

Impacts of Gender and Gender Mix on Pedestrian Fundamental Diagram

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ABSTRACT

Pedestrian movement study can be possible done by different approaches like Investigation of walker movement (field data collection), experimental observation, and conduction of controlled tests and also by creating pedestrian models. All these diverse sorts of studies are subject to develop fundamental diagrams. Movement of pedestrian along a line of the condor under the closed boundary conditions is the simplest method to know how the different condition influences the fundamental diagram. We have to study diverse angle and distinctive effects which impact person on foot movement, to give better pedestrian facilities and also help in design spaces for human circulation. So, here in this thesis it is aimed to study the impact of gender mix condition on pedestrian at different densities at fundamental level. In the is contribution it is studied through fundamental diagram, whether the impact of gender and gender mix condition influence the pedestrian behavior or not. To conduct the experiment, the simplest system, which is known as the movement of pedestrians along a line under closed boundary conditions (single file movement) is chosen with five different gender mix condition. It is found that the Mean free flow speed is 1.27ms^{-1} for male pedestrian and it is 1.24ms^{-1} for female pedestrians. While walking females are more conscious about their private space than the males. This may be because of contrasts in their self-organizing behavior. Without any statistical proof one can't tell whether there are contrasts or not. By statistical hypothesis test it is discovered quantitatively that these distinctions exist, recommending the gender and gender mix impact in fundamental diagram.

Key Words: Pedestrian, Traffic, Z-test, Anova Test, etc.

1. INTRODUCTION

Walking is perhaps the most useful, necessary and basic transportation system which is available to mankind and used by almost every person in the world. Walking is additionally included in many outing made by different modes. Whatever the fundamental method for travel, walking is normally the first and last mode utilized, giving an essential connection between area utilize and mechanized travel. It is additionally sound, economical and environmentally friendly. [1] India is the second most crowded nation on the planet more than 1.27 billion people, more than a 6th of the world's populace. As of now contains 17.5% of the world's populace and India is anticipated to be the world's most crowded nation by 2015, surpassing china so India should need a adequate pedestrian facilities to provide better design spaces for human circulation, to empower and energize walking for distinctive purpose, the physical facility must be available to backing the physiological, psychological and social need of walkers and guarantee the against overexertion, interference by other person on foot and mischance. For this reason, exploration of walker movement streams has just been given constrained consideration amid the most recent decades. Since walking is a part of the transportation chain without which barely any development is conceivable. Samples are get to and departure to open transport administration, person on foot streams in inward city ranges, focal business areas and malls, and group amid discharging of theatres and games stadiums and amid celebrations. In this thesis an attempt is made to study the behavior of the Indian pedestrian empirically on the basis of their gender analysis. Empirically, the motion of the pedestrian can be studied by conducting different type of experiments such as single file movement, flow through open corridor, bottleneck experiment, and evacuation from a hall etc.

In single file and bottleneck experiments, impact of space between pedestrians in the direction of motion can be observed on pedestrian speed [5]. In flow through open corridor experiment one can observe the lateral and longitudinal variation in density and speed in pedestrian streams due to different corridor geometry. In the experiment of evacuation from a hall one can study the effect of choice of goals and the positions of the obstacles on pedestrian motion.

In this paper, single file experiments on pedestrian movement are considered to know the impact of space between pedestrians in the direction of motion on pedestrian speed. Because to know the impacts of gender and gender mix condition on pedestrian fundamental diagram, it is necessary to study speed/density/volume relationship to add to a comprehension of any traffic flow phenomena because these parameters are important portrayal of stream qualities, they are reasonably simple to gauge and to understand. The past investigations of vehicle stream have recognized essential prerequisites in the relationship between these parameters that are valuable in comprehension stream systems, administration properties, and outline standards. Several studies that managed vehicular stream portrayed the fantastic relationship in between speed and density, which was picked as a beginning stage for an investigation of the attributes of pedestrian movement stream to know the gender effect in pedestrian traffic flow.

At the macroscopic level one may study over the essential stream parameters of pedestrian movement. At microscopic level one may track the way took after by individual walker while moving. Such studies help in seeing how pedestrian arrange their way while traveling through a stream space at different densities. At mesoscopic level one can contemplate pedestrian movement by focusing on how the stream parameters change spatially (both in transverse and longitudinal directions) and briefly.

