Note his or her entry and exit time in and out of the area;
- 3) Pedestrian walking time is thus obtained by subtracting time of entry into the rectangular box from time of exit;
- 4) Walking speed is then derived by dividing the known length of the box by the walking time, previously calculated in step 3;
- 5) Rewind the tape back to when the test subjected was in the middle of rectangular box;
- 6) As selected pedestrian is in the middle of the study area. Pause the tape and count the total number of the other pedestrian in rectangular box with the selected subject;
- 7) Divided the total number of pedestrian in the study region by the area of the rectangular box give the density;
- 8) Record the other detail of pedestrian test (age, gender, etc.) as required from the data and
- 9) Go back to step 1 and repeat the process until the video tape is completely analyzed or the required sample size is obtained.



Fig. (a)



Fig. (b)

A. Experimental Setup

Length of first location $L=3.0\text{m}$ and width of first section $W=1.8\text{m}$, these total section will be used for data collection. A camera is fix at a distance 2.1m from inner edge of the observed section. Camera is fixed above tripod stand at proper location. Where is the place to cover all four edge of an observed section.

Length of second location $L=3.0\text{m}$ and width $W=2.3\text{m}$. pedestrian walking speed is very less as compare to vehicles speed, because data collection section is very small length. Before camera fixed above the tripod check and adjust horizontal leveling then fixed video recorder.

Observation site	Dimension	
	Length(m)	Width(m)
1) CRPFGATE NO. 3	3	1.8
2) SITA BURDI	3	2.3

Table.2

B. Result Of The Study

Density will be calculating counting number of pedestrian within boundaries of the observation site. Flow will be calculating by counting number of pedestrian passing centerline of observation site within time interval.

- 1) Pedestrian speed calculating by using this equation

$$up = \frac{lo}{tin - tout}$$

Where up= pedestrian speed (m/s), tin-tout= per crossing time.

- 2) Pedestrian flow will be calculating minute wise by using this equation.

$$q = \frac{n}{t}$$

Where n= no of pedestrian cross the section, t= time in minutes.

- 3) Density calculating by using this equation $q=u*k$.

Where q= pedestrian flow (ped/sec), u = pedestrian speed (m/sec), k= pedestrian density (ped/m).

C. Analysis Of Results

Location 1 Mean walking pedestrian speed is 1.13m/s. male pedestrian walking speed is 1.21m/s and female pedestrian walking speed 1.04m/s.

Location 2 Mean walking pedestrian speed is 1.21m/s. male pedestrian walking speed is 1.27m/s and female pedestrian walking speed is 1.16m/s.

Table.3

Location	Average speed(m/s)	Max flow (ped/m)	Density (ped/m)	Total pedestrian
1	1.13	10	0.14	597
2	1.21	7	0.10	410

Fundamental relationship speed-flow-density-

The speed (u)-density (k), flow (q)-density (k), speed (u)-flow (q) curves will be plotted data obtaining from above two location fig(c),fig(d),fig(e)

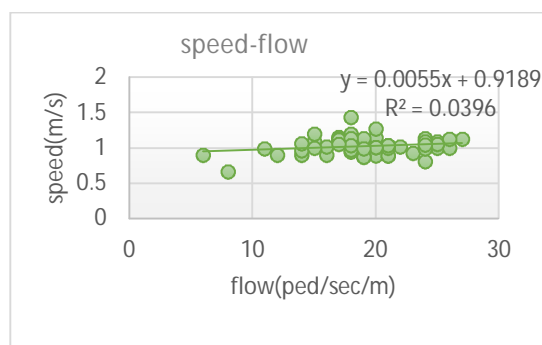


Fig. (c)

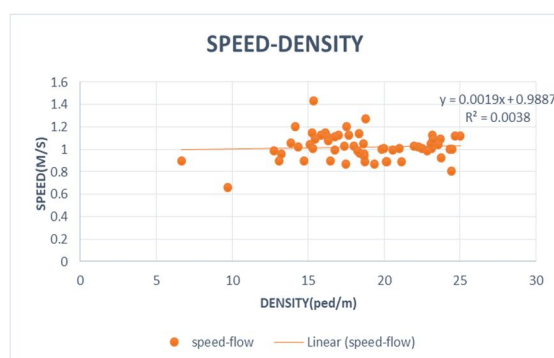


Fig. (d)

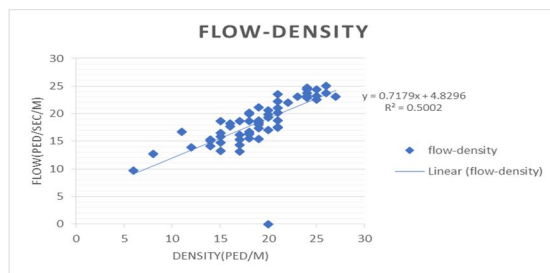


Fig. (e)

Location 2 relationship speed-flow-density

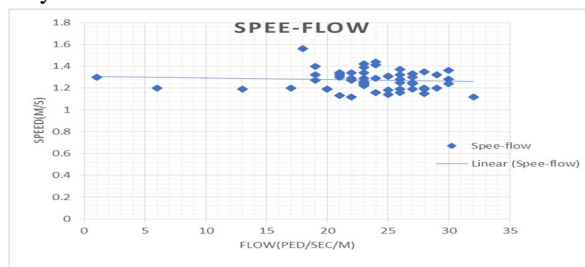


Fig. (f)

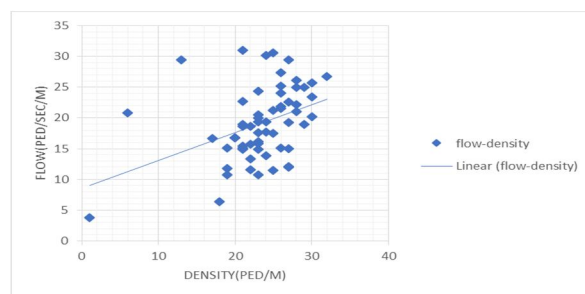


Fig. (g)

From above flow versus density data show in fig have used to find out capacity of the section. These capacity will be using in the construction of better pedestrian facility in Nagpur city.

III. SUMMARY AND CONCLUSION

This study was conducted to find out different location pedestrian speed. Filed study is done with respect to mix gender criteria in this study. As compare to CRPF gate no.3 pedestrian speed is slower than SITA BURDI pedestrian speed was found.

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