EMPIRICAL STUDIES ON PEDESTRIAN DYNAMICS: EVACUATION AND QUEUE

Master of Technology

In

Transportation Engineering

By

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A THESIS SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIRMENTS FOR THE DEGREE OF

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CERTIFICATE

This is to certify that the thesis entitled "**EMPIRICAL STUDIES ON PEDESTRIAN DYNAMICS: EVACUATION AND QUEUE"** *Submitted by* **RATHIKRINDA VINOD KUMAR** *Bearing Roll No*: **212CE3059***in partial fulfilment of the requirements for the award of* **Master of Technology in Civil Engineering** *with specialization in* "**Transportation Engineering"** *during 2012-2014 session at the National Institute of Technology, Rourkela is an authentic work carried out by him under my supervision and guidance. To the best of my knowledge, the results contained in this thesis have not been submitted to any other University or Institute for the award of any degree or diploma.*

Date**:**

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RATHIKRINDA VINOD KUMAR

Abstract

Studies on egress time spatial, temporal progression of pedestrian inside a hall are important for deign of exit of halls. Pedestrians act is different in some situations. Study experiments on evacuation from a hall are conducted to realize the impact of exits and the geometry of the flow space on pedestrian flow. This in an attempt to study the impact of geometric variations in Hall on the flow of pedestrians; how to behave pedestrians in the flow or motion are studied. The impact of geometry on flow is studied in terms of lateral and longitudinal variations in densities and longitudinal variations in speed along the Hall. These results may help in enclosed space geometry and exits. Evacuation experiments designed to investigate the progression of pedestrians in a hall have been conducted. And also study one of the interesting pedestrian flow spaces is queue before point based server. Only, it should be such that our generalized model can explain every situation. Hither, the primary idea of the model remains the same; but requires some switches are off and applying some changes. In this study, we are assuming that we are unable to change the arrival distribution, arrival source, service distribution, number of servers and service discipline. Here we will consider the pedestrian behavior in queue at microscopic level and some measuring parameters in macroscopic level. The amounts of these macroscopic parameters are necessary for queue space design.

Keywords: Pedestrian flow, Flow pattern, Trajectories, Pedestrian fundamental diagram

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Chapter 1

1. Introduction

1.1 Definition of the subject and its importance

Today, there are many occasions where a large number of people gather in a rather small area. Buildings and residence become larger and a lot of difficulties. Very massive events related to sports, diversion or cultural and spiritual (for example, airport terminals, sidewalks, shopping malls, fair grounds, etc.,) actions are command all over the globe on a daily basis. These create serious problems with safety for the participants and additionally the organizers who need to be ready for any case of emergency or important situation. Generally in such cases the participants need to be guided removed from the dangerous house as fast as possible. That the understanding of the dynamics teams groups of individuals is extremely necessary.

In general, evacuation is that the egress from an area, a building or vessel due to an attainable or actual threat. within the cases delineate on primary of the dynamics of the evacuation processes is kind of advanced as a result of the massive vary of people and their communication, outside causes like fire etc., advanced building geometries,...Evacuation dynamics should be delineate and understood on different levels : physical, physiological, psychological, and social. Consequently, the scientific investigation of evacuation dynamics involves many analysis areas and disciplines. The system evacuation method (i.e. the population and additionally the environment) may be modeled on many different levels of detail, ranging from hydro-dynamic models to artificial intelligence and multi-agent systems. There are a minimum of three aspects of evacuation dynamics that encourage its scientific investigation: 1) as in most many-particle systems many fascinating collective phenomena may be determined would like that require to be explained; 2) models ought to be developed that are able to reproduce pedestrian dynamics in a realistic way,3) the applying of pedestrian dynamics to facility and emergency preparation and management. The investigation of evacuation dynamics could be a difficult problem that need s close collaboration between different fields. The origin of the apparent complexity lies within the proven fact that one is bothered with a many-particle system with advanced interactions that are not totally understood. Generally the systems area unit faraway from equilibrium and then area unit e.g. rather sensitive to boundary conditions. Motion and behavior are influenced by many external factors and often crowds may be rather homogeneous. In this object we would like to deal with these issues from different views. Walking is one of man's most Opulent abilities, a significant factor in his long journey up the evolutionary ladder and hid progress towards civilization.

Experimentally, pedestrian motion through hall can be studied at various levels. In this study experiments on evacuation from a hall are conducted to understand the impact of exits and the geometry of the flow space on pedestrian flow. This in an attempt to study the impact of geometric variations in Hall on the flow of pedestrians; how to behave pedestrians in the flow or motion are studied. The impact of geometry on flow is studied in terms of lateral and longitudinal variations in densities and longitudinal variations in speed along the Hall. These results may help in enclosed space geometry and exits. Various experiments designed to investigate the progression of pedestrians while evacuating from a hall have been conducted as a part of this study.

1.2 General

Knowledge about pedestrian dynamics allows the design and optimization of facilities with respect to safety, level of service and economy. The space provided for human circulation (for example, airport terminals, sidewalks, shopping malls, fairgrounds, etc.,) involves movement of pedestrians. Efficient design of facilities catering to pedestrian movement can be achieved only if one understands pedestrian flow. The awareness that emergency exits area unit one of the most important factors to ensure the safety of persons in buildings may be traced quite one hundred years. The disasters due to the fires within the Ring Theater in Vienna and also the urban theater in Nizza in 1881 with many hundred fatalities result in a rethinking of the safety in buildings. Firstly, it absolutely was trying to boost safety by exploitation non-flammable building materials. However, the disaster at the Troquois Theater in Chicago with quite five hundred fatalities, wherever only the decoration burned, caused a rethinking. It absolutely was a start line for determining the influences of emergency exits and thus the dynamics of pedestrian streams.

Which allow communication and spatial cohesion among members during the Movement. At low density, cluster members be likely to guide aspect by aspect, forming a line perpendicular to the walking direction (line-abreast pattern); because the density will increase, the linear walking formation change into a V-like pattern, with the center individual positioned slightly behind in similarity on to the lateral individuals; in situation of high density, the special distribution of cluster members ends up in a river-like pattern and lane formation.

Chapter 2

Literature Review

2. Literature Review

The literature review is present's in empirical studies on pedestrian movements and model pedestrian flow.

2.1 Empirical studies on pedestrian flow

Empirical studies on pedestrian flow can be broadly classified as (i) studies on speed, density and their interrelationship and (ii) studies on the various different phenomena that can be observed in pedestrian dynamics Adopted from U Chattaraj (2010) et al. First, studies related to speed, density and their interrelationship are discussed. Later studies related to different pedestrian dynamics phenomena are presented.

Over the years various studies on speed—density (or flow—density or speed—flow) relationships (also known as fundamental relationship) of pedestrian streams have been reported (for example, Hankin and Wright (1958), Oeding (1963), Older (1968), Navin and Wheeler (1969), Mori and Tsukaguchi (1987), Weidmann (1993), Seyfried et al. (2005) and Helbing et al. (2007)). The results however varied substantially primarily due to differences in the ways the data was collected and represented. Seyfried et al. (2005) has tried to develop an experiment scenario which tries to capture only the impact of density on speed. Others have studied such relations in the specific case of experiment/observation without nullifying the impacts of influencing factors like entrance and exit condition of the corridor, width of the corridor, overtaking, pedestrians moving side by side, etc. (Hankin[3] and Wright, 1958; Oeding, 1963; Older, 1968; Navin and Wheeler, 1969; Mori and Tsukaguchi, 1987; Weidmann, 1993; Helbing et al., 2007). Morrall et al. (1991) and Chattaraj et al. (2009) have studied whether cultural differences impact the fundamental diagram.Many studies relate to empirical observations on motivating phenomena that occur in pedestrian flow. Many authors, for example, have studied the unstructured formation of lane like structures in primarily bi–directional flow. Isobe et al. have observed pattern formation and jamming transition (occurrence of jam when the density exceeds certain threshold value) in pedestrian counter flow. Kretz et al. have plotted frequency distribution of number of lanes formed for bi–directional pedestrian flow. Hoogendoorn[2] and Daamen have studied lane formation and cluster formation for bi–directional pedestrian flow. Zhang et al. have studied ordering in bidirectional pedestrian streams and its influence on the fundamental diagram. They found that the maximum of the specific flow in bidirectional streams is significantly lower than that in unidirectional streams. In another study Hoogendoorn and Daamen have observed zipper effect (staggered positioning of pedestrians when the width of the Hall is in excess than that required for single file movement but not sufficient for two pedestrians moving side by side) at bottlenecks. Oscillations at bi–directional bottlenecks (alternate passing of pedestrians from one direction blocking pedestrians from the opposite direction) with emphasis on alternate passing time and frequency distribution of time headway was studied by Helbing et al. Helbing et al. [8] have observed upstream moving (back–propagating) stop and go shock waves forming in pedestrian streams.

There are yet other studies which relate to speed of pedestrian only. For example, Henderson and Lyons (1972) experimental male and female pedestrian in the same uniform mix follow different speed distribution. A similar, but more restraining, remark was also made by Polus et al. (1983), who observed that speeds of male pedestrians are far greater than female pedestrians. Young (1999) has done some speed studies on pedestrian in airport terminals. It is evident from the literature reviewed that till now reasonable numbers of experimental studies has been done on speed, density and their interrelationship. But, till now there is no experimental study available in literature to understand how pedestrian flow parameters (speed and density) change spatially and temporally, especially, in response to geometric and other factors of the flow space.

