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The Flow Behaviours of Pedestrians Along Sidewalks

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ABSTRACT

In Indian cities, walking is an essential kind of transportation because it's a practical way to get from one place to another. The purpose of this study was to collect data on pedestrian pavement from three different locations in Patna, India. Both unidirectional flow data from Gandhi Maidan to NIT Patna and bidirectional flow unstable data were included in the three locations' data collection. The study focused on identifying pedestrian characteristics such as speed, flow, and density, while also assisting in the creation of basic diagrams. Pedestrian activity is influenced by various factors, including age, gender, and the availability of amenities like designated precincts, wider sidewalks, and standard sidewalks. "Characteristics of pedestrians, fundamental diagrams for unidirectional and bidirectional flow, comparison of pedestrian fundamental diagrams between unidirectional and bidirectional flow, capacity, and level of service (LOS) for the three sections mentioned above." This research was carried out. This research performed hypothesis testing to analyze pedestrian speeds across different sections and combinations.

Keywords: capacity and level of service, sidewalks, pedestrian characteristics

Introduction

Walking functions as a mode of transportation that involves progressing towards a specific destination on foot. This transportation method is effectively utilized for brief trips. In cities characterized by middle and lower socioeconomic status, walking serves as a crucial mode of transportation. In the field of transportation, numerous journeys commence and conclude with walking as the exclusive means of travel. In a developing country like India, walking serves as an important means of transportation for pedestrians. India's urban population has been experiencing annual growth. In the year 2001, the percentage of the urban population stood at 27.81%. By 2011, this figure increased to 31.16%, due to the enhancements made to pedestrian facilities that have been put in place. A study carried out in Tiruchirapalli city indicated that 65.9% of all trips are undertaken on foot Arasan et al. (1994). A study carried out in Patna revealed that all individuals engage in daily
walking, irrespective of their income level Montgomery (2006). Enhanced facilities for pedestrians are crucial elements in urban environments. Local authorities are currently focusing on enhancing pedestrian infrastructure to promote walking.
A modal split study conducted in Patna, India, indicated that approximately 2.85 million trips were analyses, with 52.4% classified as walking trips (MMRDA 2008). African cities demonstrate a greater prevalence of walking trips when compared to cities in Asia and Latin America. The average percentage of walking trips in urban areas is 57% in Africa, 37% in Asia, and 22% in Latin America (Montgomery 2006).
Pedestrian movements are divided into two categories: sidewalks for pedestrians and crosswalks for pedestrians. This document addresses the pedestrian sidewalk. The enhancement and accessibility of pavement facilities are of significant importance in urban areas. Urban areas display various types of pavement, such as standard pavements, wide pavements, and precincts. This document provides an analysis of pedestrian capacity and LOS.

The term capacity denotes the highest number of pedestrians that can traverse a specific point within a defined time period. The level of service (LOS) is a criterion used to assess pavement quality, emphasizing factors such as speed, convenience. The capacity and LOS of pedestrian sidewalks are influenced by factors such as pedestrian speed, density, and flow.
Factors such as age, gender, and the availability of facilities influence the walking speed of pedestrians. Pedestrians demonstrate increased walking speeds on wider pavements compared to those in precinct areas. Male pedestrians exhibit a faster walking speed compared to female pedestrians. Elderly pedestrians exhibit a slower speed compared to younger pedestrians.

Objectives

- To pedestrian density, speed as well as the relationships between them.
- Comparing pedestrian attributes using hypothesis testing.
- To compare the basic diagrams of unidirectional and bidirectional pedestrian flows in order.
- To determine the level of service(LOS) and pedestrian capacity study for improving sidewalk.