2. EXPERIMENT DATA COLLECTION AND DATA DECODING

[6] Pedestrian activity has been discovered to be affected by mental, physiological, social and ecological variables. The elements which affect studies for characterizing the qualities of pedestrian stream are age, sex, physical wellness, pedestrian interaction and the geometry of the facility. In this study five similar types of experiments are done. All the five sets of experiments are done in to study the impact of space between pedestrians in the direction of motion which can be observed on pedestrian speed. The fundamental diagram between speed and linear density of pedestrian motion is obtained from this study. In this chapter, Section presents the experiment on single file movements. Section represents the information accumulation and its approach from investigations where pedestrians need to move in a single file experiment. These single file tests on walker movement are intended to comprehend the variety in speed and density in walkers' stream of different gender group. Tests are designed, where diverse decisions of objectives are given to people on foot and their movement concentrated on, keeping in mind the end goal to see the impact contending objectives have on pedestrian movement. Five different groups of gender mix conditions of pedestrians in these experiments are introduced. Section represents the data decoding process, which is obtained from the single file experiments.

Experimental set-up for Single-File movement

The experiment corridor is encircled via chairs and ropes. The size and shape of the experiment corridor is same as said in [2] for similar experiment in India furthermore, Germany. A closed corridor of the size and shape as demonstrated in Figure .1 is developed on a cleared ground and utilized as a part of this experiment. Analyses were led in Community Hall which amid daytime in wonderful climate. The length of the passage, $l_p = 17.3$ m. It might be noticed that despite the fact that walkers move along the corridor, information is gathered just in the shaded segment which is called observation section as indicated in Figure 1. The length of the observation segment, $l_o = 2$ m and is built by raising two running poles at the section and way out lines of the observation section. The camera was situated at a separation of 10 m from the observation segment along the perpendicular bisector of the observation area to diminish parallax error. The width of the path in the straight area is 0.8 m; this is adequate for single file movement yet not for overtaking. In the curved section the width is expanded to a most extreme of 1.2 m through elliptic transit curve. The explanation behind expanding the width at the curved segment is that a curved part of 0.8 m width may reduce speed which is undesirable. The experiments are done on cleared ground. The subjects are consisting of students. The subjects are told not to surpass and not to push others. To acquire data at different densities, seven arrangements of experiment with number of subjects $N = 1, 6, 12, 18, 24, 30, 36$ are performed.

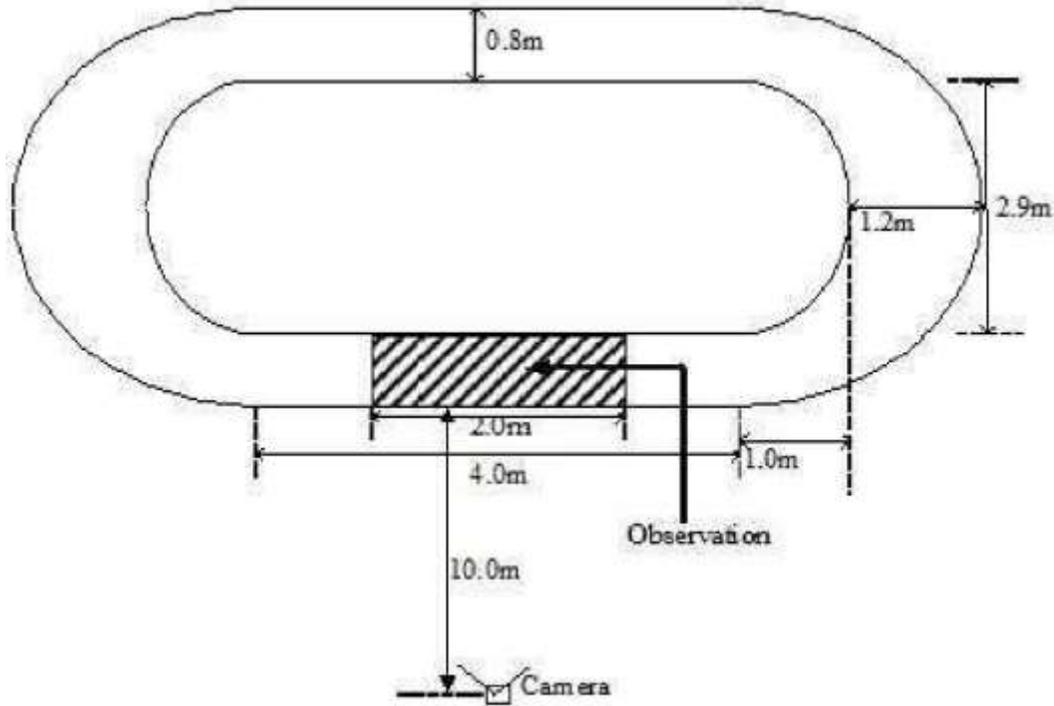


Figure 1. Sketch of the experimental setup for single file movement adapted

For this experiment (with the exception of $N = 1$) all the subject subtilized as a part of that cycle were at first circulated consistently in the corridor in a steady progression. At that point the direction to begin was given to each subject goes around the corridor three times. After that an opening is molded in the closed corridor through which the subjects are permitted to leave and continue walking for a sufficient far separation far from the passage to avoid tailback impact. The subjects for the experiment consisted of both male and female graduate students of the L.U Faridabad. The moving direction of the experiment was anticlockwise direction according to standard Indian design aspect. To show the gender and gender mix condition, the experiment was done on five different categories. The five different categories which were taken into consideration are:

- All boys
- Two boys & one girl alternatively
- One boy & one girl alternatively
- One boy & two girls alternatively
- All girls



Figure 2. Snapshot for the run with $N = 30$



Figure 3. Snapshot for the run with $N = 30$ of One boy & One girl Alternately



Figure 4. Snapshots for the run with N = 30 of All girls

Data Collection

In the first place to gather the velocity-density information, a digital video camcorder ((Mode: HXR-NX30E/NX30P, Make: Sony), Frame rate(25 frames/s) with Resolution (640 × 480) is set as indicated in figures 2, 3 & 4 recorded the movement of people on foot in the observed section as shown in Figure 5. In the test two ranging bars are set independently to find the rectangular measured segment indicated in fig. From the video data as indicated in fig, the snapshot of the observed section is found. To acquire the crossing time of each person (say person p) from the rectangle area, passage time (*t_{p in}*) and way out time (*t_{p out}*) are noted. Speed and density of individual person are obtained from these data sets. By these information set, speed, density for the individual person on foot is found. After acquire the density information set, the distance head way is obtained by the reciprocal of the density. As the people on foot are moving so slowly, proper accuracy was taken at the time of information gathering.

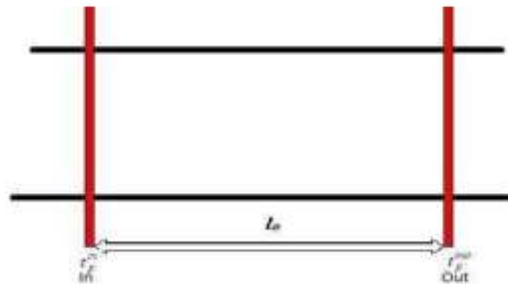


Figure 5. Observed section for data collection

Data Decoding

The information was decoded by playing the feature utilizing software Avidemux. For data decoding, results and discussions, [3] was referred. As the entry time and exit time was noted from the video to obtained the speed and density data. The individual velocity is determined from the formula:

Individual velocities = $V_i \text{ man} = L_m / t_{out} - t_{in}$

Velocities = $\rho(t) \text{ man} = n / t = 1 [h]I(t) / L_m$

$$\Theta_i(t) = \begin{cases} \frac{t - t_i^{in}}{t_{i+1}^{in} - t_i^{in}} & t \in [t_i^{in}, t_{i+1}^{in}] \\ 1 & t \in [t_{i+1}^{in}, t_i^{out}] \\ \frac{t_{i+1}^{out} - t}{t_{i+1}^{out} - t_i^{out}} & t \in [t_i^{out}, t_{i+1}^{out}] \\ 0 & \text{otherwise} \end{cases}$$

$\Theta_i(t)$ gives the „fraction“ to which the space between person *i* and person *i* + 1 is inside.

3. ANALYSIS OF EMPIRICAL DATA

Figures 6, 7, 8, 9 & 10 depict the relationship between speed and density for different categories. Speed-density relationship is the basic input to the pedestrian fundamental diagram. The speed (u)–density (k) was need in closed corridor condition obtained by five different categories of experiments such as:

- All boys
- Two boys & One girl alternatively
- One boy & One girl alternatively
- One boy & two girls alternatively
- All girl

It is observed that when density is increasing, speed will be decreasing and vice versa. It is clearly noticeable from the graph that the speed-density relationship is non-linear in nature.