These motivated the present study. It can be thought that pedestrian movement is broadly classified as either movement inside enclosed spaces with few entry–exit points or movement through corridors. In this paper results from experiments on evacuation from a hall are presented. Results on lateral and longitudinal variations of density and speed along a corridor having geometric variations along it are presented in [21].This category of experiments is on evacuation from a hall with two doors. The width of the door openings as well as shape, size and positioning of obstacles are varied to change the nature of the goals and the geometry of the flow space. As stated earlier, these experiments are conducted to understand the impact of goals and the geometry of the flow space on pedestrian flow. Various experiments designed to investigate the progression of pedestrians while evacuating from a hall have been conducted as a part of this study [22].

2.2 PROBLEM STATEMENT

Studies on egress time and spatial-temporal progression of pedestrians inside are important for the design of exits of the hallway. In this study experiments on evacuation from a hall are conducted to understand the impact of exits and the geometry of the flow space on pedestrian flow. The width of the door openings as well as number, shape, size and positioning of obstacles are varied to change the nature of the goals and the geometry of the flow space. Results from this study explain how evacuation time from an enclosed space varies with number of persons inside the flow space and nature of exits present in the flow space as well as geometry of the space. Results also show how pedestrian distribute themselves inside the flow space while evacuating due to the above mentioned variations in the space. These results may help in enclosed space geometry and exits.

Chapter 3

MODELING PEDESTRIAN FLOW IN QUEUE

3. MODELING PEDESTRIAN FLOW IN QUEUE

Pedestrians behave differently in different situations. One of the interesting pedestrian flow spaces is queue before point based server. But, it should be such that our generalized model can explain every situation. Here, the main theme of the model remains the same; only requires some switches to be off and applying some modifications.

Depending on the number and arrangement of servers queues can be of three types:

a) Single server queue
b) Multiple serial servers queue, where each person needs service from any of similar servers in order series. Here, the departure of a queue is the arrival of its next queue. After taking service from one queue a person must join to its immediate next queue. So, there is no difference from single server queue in terms of queue dynamics. Only it has importance to queuing theory. So, this case will not be considered in this study.
c) Multiple parallel servers queue, where each person can take service from any of the identical servers. Parallel server queues are interrelated in terms of queue choices (either at joining or at later phase). So, this case is of interest to queue dynamics and will be considered for study here.

3.1 SOME BASICS OF QUEUEING THEORY

The behavior of customers in queue has some characteristic features like arrival process, size of the source from where arrival occurs and the waiting process. The feature of the queue space is the maximum number of customers allowed in the system. And the characteristic features of the server are service process, number of servers and service discipline. A convenient notation for summarizing the queuing situation is given by the following format

(a/b/c) : (d/e/f)

Where,

a: arrival distribution

b: departure distribution

c: number of parallel servers

d: service discipline

e: system size

f: source size

'a' and 'b' may assume any type of distribution like Markovian, Constant, Erlang, gamma or any General.

'c' is any finite number.

‘d’ may be ‘first in first out’ (FIFO), ‘last in first out’ (LIFO), ‘service in random order’ (SIRO) or ‘priority service’.

‘e’ and ‘f’ may be any finite number or infinite.

The waiting process which is not included in the above format (because of it being individual property) may be like

i) The customer waits until he is served.

ii) He does not wait at all but disappears immediately and never returns (BALK) or he may return after some time.

iii) He joins the queue. But, if after some time, which may vary from person to person he has still not been served, he disappears (RENEGE).

iv) He may change the queue in case of multiple parallel servers (JOCKEY).N.B. The key word queue length (Q) used throughout this study is the number of persons in the system (person getting service + number of persons in the queue).

Video recording

The flow was recorded in video tape and computerized to capture the temporal wandering of individuals in queue and the arrival/departure process. These two forms of raw data are the requirement of our study after processing and smoothening. Since we are using cellular movement it is necessary to divide the flow space into cells of grid. Since we are interested in the footsteps in the floor plan if we could be able to position the camera at the roof facing downwards it could record proportionate sizes. But, camera could not be positioned at the roof of the flow space but put at an elevated position focusing the queues. So, the near part will look bigger in comparison to the farther part. So, afterwards superimposing grid will be erroneous. To capture the actual size of grids the following method was followed:

The flow space is divided into cells of grid with lines of chalk. Now a colored measuring tape was held at on each line successively and recorded in the video camera. Later during observation inextensible black thread is pasted on each line to prepare the cells of grid.

Data analysis

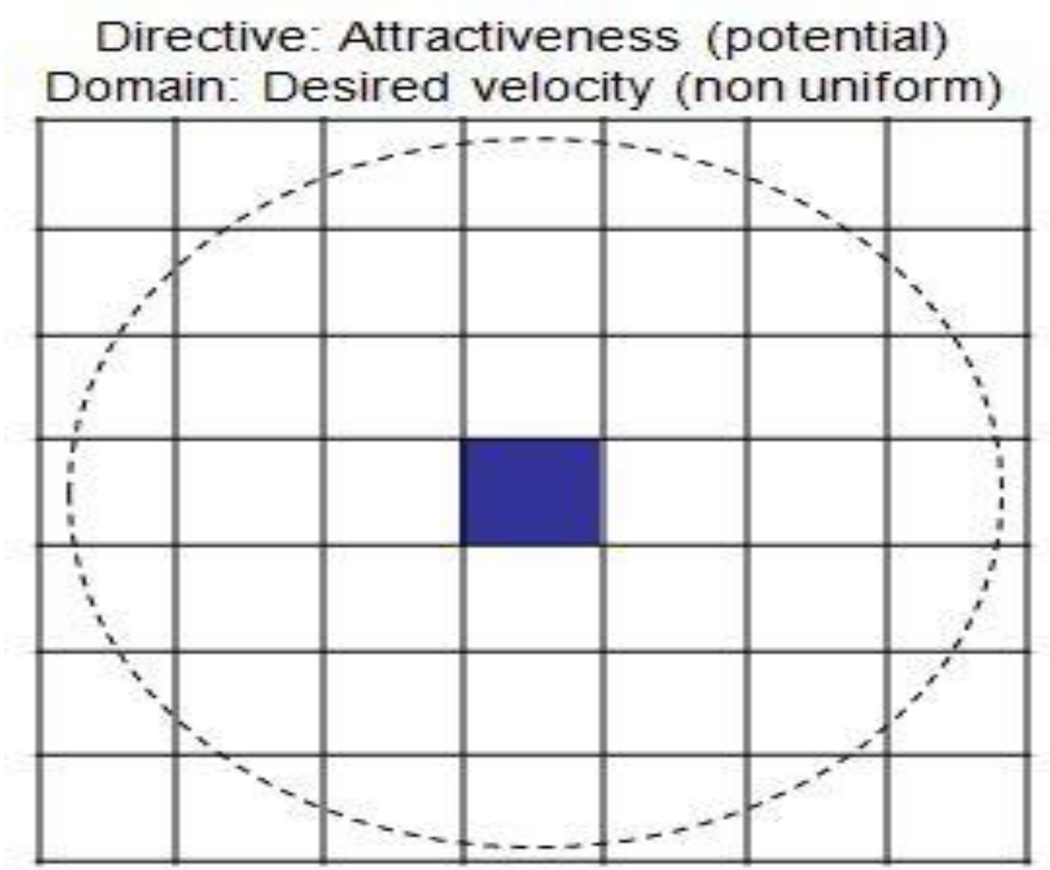
The video data were decoded to obtain the positions of pedestrian at every time step and arrival/departure time of every pedestrian which are used to determine the parameters defining the properties of queue.

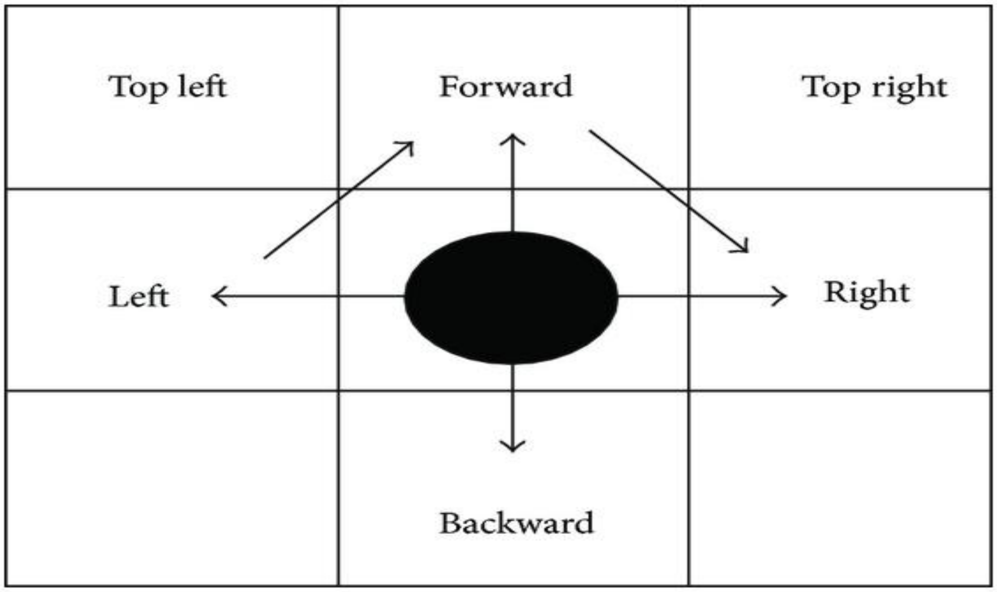
3.2 MODEL

The underlying structure may be a two-dimensional grid which might be closed periodically in one or both directions. Every cell will either be empty or occupied by specifically one particle (pedestrian). The scale of a cell corresponds to 0.4m × 0.4m. This is the everyday house occupied by a pedestrian in an exceedingly dense crowd [26]. For special situations it would be desirable to use a finer discretization, e.g. specified every pedestrian occupies four cells rather than one. During this paper, however, we consider the simplest case that looks to be sufficient for many functions. The update is finished in parallel for all particles.