Methodology

This section examines the key factors affecting pedestrian flow on pavements, with a particular emphasis on gender and the direction of pedestrian movement. This study involves the conduction of two distinct types of experiments. The initial experiment focused on analyzing pedestrian characteristics, including density, flow, and speed, in relation to gender and their interactions along sidewalks. This document outlines the essential diagrams that depict the interrelationships between
distance headway, density, flow, and speed. Section 3.1 outlines the experimental design and describes the data collection process in detail.
The growing interest in this field will lead to increased opportunities for further research. Although a lot of research has been done in this field, there is still a lot of need for more study. Experiments will be carried out in different parts of Patna city after this study area has been chosen. Determine which area of Patna city has the most foot traffic after first identifying many areas. Choose a site for data collection once this area has been identified. The experimental setup and data collecting in 3.1 are described in this section. Only weekdays will be used for data collecting.
Investigations into how pedestrian gender affects pedestrian traits

This section outlines the experiments carried out in Patna city, concentrating on the creation of fundamental diagrams for pedestrian flow on pavements. Previous experiments were carried out to establish the fundamental diagrams for different locations in India and around the world. This following subsection will outline the experimental setup and the methods used for data collection. Setting up the experiment and gathering data

The dimensions and configuration of the data collection section are illustrated. relate to paved sidewalks. This data will demonstrate the two-way movement of pedestrians. Figure 3.4 illustrates the area at NIT Patna, allocated for the gathering of pedestrian uni-directional flow data. Following the initial data collection, additional data will be gathered from Ambala and Sector 2 for further analysis. The data was gathered from three main sites within Patna city, with the initial site designated as the daily market. The initial section measures l = 3.0 m in length and w = 1.8 m in width. The designated sections will serve the purpose of data collection. The camera is located 2.3 meters. camera is securely mounted on tripod, optimally arranged to ensure visibility of all all corners of the observed area. The details for the second section are provided below: The length (l) is measured at
3.0 meters, and the width (w) is recorded as 2.3 meters. The specifications for the third section are as follows: a length of 2.5 meters and a width of 2.7 meters. The experimental area has been delineated with chalk to define the specified location. The section measures 3 meters in length, with a width that matches that of the pavement. The speed of pedestrians is expected to show less variation compared to vehicle speed, given that the data collection was carried out over a very short distance. The section's width will align with the sidewalk's width. The video camera is mounted on the tripod, which will be calibrated for horizontal alignment. Upon completion of the camera repair, we will document the timing and then proceed to activate the video camera.
This research will employ a digital camera for the purpose of data collection. The camera operates at a frame rate of 25 frames per second and features a resolution of 640x480 pixels. The installation will be located adjacent to the sidewalk to facilitate data collection activities. Once the data collection is finished, turn off the video camera and move on to extracting the data from it.

Data Collection

Upon completion of data collection, I will proceed to decrypt the data. Once the number of pedestrians crossing the section has been established, document the duration for each pedestrian to enter and exit. Next, apply the equation provided below to determine the speeds of each pedestrian.
To determine the pedestrian speeds at each of these three places, the equation above will be utilized. After figuring out the speeds in each of the three places, figure out the pedestrian flow minute by minute. The pedestrian flow refers to the quantity of pedestrians traversing a segment within a designated timeframe; this flow will now be calculated on a minute-by-minute basis for each The equation mentioned above has been used to calculate flow. In the equation above, n stands for the number of pedestrians who cross the segment, and t for the time in minutes. pedestrians in the area being observed at any one time was determined using the density. time and the length of the observed segment.