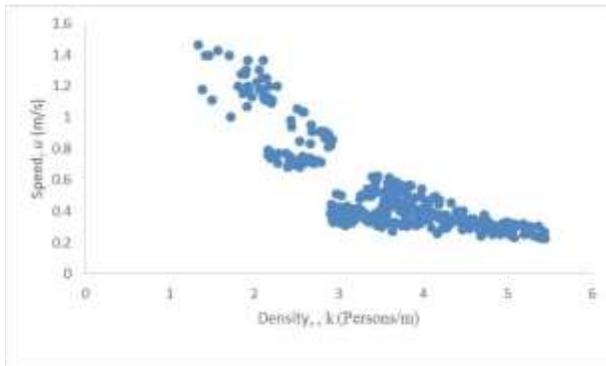


Figure 6. Speed-density plot for all boys

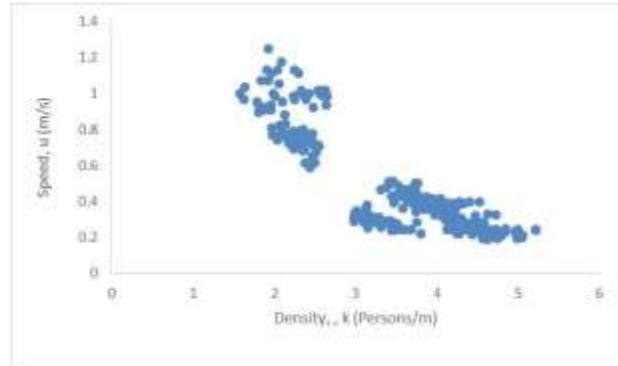


Figure 7. Speed-density plot for two boys and one girl alternatively

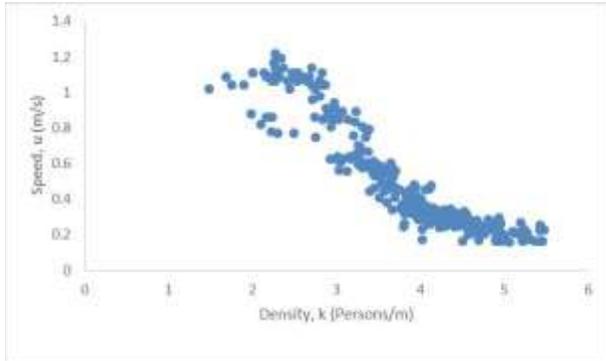


Figure 8. Speed-density for One boy and one girl alternatively

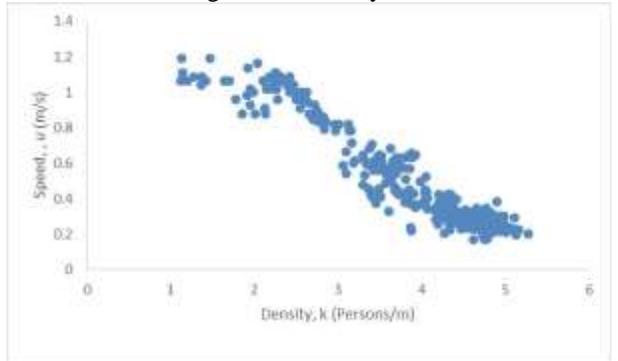


Figure 9. Speed-density for one boy and two girls alternatively

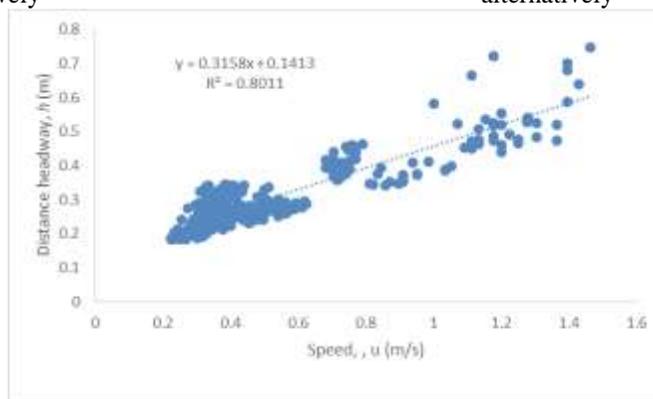


Figure 10. Speed-density for all girls

A Z-test is a statistical test for which the distribution of the test statistic under the null hypothesis can be approximated by a normal distribution. Because of the central limit theorem, many test statistics are approximately normally distributed for large samples. For each significance level, the Z-test has a single critical value which makes it more convenient than the Students t-test which has separate critical values for each sample size. Therefore, many statistical tests can be conveniently performed as approximate Z-tests if the sample size is large or the population variance known. Hypothesis test was done to show the statistical analysis.

$$Z = \frac{\bar{x}_1 - \bar{x}_2 - \Delta}{\sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}}}$$

Where,

x = Standardized random variable

\bar{x} = Mean of the data

σ = Population standard deviation

Null hypothesis: $H_0: \mu_1 = \mu_2$

Or $H_0: \mu_1 - \mu_2 = 0$

Alternative hypothesis: $H_a: \mu_1 \neq \mu_2$

Statistical analysis can be done by different hypothesis test but in this experiment as the number of data points is more so, z-test is conducted between two different categories of experiment out of five different categories, to show the impacts of gender and gender mix condition. For statistical analysis by z- test, first slope and intercept of the fundamental diagram was studied as shown in Table 1.