The model during this experiment is presented within the two-dimensional plane system. The underlying social system could be a cell grid, wherever L is that the system size. Every cell will either be empty or occupied by precisely one pedestrian. The scale of a cell o.4 × 0.4. This house takes the pertinence of the model for the high density crowd seriously. According to [19] in line with, the human's body will show the deformation and compaction due to the pressure; the density of the group is probably failing to win in eight individuals per square meter in restricted shells. In [20] the foremost tolerable density of our country's crowd is nine persons per square meter at associate degree extreme state of affairs once a definite calculation. That's the explanation why most models don't accurately simulate the evacuation method.

The theme of the model is same as the parent model only some switches kept off and some modifications applied. The flow space is divided into units of square of size of one person (fig.1). The movement of pedestrians in the flow space is directed by some attractiveness which is the algebraic sum of some negative potential (due to attractors) and some positive potential (due to repellants). Pedestrians move to the most attractive cell (least potential) in the field. The field is defined by his desired velocity. The domain is a circle whose radius is equal to the distance he can move at one time step with his desired velocity (fig. 1).



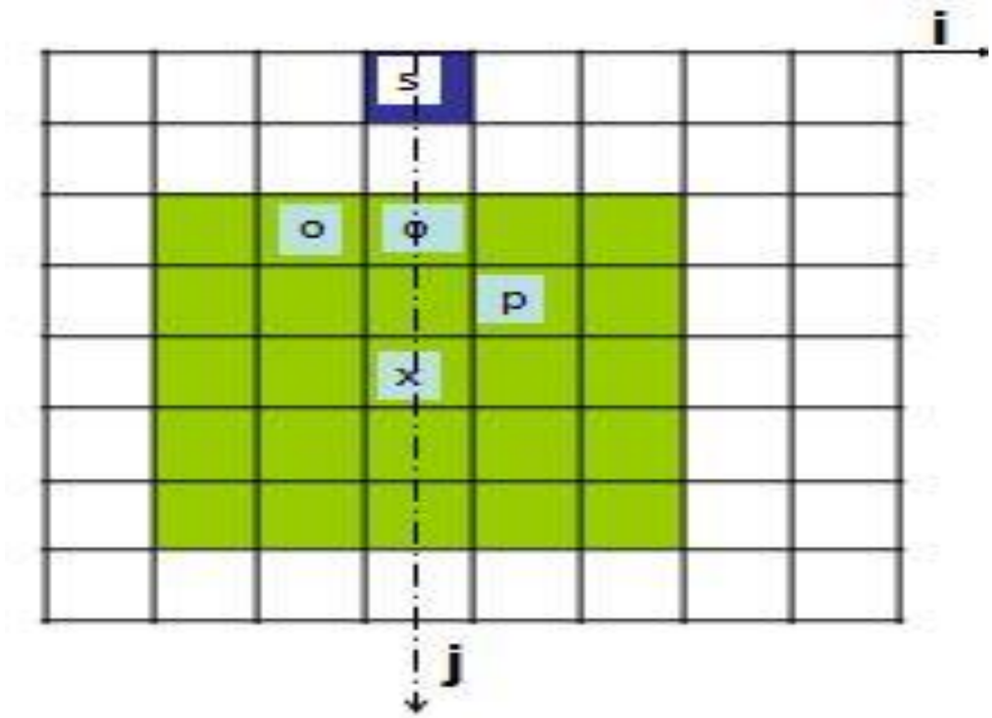


3.3 Potential

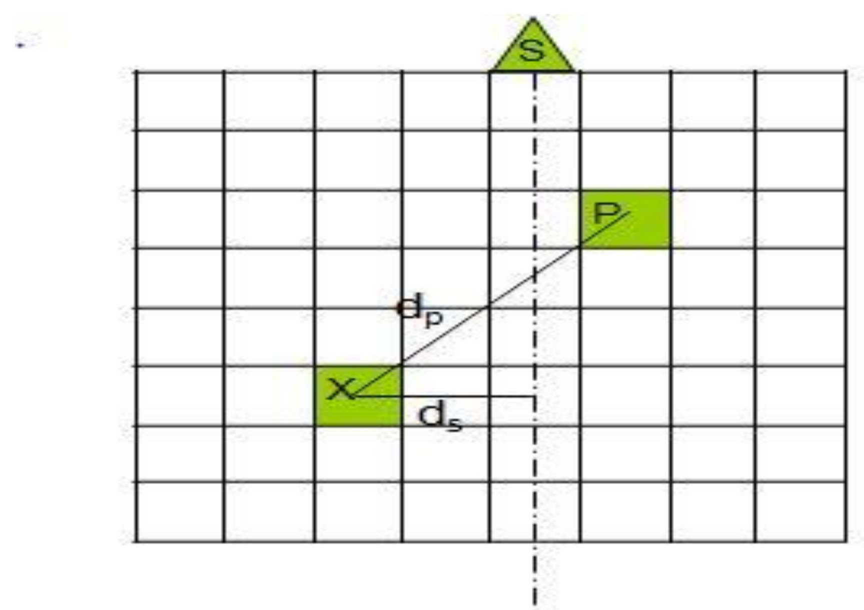
Although a person does not experience any sort of Columbic attraction/repulsion towards anything, but it can be imagined that he feels the urge to move towards the attractors and away from the repellants. This feeling can be incorporated to define the rule set of CA modeling. Some control factors decide the movement of pedestrians in the flow space. Here the targets are of two types i) ultimate target is the point based server ii) immediate target is the predecessor of the person besides which he needs to stand so that finally he can be able to reach the server. Although the server is the ultimate target he does not rush towards it breaking queue discipline rather stays close to the server center line remaining adjacent to his predecessor.

Both of these predecessor and server center line are attractors so they pose negative potential. During his stay in the queue he likes to keep the server at his eyes. So, the obstructions to his eyes towards the server cause inconveniences leading to positive potential. He also does not like to be close to other persons/obstacles. So, feels repulsion from them leading to positive potential.

So, these predecessor, server center line, obstacles etc. are control factors (fig.3). Now all of these potentials are functions of distance from the control factors.



Distances from attractors (fig.4)



$d_p = [(i_x-i_p)^2 + (j_x-j_p)^2]^{0.5}$

$d_s = |i_x - i_s|$

Where, d_p and d_s are the distances from predecessor and centre line of server

(i_x, j_x): coordinates of decision cell

(i_p, j_p): coordinates of the cell of the predecessor

(i_s, j_s): coordinates of the cell of the server

3.4 PROPERTIES OF QUEUE

The properties of a queue are its direction of spreading, serpentineness, compactness and queue length which are of necessity to design queue space.

Direction can be measured by the **angle** (**θ**) and the **intercept (σ)** made by the best fit straight line of the pedestrian colony with the perpendicular to the server plane at the midpoint of the server. This angle is measured in *degrees* and only the positive value is taken because the interest is to determine the amount of deviation, not in which side. It is expected that the queue should pass through the origin i.e. the first person of the queue almost adjacent to the server. So, if from the study it is seen that the intercept term is insignificant it can be eliminated. In this study it happened so and the intercept term got eliminated.

Serpentineness can be measured by amplitude and frequency assuming the queue as a sinusoidal curve.

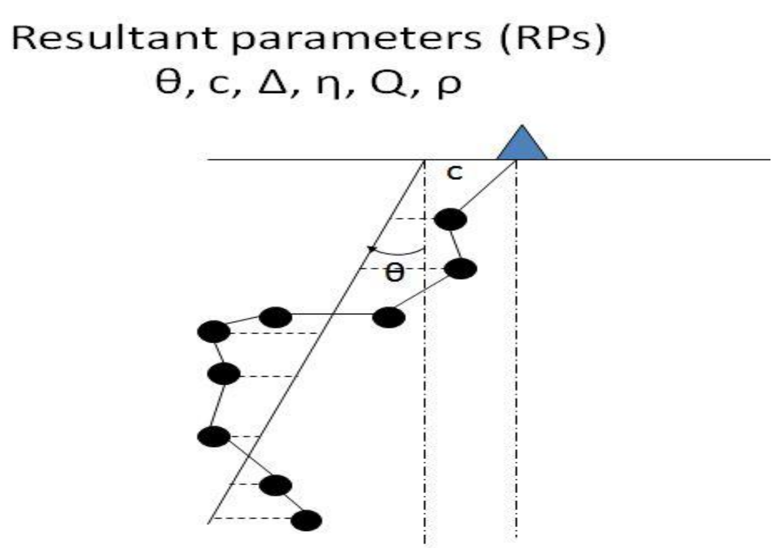
Amplitude (Δ) is the mean deviation (average absolute deviation) of persons in the queue from the best fit straight line. It has the unit of *m*.

Frequency (η) is the number of crisscrosses per person. Crisscrosses occur when the queue crosses best fit line from one side to another. It has the unit of *per person*.

Compactness can be measured by **density** (ρ). Density is the number of persons in unit length of the queue. It has the unit of *persons/m*.

Queue length (Q) is the number of persons in the queue. It has the unit of *persons*.