By calculating the flow, we may ascertain the density of the pavement. The density of a section is determined by dividing its length in meters by the number of pedestrians. Densities, flow, and speed in each component can be calculated using this method.
This section will focus on calculating pedestrian distance headway, which is the inverse of pedestrian density. The pedestrian distance headway, also known as the pedestrian space, indicates the average area given to each pedestrian in the walkway segment. Distance from headway a 1/density. The unit of headway/pedestrian space is m2/ped.
Pedestrian speed, flow, density, and headway have all been calculated using the previously described method. The capacity, service level, and pedestrian free flow speed of the walkway will all be assessed using this data. The capacity indicates the maximum number of pedestrians that can cross a stretch in a specified amount of time. After this, as the pedestrian density on the walkway increases, the flow will diminish. In this study, capacity has been determined using a flow-density diagram. The curve's peak and the associated flow value are displayed in the diagram. The flow of this portion is called its capacity. The capacities will be calculated throughout a variety of time periods measurement by averaging all capacities. The capability of the full segment will then be available to us for the duration.
The pedestrian level of service (LOS) has been determined by looking at several pedestrian characteristics, such as pedestrian space, pedestrian speed, and the volume to capacity ratio (V/C). The volume-to-capacity ratio (V/C), average spacing, and speed are some of the variables that will be used to define the Level of Service (LOS) for each section based on pedestrian characteristics. This section details an extra test that was performed on male, female, and a combination of both genders at all three sites to allow for a comparison of pedestrian speeds. The evaluation employed in this work is the

Z-test, sometimes referred to as hypothesis testing. In this study, pedestrian speeds in different combinations will be evaluated using a two-tailed Z-test. The following combinations will be used to assess the Z-test implementation.

A statistical technique used in hypothesis testing—the process of selecting samples to gain a better understanding of the characteristics of a specific population—is the Z-test. Hypothesis testing is a systematic process for assessing claims or opinions regarding a certain group or community. Use these four stages to test a hypothesis:

1. Explain the theory: The average number of pedestrians (μ1) at a given location equals the sample mean (μ2) for that place (μ1=μ2). In this instance, the null hypothesis (H0) is applicable. We can utilise the alternative hypothesis (Ha/H1) if the null hypothesis proves to be incorrect. The alternative hypothesis (H1) is relevant in the following three scenarios: $\mu1 \neq \mu2$; $\mu1 > \mu2$; and $\mu1 < \mu2$.
2. Determine the decision criteria: We give the "level of significance" for a test in order to develop criteria for decision-making. the probability that, should the null hypothesis be true, a statistic shown in a sample will be attained. The significance level is often set at 5%. If the null hypothesis were true, there would be a less than 5% chance of obtaining a sample mean.
3. Find the test statistic, which is a mathematical formula that can be applied in the event that the null hypothesis is true.
4. Choose: The test statistic can be used to assess the validity of the 5%. Paper will investigate pedestrian speeds within and between areas using hypotheses. In this study, the two-tailed Z-test will be employed.

This experiment, which focusses on the differences in pedestrian characteristics under unidirectional and bidirectional flow circumstances, is the second phase of the investigation. Bi-directional flow data was first collected for this study from three different sites: two inside the daily market and one along Patna city's Nala Road. Information about unidirectional flow will be gathered from the campus of NIT Patna. The selected areas were used for the data collection. Whereas unidirectional flow restricts pedestrian movement to either left-to-right or right-to-left exclusively, bi-directional flow indicates that pedestrian movement can occur in both directions. Because pedestrian interruptions

happen more frequently in bi-directional flow than in movement will occur in both directions. Enough pedestrian space must be allowed for those approaching from the opposite direction within the same location when there is bi-directional flow. Pedestrians require more room correlations have been found in this study when data collecting is complete. Basic flow diagrams were made to compare unidirectional and bidirectional flow once the pedestrian characteristics investigation was completed. We then calculated the capacities for both unidirectional and bidirectional flow. Using the information supplied, the pedestrian distance headway has been computed. A basic diagram that shows the connection between speed and distance headway has been created. This basic graphic has been used to determine the lines' slope and intercept.