Table 1: Study on intercept (a) and slope (b) of the fundamental

S.NO	DATA	INTERCEPT(a)	SLOPE (b)	R2	Data point
1	All boys	0.143	0.315	0.801	339
2	Two boys and one girl	0.154	0.231	0.884	293
3	One boy and two girl	0.16	0.328	0.787	316
4	One boy and two girl	0.16	0.240	0.81	316
5	All girl	0.107	0.361	0.729	306

One-way analysis of variance is a technique in statistics, used to compare means of three or more samples using the F distribution. This technique is used only for numerical data. It is used to find the significant relationship between various variables.

Table 2: ANOVA test for Distance headway

Test Type	p-value	p-value summary	P<0.05
Brown- forsythe Test	<0.0001	****	Yes
Bartlett's Test	<0.0001	****	Yes

Here **** means highly significant

Table 3: ANOVA test for Speed

Test Type	p-value	p-value summary	P<0.05
Brown- forsythe Test	0.255	NS	NO
Bartlett's Test	0.1316	NS	NO

Here NS- not significant

ANOVA For Multiple Factors

ANOVA sums up to the investigation of the impacts of various elements. At the point when the analysis incorporates perceptions at all mixes of levels of every component as shown in table 2 & 3, it is termed factorial. Factorial trials are more effective than a progression of single component analyses and the effectiveness develops as the quantity of components increments. Thus, factorial experiments are vigorously utilized. The utilization of ANOVA to study the impacts of various elements has a complexity. In a 3-way ANOVA with elements x, y and z, the ANOVA model incorporates terms for the fundamental impacts (x, y, z) and terms for collaborations (xy, xz, yz, xyz). All terms require hypothesis tests. The multiplication of cooperation terms expands the danger that a few

theory tests will deliver a false positive by shot. Luckily, experience says that high order interaction is rare. The capacity to recognize associations is a noteworthy point of preference of numerous element ANOVA. Testing one element at a time hides interactions, but produces apparently in consistent experimental results. Brown-Forsythe shows the F test from an ANOVA where the response is the absolute value of the difference of each observation and the group median [4] Bartlett- Compares the weighted arithmetic average of the sample variances to the weighted geometric average of the sample variances. The geometric average is always less than or equal to the arithmetic average with equality holding only when all sample variances are equal. The more variation there is among the group variances, the more these two averages differ. A function of these two averages is created, which approximates a q^2 -distribution (or in fact, an F distribution under a certain formulation).

Large values correspond to large values of the arithmetic or geometric ratio, and therefore to widely varying group variances. From the above one-way ANOVA test, it was clearly observed that the speed was almost equal for five different categories but the distance headway was not same for the five different categories, because distance headway represented the distance between the two successive pedestrians in a group. When there was both male and female, the speed was almost same but the space between them was not same. Everyone maintained noticeable distance in mix gender condition because of the human behavior. So the efficiency of the pedestrian movement decreases in gender mix condition as they try to maintain distance from each other.

4. CONCLUSION AND FUTURE SCOPE

In this thesis, the experiments on pedestrian motion under closed boundary condition using the single file pedestrian motion are conducted to observe the impacts of gender and gender mix condition on fundamental diagram. The objective of this study to show the impacts of gender effect on pedestrian fundamental diagram using different hypothesis test. The results were compared statistically using z-test and ANOVA test. The following observation is found from this study: The Mean free flow speed is 1.27ms⁻¹ for male pedestrian and it is 1.24ms for female pedestrians. While walking females are more conscious about their private space than the males. Security distance is introduced to explain the private space concept. From this experiment it appears that the male group of test persons are less concerned about their personal space and thus the security distance is smaller compared to the female group. It is clearly notice that the impacts of gender are existed in pedestrian crowd flow and mostly gender condition affects the space between the pedestrians present in mix pedestrian traffic.

From this thesis work, it is clearly observed that; fundamental diagram is significantly different for different gender mix condition. Thus, it is expected that, in future, if gender mix condition can be compared with some other factors like age, at different time during a day and weather condition so as to find the more clarity in the pedestrian behavior. In the present experimental work, fundamental diagram of different gender mix condition is compared. In the future, the same study can be conducted with different sample size of mixed gender pedestrians to see whether the impact is existing or not. In the future, the same study can be conducted with different geometric size of the corridor to see whether the impact of corridor exist with the gender effect or not.

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