Queue joining criteria: Queue is defined as the continuous collection of people starting from server. Initially when a person comes in the system, he is not in queue. At that time he moves towards the queue considering the last person in queue as his predecessor. When he manages to keep his gap ($\leq d_{th}$) with the last person he becomes the last person of queue and obviously he is now in queue. Onwards he moves towards the server being the follower of his predecessor until he gets served and moves out of system (fig.5).



Chapter 4

Experimental setup-procedure and data decoding

4.1 Experimental setup-procedure and data decoding

These experiments on evacuation are conducted in an indoor hall with two doors and paved floor. The lighting in the hall was very good during the experiments. Figure 1 shows a schematic of the experimental set-up. The size of the goals and obstacles can be varied. Different combinations of the goal sizes and obstacles lead to different experiments. At their initial position they keep 0.4m gap from the person immediately ahead and immediately behind. They also keep 0.4m gap from the persons on either position. In all the experiments the pedestrians are initially in a waiting zone as shown in figure 1.

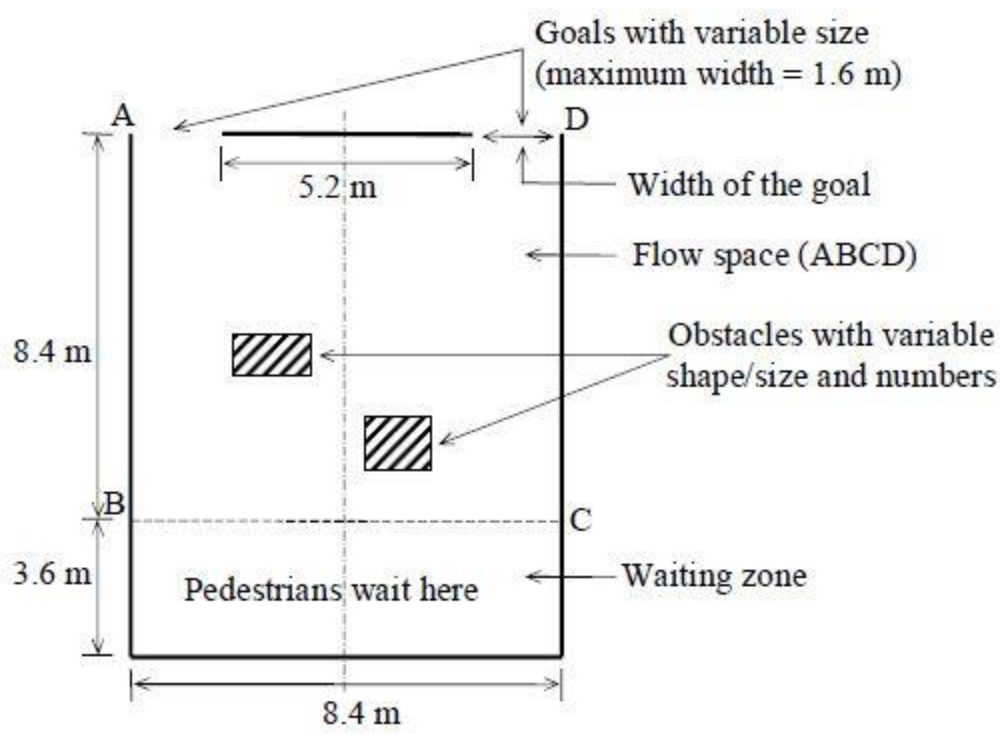


Fig.4.1 Sketch of the flow space for evacuation from a hall (adopted from U.Chattaraj (2013)).

This 0.4m is approximate body size of a human being. After the instruction to start is given the pedestrians move through the flow space at their comfortable speed and go out of the flow space through the goal (door) of their choice. Each experiment is conducted three times. Data is collected by video recording by overhead camera. In order to determine the position of pedestrians on the flow space a grid (0.4 m × 0.4 m) is constructed using thin but highly visible wires at a height of 1.65 m (this is approximately equal to the average height of Indian people [23]) from the ground. Once the grid is constructed the fixed cameras record this grid. Once the grid is recorded neither the camera position nor the camera angle is altered till all the experiments are over. The grid is removed before the experiments begin. The video recordings of the experiments are projected on a 53 inch television for extraction of data. Before beginning to extract data from the recording, the grid recorded by the camera is painstakingly recreated by using removable marker to mark each line of the grid on the television screen. These lines on the screen constitute a virtual grid on which the motion of pedestrians recorded on tapes is played back. For every experiment, at every instant of time't' the cells (i, j) that are occupied are noted .The set of experiments conducted here are as follows:

(i) Both doors are fully open; no obstacle present in the flow space.

(ii) Left door is fully open and right door is half open; no obstacle present in the flow space.

(iii) Both doors are half open; no obstacle present in the flow space.

(iv)Left door is fully open and right door is closed; no obstacle present in the flow space.

(v) Left door is half open and right door is closed; no obstacle present in the flow space.

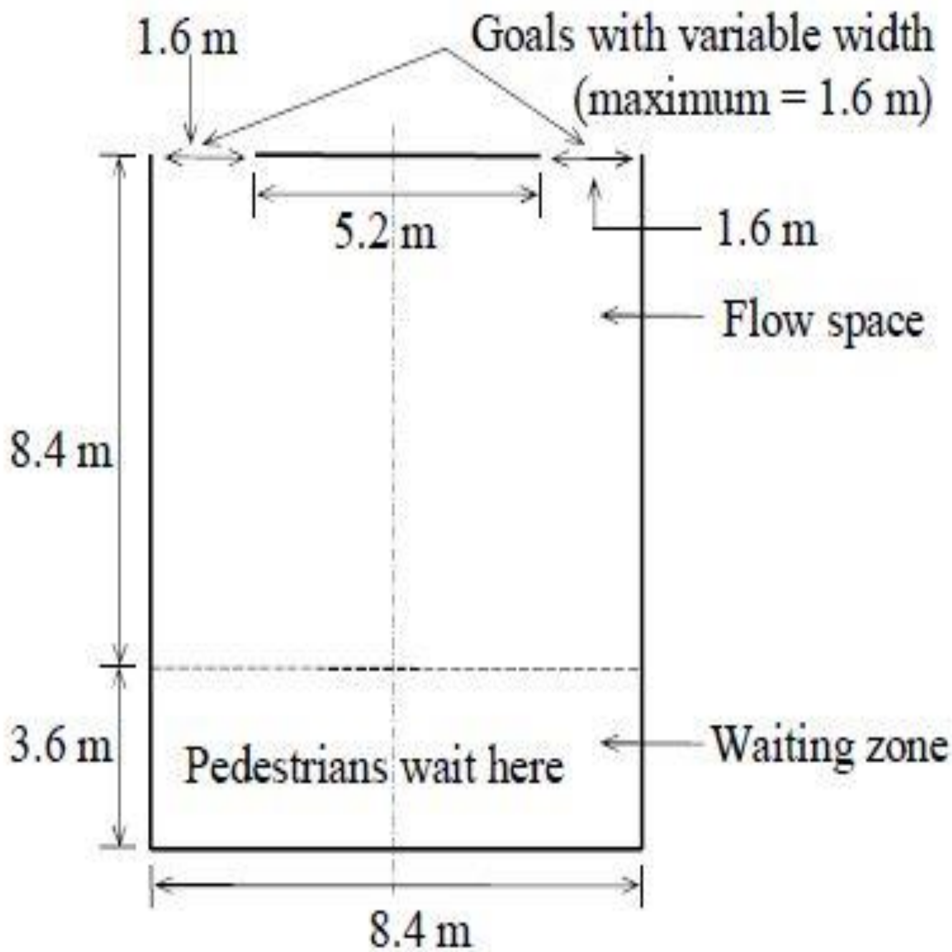
(vi)Both doors are fully open; a rectangular obstacle in the form of a barrier as shown in Fig.2 (a) is in the flow space.

(vii) Both doors are fully open; an obstacle near the initial position of the pedestrians as shown in Figure 2 (b) is placed in the flow space.

(viii) Both doors are fully open; a rectangular obstacle near the left door as shown in Figure 2 (c) is placed in the flow space.