Result and Discussions

The results of this thesis are divided into four divisions. The results pertaining to free flow speed will be summarised in the section that follows. The results pertaining to the fundamental interactions of pedestrians will be summarised in the section that follows. The level of service (LOS) and pedestrian capacity will be covered in detail in the third part. The effect of pedestrian flow, which includes both one-way and two-way directional movement, on the basic relationships of pedestrian dynamics will be covered in the fourth part.

study of the speed of free flow

This thesis aims to determine the pedestrian free flow speed at multiple locations throughout Patna city. The speeds for free flow are as follows

- The average speed of pedestrians at location 1 (daily market) is 1.17 m/s. The average speed of male pedestrians at this location is 1.24 m/s, whereas the average speed of female pedestrians is 1.09 m/s.
- At site 2, which is the daily market, the average pedestrian pace is 1.24 meters per second. For male pedestrians, the average speed at this place is 1.34 m/s, and for female pedestrians, it is 1.14 m/s.

The two locations referenced are situated within the same vicinity; however, the average speeds recorded at the first location are considerably lower than those observed at the second location. At the initial site, certain obstructions exist as a result of diminished pedestrian speeds. The second section is free of obstructions, attributed to the heightened pedestrian speeds.

- The average speed of pedestrians on Nala Road is 1.30 m/s. The average speed of male pedestrians in this area is 1.40 m/s, whereas the average speed of female pedestrians in this location is 1.21 m/s.
- The average speed of pedestrians at Sabjibhag market is measured at 1.24 m/s. The average
- speed of male pedestrians in this area is 1.27 m/s, whereas the average speed for female pedestrians is 1.20 m/s.
- The mean velocity of pedestrians in the vicinity of sector 2 circle is 1.22 m/s. The typical speed of male pedestrians in this region is 1.26 m/s, whereas female pedestrians average a speed of
- 1.17 m/s.

The pedestrian speed on Nala Road will increase after the daily market concludes. The highest average speed recorded for pedestrians in Patna is 1.30 m/s. The minimum average speed of all pedestrians is 1.17 m/s. The highest average speed of male pedestrians on Nala Road is 1.40 m/s.

4.2. Investigation of pedestrian speed comparison using hypothesis testing

At the three Patna locations previously stated, a hypothesis test was performed to compare pedestrian speeds across various combinations. In order to show in the figure 1. the differences in pedestrian speed between males and girls in all three sections, this study started the first hypothesis test. In line with sections 2 and 3 (m2&f2; m3&f3), the combinations at section 1 (m1&f1) contained both male and female pedestrians. Male pedestrian speeds in various portions. A plot of flow against density data. which makes it easier to visually inspect the flow versus density curve and assess this section's capacity. The curve seen in the diagram rises to a peak and then descends. This point represents the shift in the trajectory capacity of the curve for

this location. 1. We are able to determine the slope and intercept values by using the given speed vs distance headway diagram. The intercept is 0.4548 meters, and the slope has been determined to be 3.6489. To fit the data, the formula h = a + b*u is applied. The values for a and b, which indicate the respectively, are 0.4548m and 3.6489. The basic schematic that illustrates. Location 2 at the Patna city daily market is where the following.