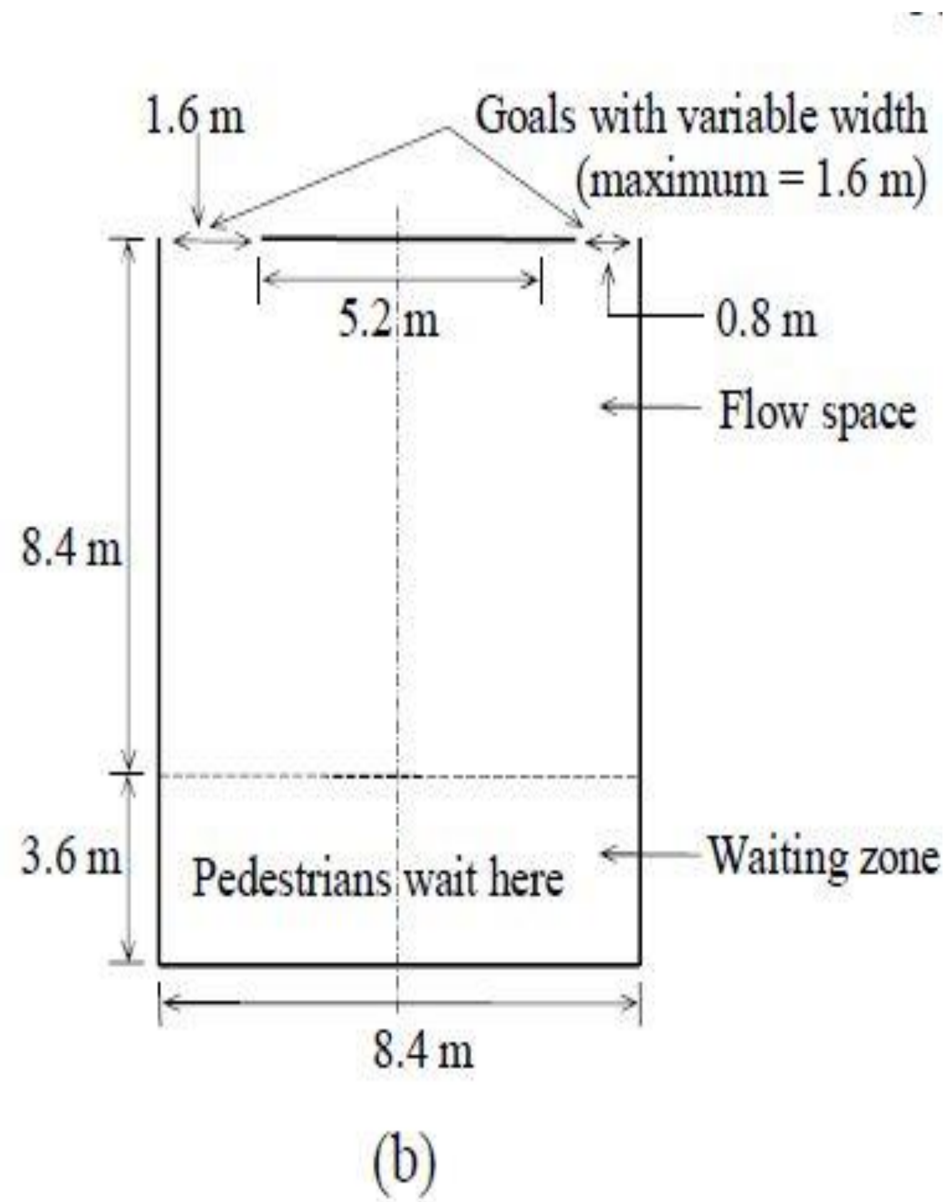
Sketch of flow space for evacuation when both the doors are fully open and (a) a rectangular obstacle in the form of a barrier (b) an obstacle near the initial position of the pedestrians and (c) a rectangular obstacle near the left door In all the three cases where obstacles are present, height of the obstacle is kept low so that the doors are visible. Further, each experiment is done with one levels of initial density; in one set of experiments 14 people are used. The subjects are all male in the age group of twenty to thirty and during the experiments they standing position is same. They are not interacting with one another. Once see the below snap for how to pedestrian movement and how to get to the destination. These results may help in the geometry of the width and exit design.

Above snap represent Both Doors Fully Open (Rectangular obstacle near left door)(adopted from U chattaraj (2013)).

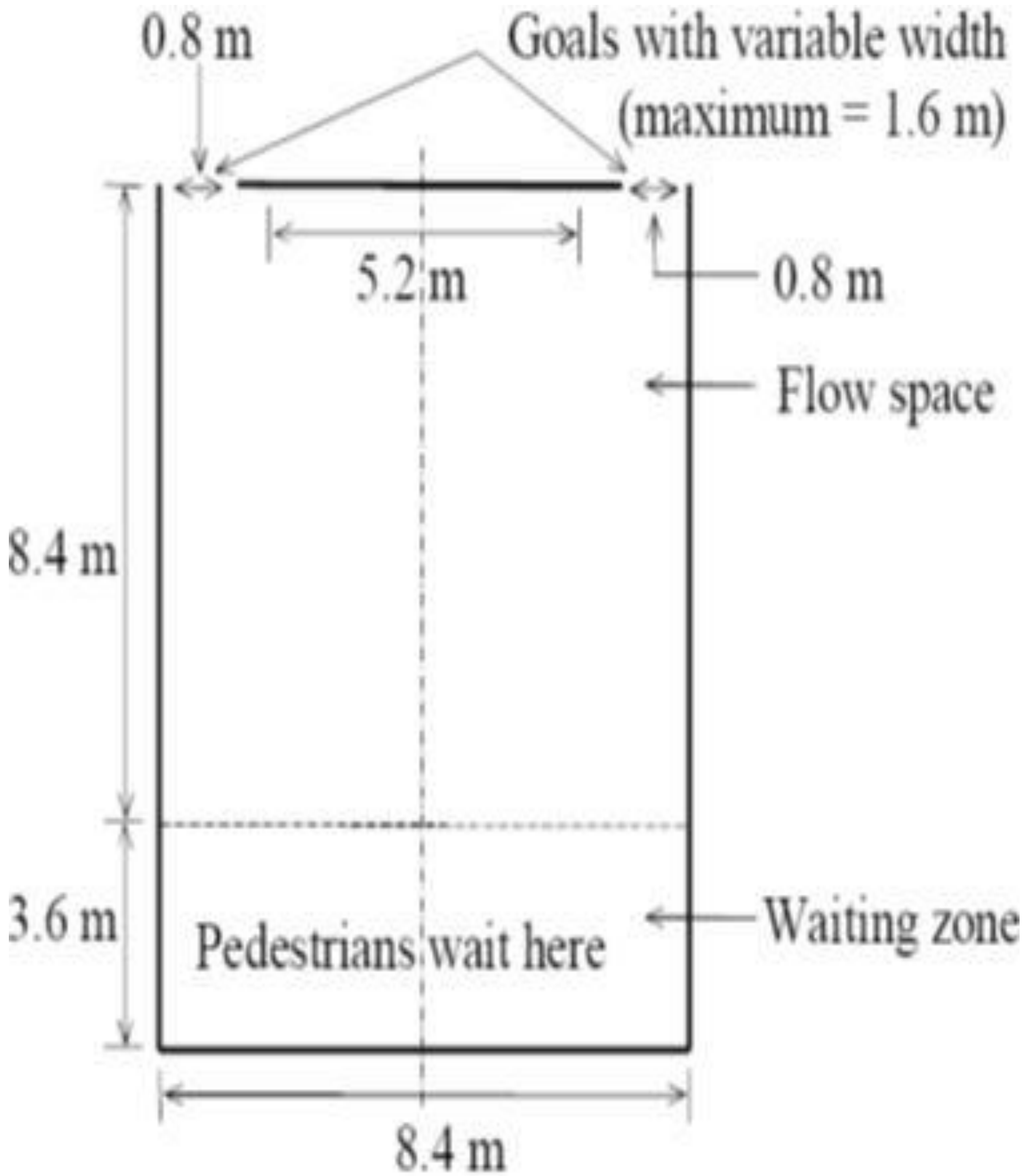


(a)

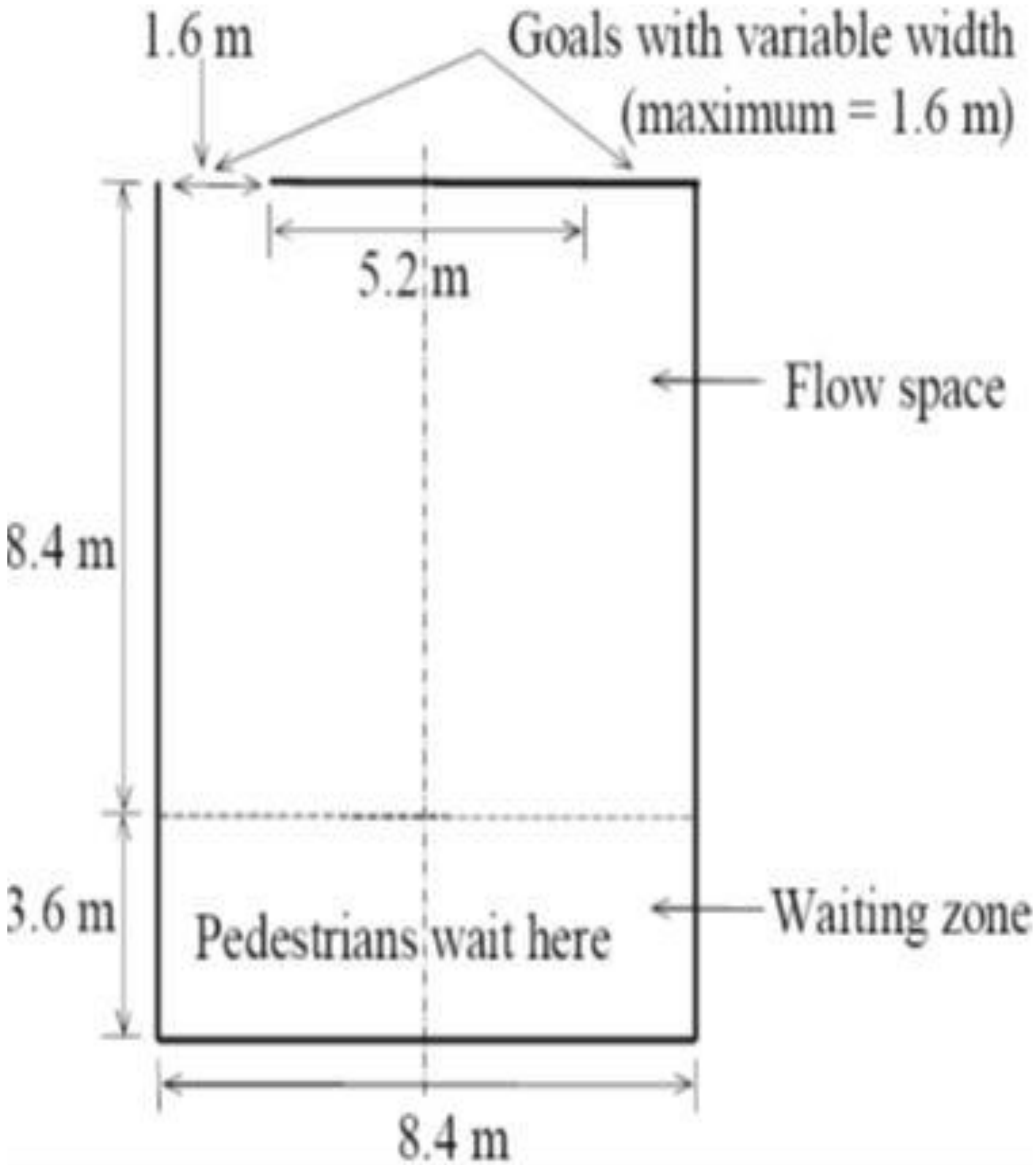
Show the Figure 4.1(a), 4.1(a) represent both doors are fully open and there measurements,(adopted from U chattaraj(2013)).