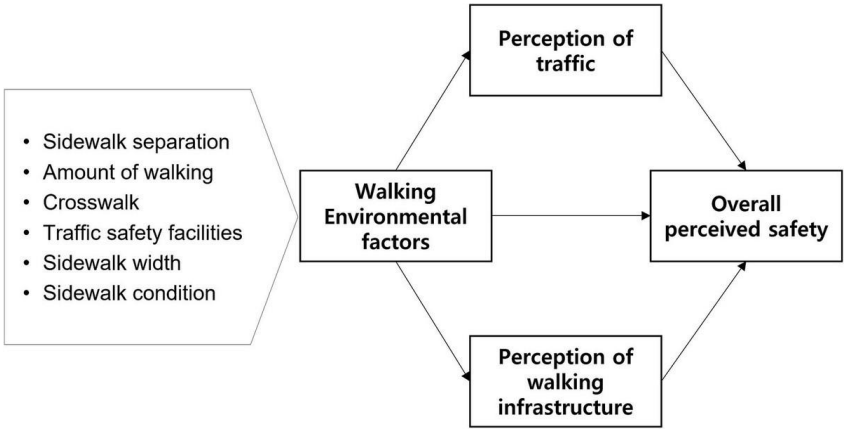

Figure.1. pedestrian speed comparison using hypothesis testing

Z-test findings for every combination in the three places mentioned above

combination	z(Observed value)	|z| (Critical value)	p-value(Two-tailed)	alpha
f1&f2	-2.219	2.02	0.029	0.06
f1&f3	-8.945	2.02	<0.001	0.06
f2&f3	-4.12	2.02	0	0.06
m1&m2	-3.622	2.03	0	0.06
m1&m3	-7.214	2.02	<0.001	0.06
m2&m3	-0.96	2.02	0.351	0.06
m1&f1	10.902	2.02	<0.001	0.06
m2&f2	5.238	2.02	<0.001	0.06
m3&f3	4.501	2.03	<0.001	0.06
T1&T2	-3.331	2.02	0.001	0.06
T2&T3	-3.298	2.02	0.01	0.06
T1&T3	-10.501	2.02	<0.001	0.06
M&F	11.597	2.02	<0.001	0.06

The section's capacity has been evaluated using the flow versus density data displayed. The capabilities will be used to create improved pedestrian infrastructure in Patna. The link between speed and distance headway data. According to the data, the best model for characterising it is a linear connection. The data has been subjected to a model of the kind h = a + b*u. For a and b, the corresponding values are 2.4215 m and 1.4111 s.

The fundamental diagrams shown above depict pedestrian characteristics in sections 1, 2, and 3. In section 3, the pedestrian speed is elevated, whereas in section 1, it is reduced. The observations presented here are based on the speed versus distance headway diagrams discussed in the preceding sections. The speed versus distance headway diagram shows that the intercept at section 1 is 3.6489 m, at section 2 is 3.3434 m, and at section 3 is 1.4111 m. The observed increase in intercept is associated with a rise in pedestrian flow, subsequently resulting in an increase in pedestrian speed.

4.3. Study on Level of Service (LOS) and Capacity

The fundamental diagram has been used to Capacity, level of service. The flow versus density diagram has been employed to assess the three locations illustrated above.

- The pedestrian capacity at location 1 is measured at 24 pedestrians per minute. The highest density recorded at location 1 is 0.42 ped/m.
- The pedestrian capacity at location 2 is 26 pedestrians per minute, with a maximum density of 0.36 pedestrians per meter.
- The pedestrian throughput at this location is 30 individuals per minute. The peak density observed at location 3 is 0.44 ped/m.

The third section will have a higher capacity compared to the first section, which will have a lower capacity. Determining the capacity level of service is a fundamental criterion for the design of enhanced facilities, as it entails evaluating the level of service across multiple dimensions. The service level has been assessed based on the volume the average space allocated for each pedestrian, and the speed of movement. The V/C ratio has been computed on a minute-by-minute basis, with subsequent averaging of all data collected from each section.

4.3(a) The HCM 2010 pedestrian level of service (LOS) score

LOS	Avg. space(ft^2/ped)	Flow q (ped/min/ft)	Speed(ft/s)	V/C ratio
A	>58	≤6	>4.31	≤0.22
B	>42-62	>6-8	>4.21-4.24	>0.22-0.32
C	>22-42	>8-11	>4-5.18	>0.32-0.45
D	>12-22	>11-16	>3.8-4.2	>0.45-0.70
E	>7-12	>16-24	>2.4-3.77	>0.67-1.1
F	≤7	variable	≤2.5	variable

4.3(b) Regarding the V/C ratio, the level of service (LOS) will be

section	Sample size	V/C	LOS
1	1110	0.59	D
2	385	0.61	D
3	665	0.58	D

4.3(c) The average space's level of service (LOS)

Section	Sample size	Avg. space	LOS
1	1030	23.97	C
2	295	29.9	C
3	577	25.02	C

4.3(d) Level of service (LOS) in relation to the typical pedestrian pace

Section	Sample Size	Avg. Speed (ft/s)	LOS
1.	1310	3.69	D
2.	585	3.97	C
3.	579	4.29	B

This study clarifies pedestrian flow on the Research on One-way and two-way Directional Pedestrian Flow pedestrian fundamental diagram. This study collects two distinct categories of data sets. The initial data set comprises bi-directional data gathered from three separate locations, while the following data set consists of uni-directional data obtained from NIT-Patna. Upon gathering the data, proceed to compute the characteristics of pedestrians, which encompass their speed, flow, and density. Subsequently, independently for the two separate data sets. In conclusion, both of these crucial diagrams are presented on a single sheet. This study indicates that uni-directional flow exhibits a greater The information above comes from an investigation of Patna city's unidirectional and bidirectional pedestrian flows. The aforementioned diagrams show that unidirectional flow has higher pedestrian speed, flow, and density values than bidirectional flow. It is now clear how pedestrian traffic and density are related. The unidirectional and bidirectional flow curves first line

up precisely. Consequently, the size of the unidirectional flow will be greater than that of the bipartisan flow. The unidirectional flow line is located above the bidirectional flow line in the graph that displays pedestrian speed in relation to density. This demonstrates that pedestrians in a unidirectional flow typically go faster than those in a bidirectional flow, for any given density value. The speed vs distance headway diagram. where the intercept for unidirectional flow is 0.1464, while the intercept for bidirectional flow is 0.0894. Bi-directional flow has a computed slope of 2.1086, while uni-directional flow has a computed slope of 1.3802.

The comparison of pedestrian fundamental diagrams for unidirectional and bidirectional traffic is illustrated by the three sets of graphs that are supplied. Every set's flow and density diagrams will show the same pattern. For a given stretch, the curves that depict unidirectional and bidirectional flow will initially overlap. The unidirectional curve will be located above the bi-directional curve after this phase.

Three categories will be used to group the fundamental graphical comparisons between unidirectional and bidirectional pedestrian flow. In the first set, the basic diagram was constructed using data from NIT Patna by comparing it with data from Location 1, which was obtained from the Patna daily market. The second set of basic diagrams was created by comparing data from the Patna daily market with data obtained from Bakarganj. Similarly, the third set was created by comparing the data from Bakarganj with the data from Patna's Nala Road. Based on the three sets of pedestrian basic diagrams depicted the slope and intercept for both unidirectional and bidirectional pedestrian flow are displayed in the following table.

Table 4.4 slopes and intercepts for both one-way and two-way flow

Diagram sets	One way flow			Two way flow		
	Slope	Intercept	Speed	Slope	Intercept	Ipeed
1.	1.4101	0.1513	1.01	1.303	0.2101	1.1
2.	1.4101	0.1513	1.01	2.805	0.0141	1.27
3.	1.4101	0.1513	1.01	1.807	0.501	1.31

Conclusions

This research investigates experiments related to pedestrian flow behaviour on sidewalks across different areas of Patna city, along with the differences in pedestrian characteristics during both directional flow. The findings of this study demonstrate that male pedestrian speeds more to exceed those of female pedestrians in all three sections analyzed. The findings of this study reveal that the average pedestrian speed is greater on Nala Road (Section 3) and diminished in the daily market (Section 1). The Nala road includes a broader pedestrian pavement in comparison to other areas, and the surface of the pavement will be level to support pedestrian use.

The pavement along Nala Road will undergo expansion. A hypothesis test will be conducted using various combinations of pedestrians in different sections. The anticipated speeds of male pedestrians in sections 2 and 3 are expected to align closely, as the Z-observed value resides within the range of the Z-critical values, suggesting, indicates that the lines representing one way and two-way flow initially overlap. As a result, the line indicating both directional.