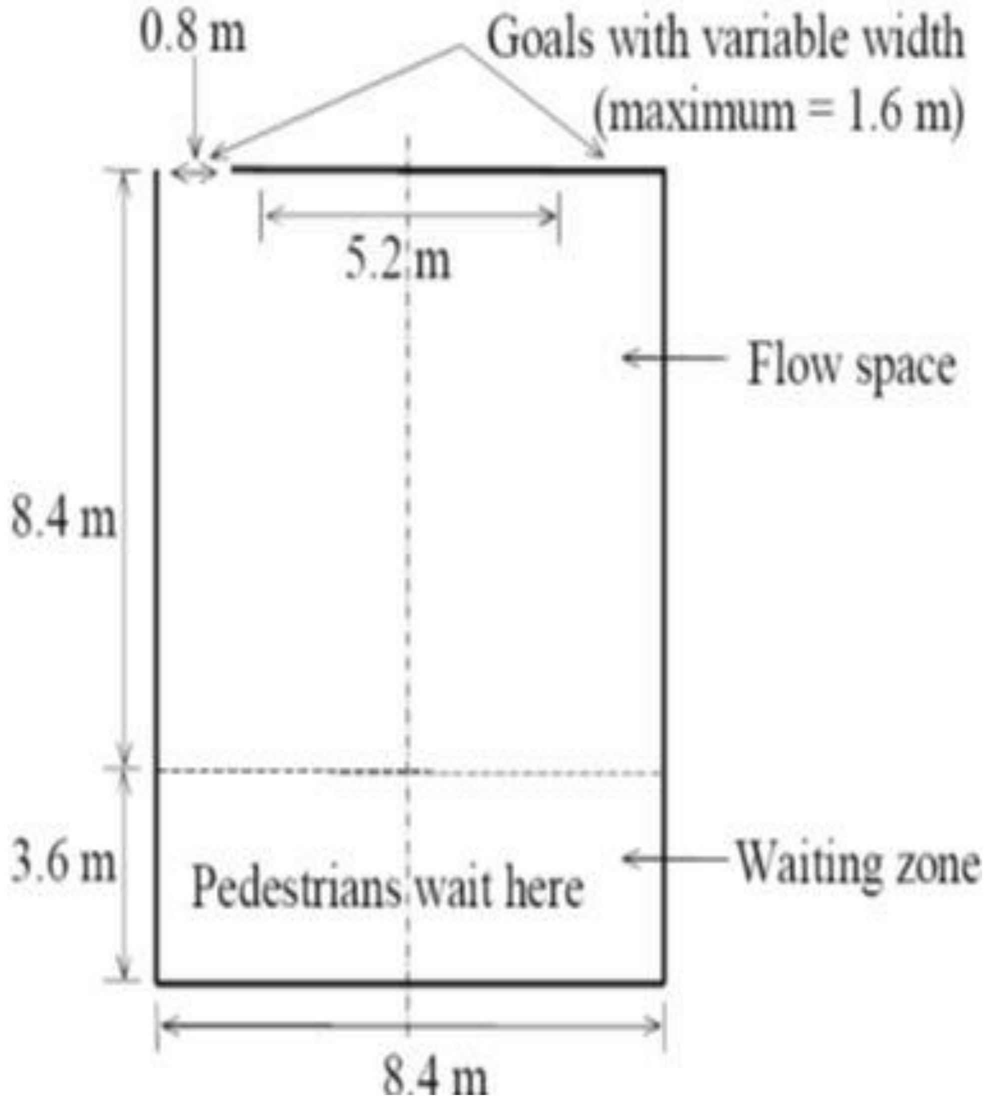
Sketch of flow space for evacuation when 4.1(b) Left door fully open, (adopted from U chattaraj (2013)).



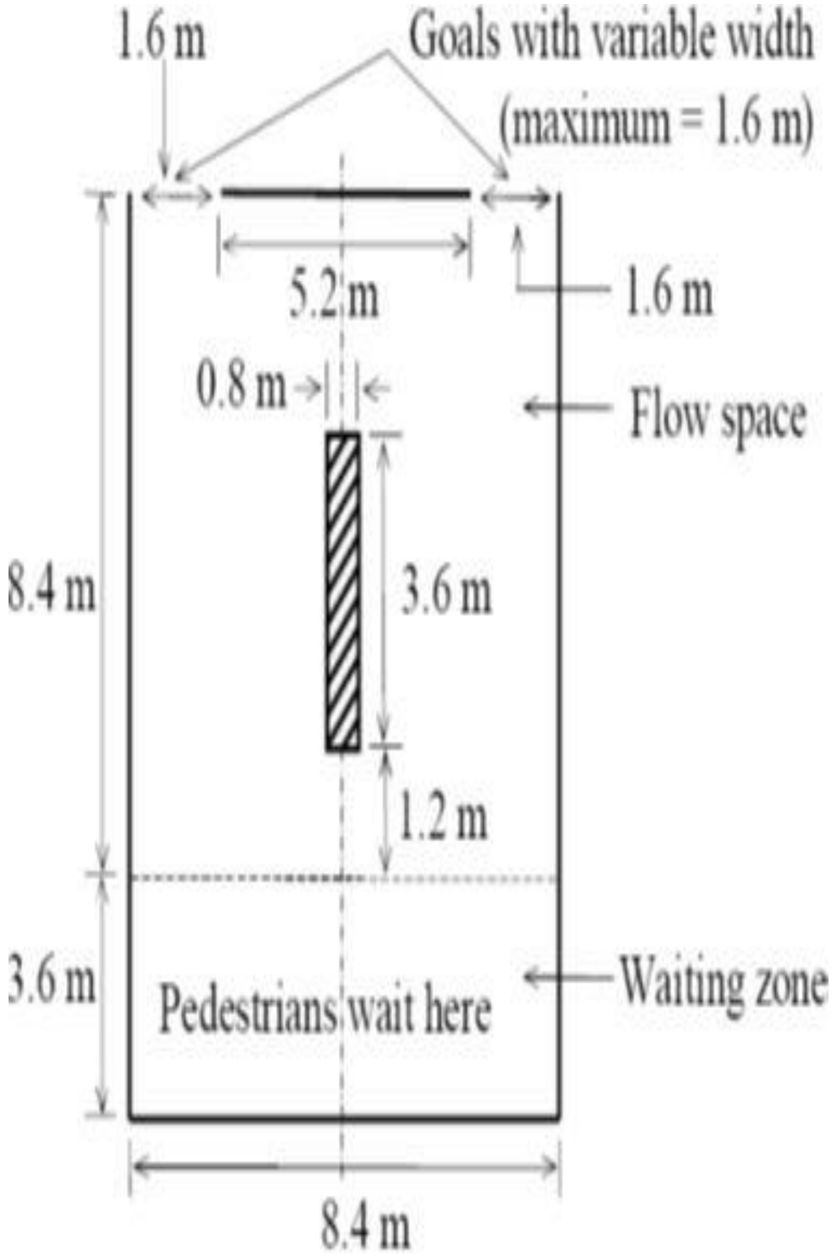
Above figure represent 4.1(c) left door is half open and right door is also half open and there measurements in this figure adopted from U chattaraj (2013).