REFERENCES

1. Hankin, B.D. and Wright, R.A. (1958). *Passenger Flow in Subways*. Operational Research Quarterly, 9(2), pp. 81–88.
2. Oeding, D. (1963). *Verkehrsbelastung und Dimensionierung von Gehwegen und Anderen Anlagen des Fußgängerverkehrs*. Tech. Rep. Forschungsbericht 22, Technische Hochschule Braunschweig.
3. Older, S.J. (1968). *Movement of Pedestrians on Footways in Shopping Streets*. Traffic Engineering and Control, 10(4), pp. 160–163.
4. Navin, F.P.D. and Wheeler, R.J. (1969). *Pedestrian Flow Characteristics*. Traffic Engineering, 39(9), pp. 30–36.
5. Mori, M. and Tsukaguchi, H. (1987). *A New Method for Evaluation of Level of Service in Pedestrian Facilities*. Transportation Research Part A, 21A (3), pp. 223– 234.
6. Weidmann, U. (1993). *Transporttechnik der Fußgängers*. Tech. Rep. 90, Institut für Verkehrsplanung, Transporttechnik, Strassen und Eisenbahnbau, Zürich.
7. Seyfried, A., Steffen, B., Klingsch, W. and Boltes, M. (2005). *The Fundamental Diagram of Pedestrian Movement Revisited*. Journal of Statistical Mechanics: Theory and Experiment, P10002.
8. Helbing, D., Johansson, A. and Al-Abideen, H.Z. (2007). *Dynamics of Crowd*
9. *Disasters: An Empirical Study*. Physical Review E, 75(4), pp. 046109 (1–7).
10. Polus, A., Joseph, J.L. and Ushpiz, A. (1983). *Pedestrian Flow and Level of Service*. Journal of Transportation Engineering, ASCE, 109(1), pp. 46–56.
11. Hoogendoorn, S.P. and Daamen, W. (2005). *Pedestrian Behavior at Bottlenecks*.Transportation Science, 39(2), pp. 147–159.
12. Seyfried, A., Passon, O., Steffen, B., Boltes, M., Rupprecht, T. and Klingsch, W. (2009). *New Insights into Pedestrian Flow through Bottlenecks*. Transportation Science, 43(3), pp. 395–406.
13. Henderson, L.F. and Lyons, D.J. (1972). *Sexual Differences in Human Crowd Motion*.Nature, 240(5380), pp. 353–355.
14. Young, S.B. (1999). *Evaluation of Pedestrian Walking Speeds in Airport Terminals*.Transportation Research Record, 1674, Transportation Research Board, National Research Council, Washington, DC, USA, pp. 20–26.
15. Morrall, J.F., Ratnayake, L.L. and Seneviratne, P.N. (1991). *Comparison of CBD Pedestrian Characteristics in Canada and Sri Lanka*. Transportation Research Record, 1294, Transportation Research Board, National Research Council, Washington, DC, USA, pp. 57–61.
16. Isobe, M., Adachi, T. and Nagatani, T. (2004). *Experiment and Simulation of Pedestrian Counter Flow*. Physica A, 336(3–4), pp. 638–650.
17. Kretz, T., Gruenebohm, A., Kaufman, M., Mazur, F. and Schreckenberg, M. (2006). *Experimental Study of Pedestrian Counterflow in a Corridor*. Journal of Statistical Mechanics: Theory and Experiment, P10001.
18. Hoogendoorn, S.P. and Daamen, W. (2004). *Self–Organization in Walker Experiments*. In Proceedings of the 5th Symposium on Traffic and Granular Flow, (Eds.: Hoogendoorn, S.P., Luding, S., Bovy, P.H.L., Schreckenberg, M. and Wolf, D.E.), Springer, Delft, the Netherlands, pp. 121–132.
19. Helbing, D., Bunza, L., Johansson, A. and Werner, T. (2005). *Self-Organized Pedestrian Crowd Dynamics: Experiments, Simulations and Design Solutions*. Transportation Science, 39(1), pp. 1–24