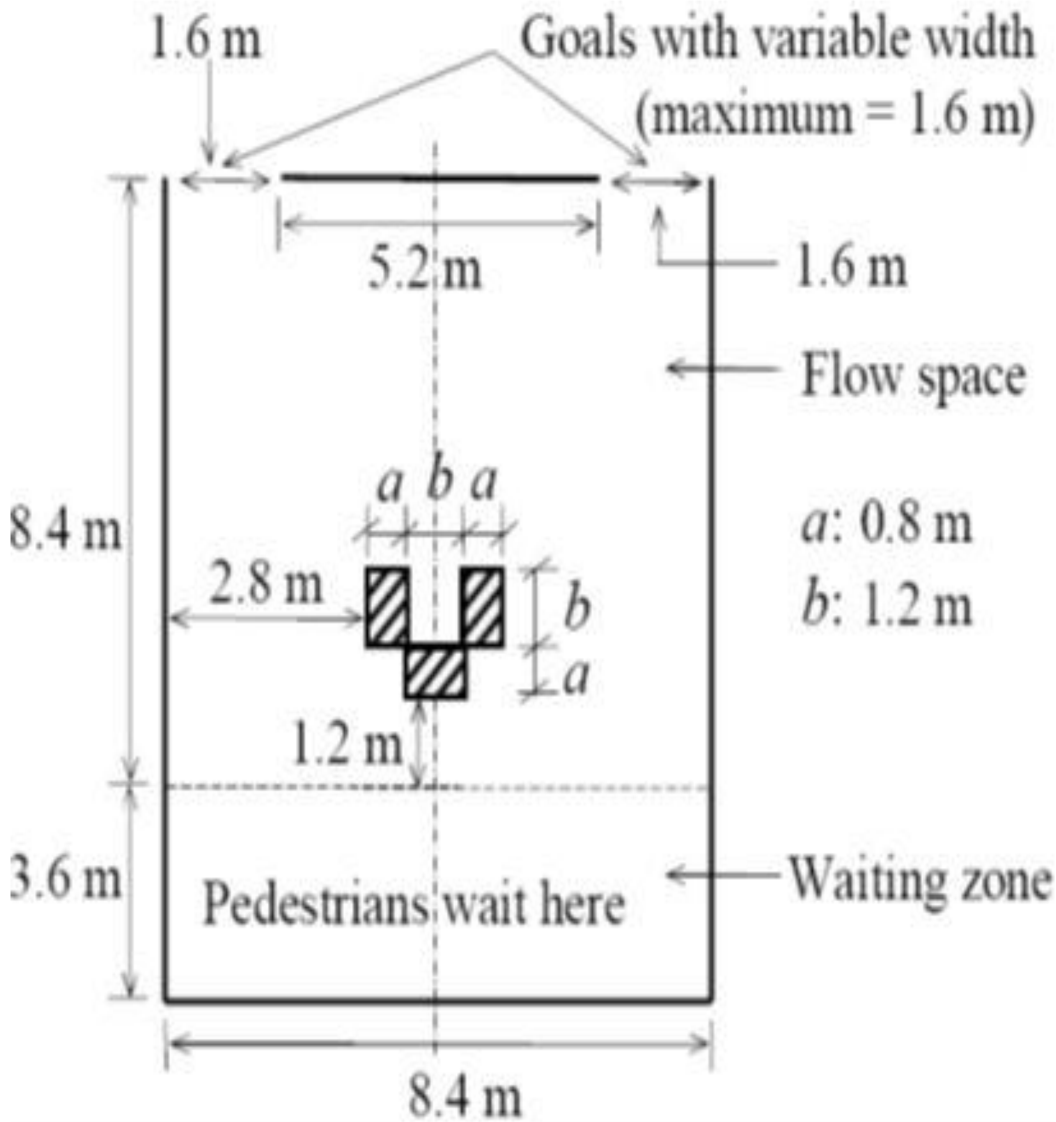
Sketch the above fig 4.1(d) represents left doors fully open, (adopted from Ujjal chattaraj (2013)).



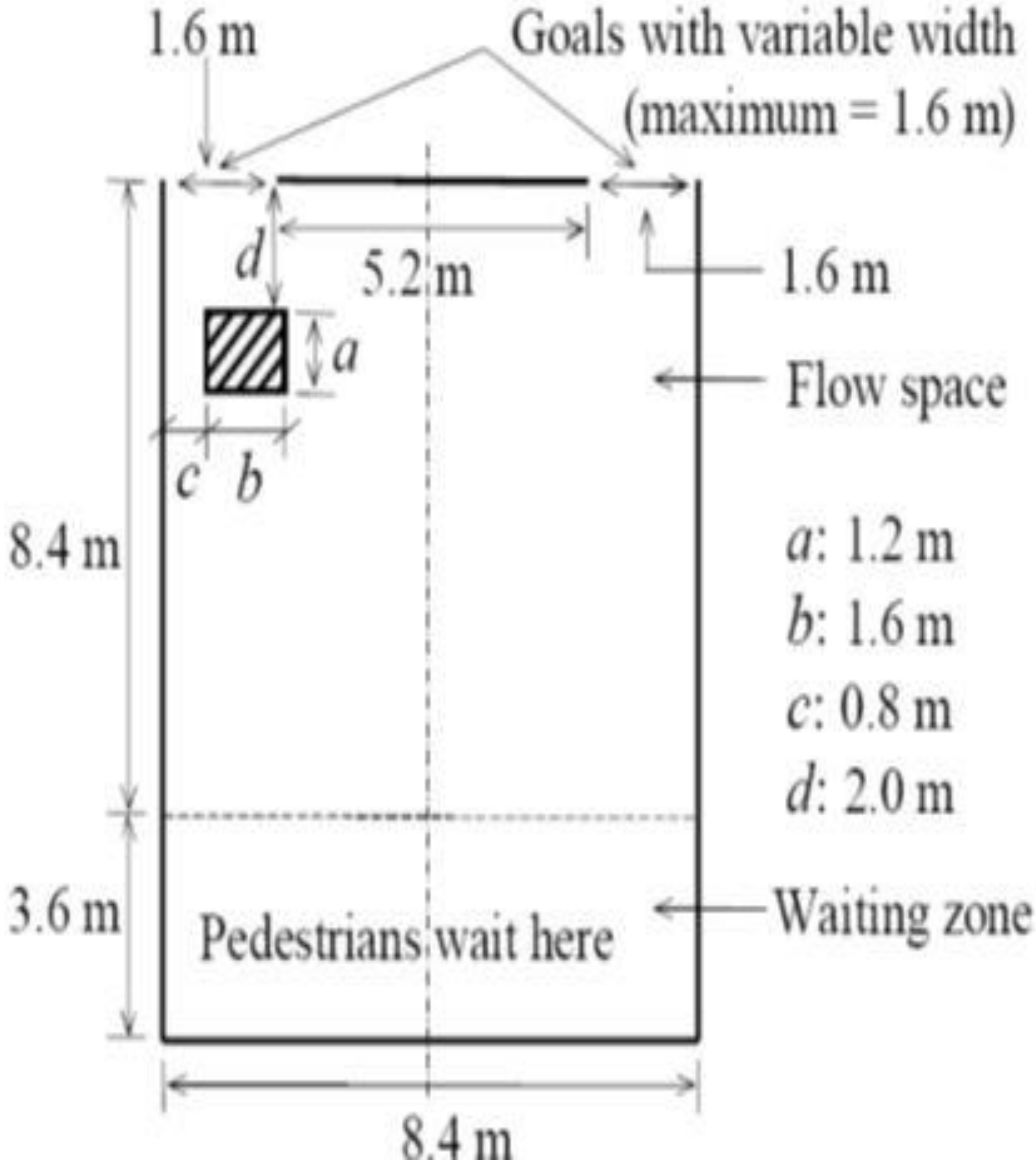
Above figure represent 4.1(e) left door half open and right door closed in this case also find the trajectories, in this figure adopted from U chattaraj (2013)



Above figure represent 4.1(f) both doors are fully open and Rectangular Obstacle in the Form of a Barrier in this case also draw trajectories. Adopted from U chattaraj (2013).



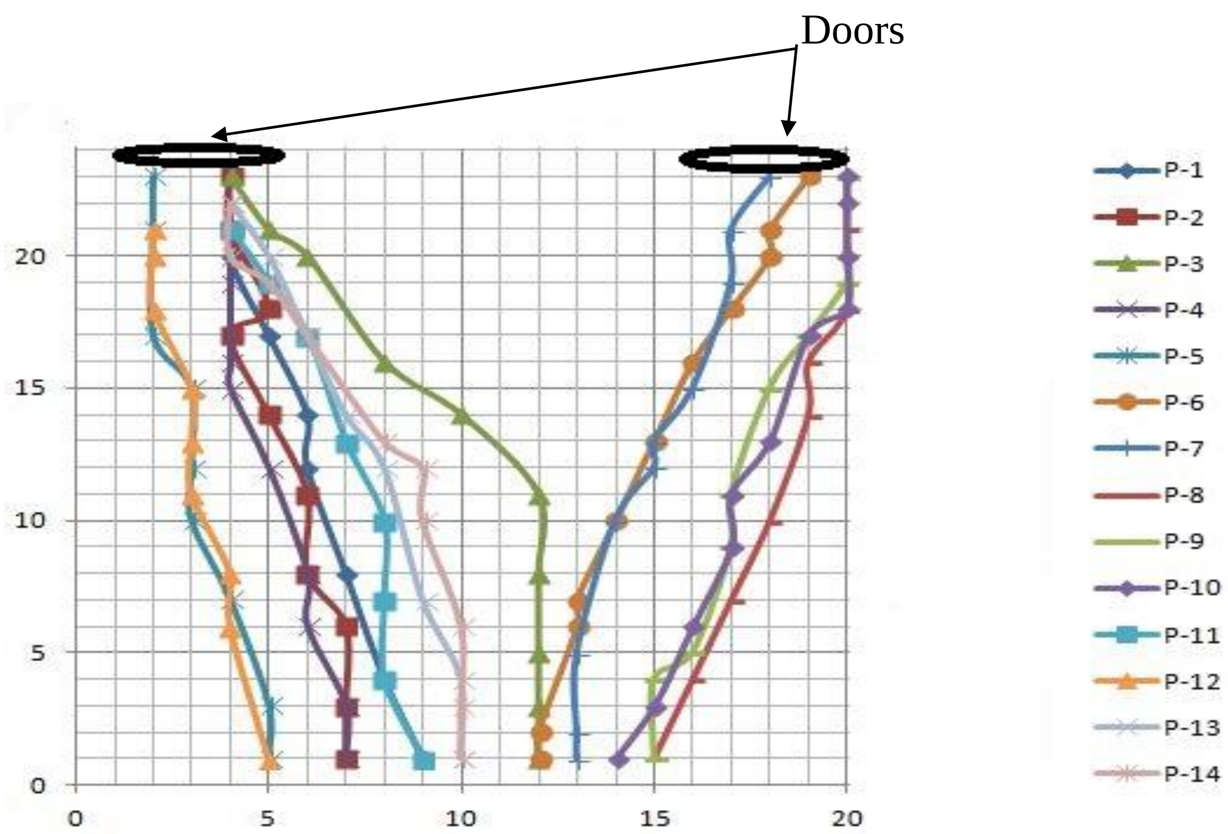
Above figure represent 4.1(g) both doors are fully open and Rectangular Obstacle near Initial Position of Pedestrians) in this case also draw trajectories. Adopted from U chattaraj (2013).



Above figure represent 4.1(g) both doors are fully open and Rectangular Obstacle near Left Door)) in this case also draw trajectories. Adopted from U chattaraj (2013).

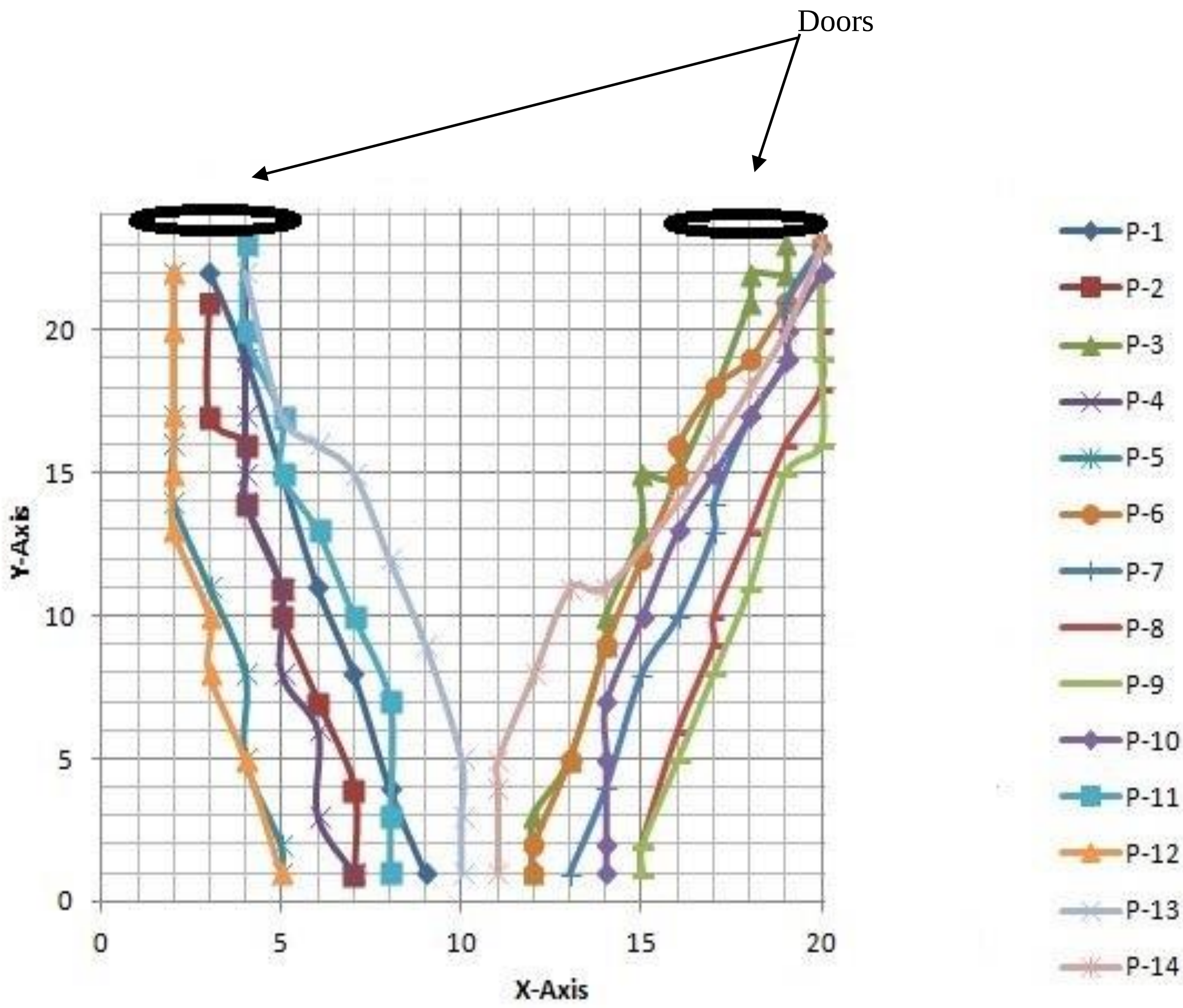
4.2 Experimental Results and Analysis

4.2.1 Case: 1 Both Doors Fully Open



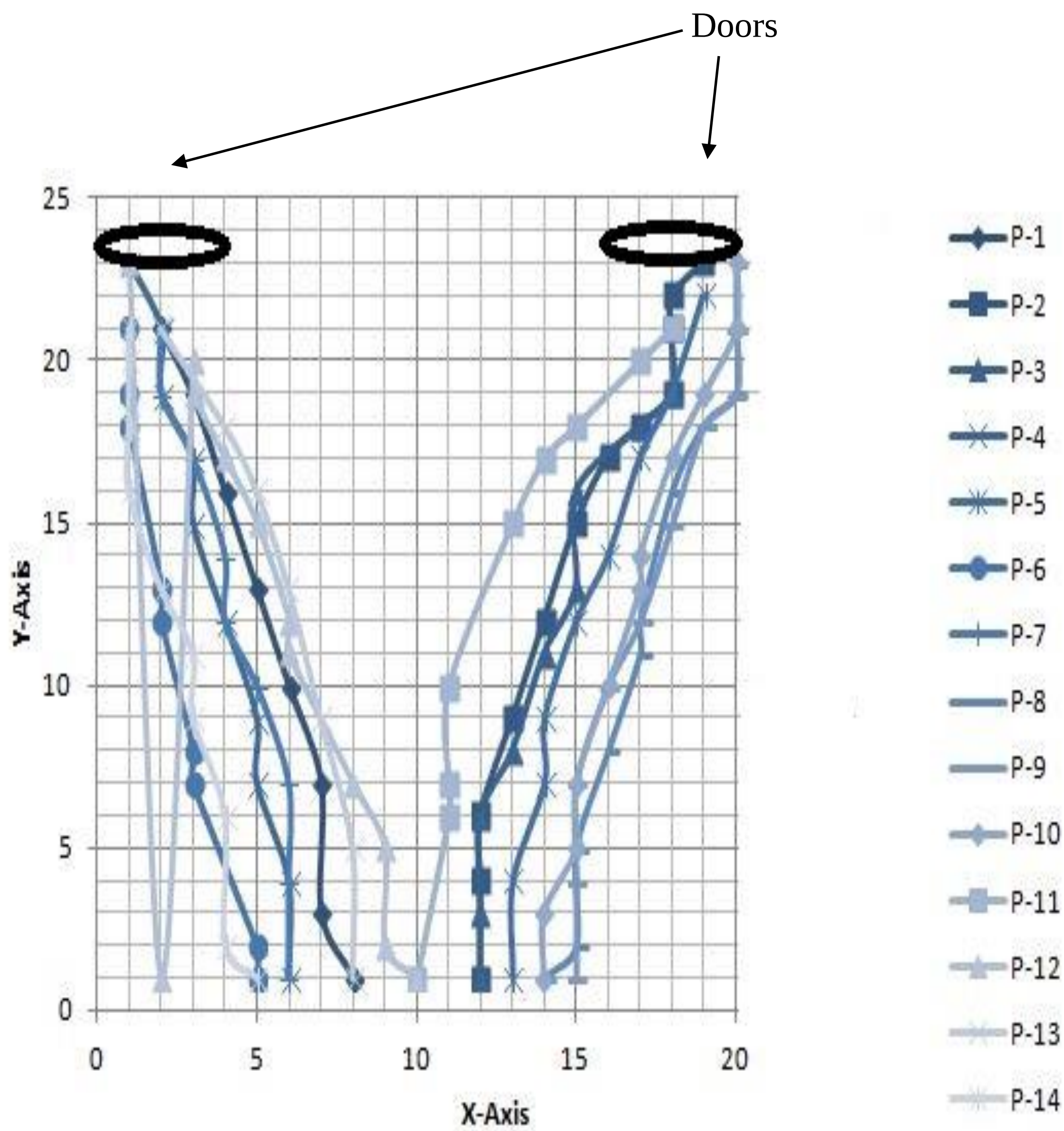
Sketch of flow space for evacuation when both the doors are fully open and (a) a rectangular obstacle in the form of a barrier (b) an obstacle near the initial position of the pedestrians and (c) a rectangular obstacle near the left door. In total 14 persons Walking time and they will walk path all data was considered. In that Data using I was Draw pedestrian trajectories, in the above graph Represented to case 1 (Both doors fully open) After Data decoding. Sketch of flow space for evacuation when both the doors are fully open, Experiment is done with one set of experiments 14 people are used.

4.2.2 CASE: 2 (Left Door Fully Open and Right Door Half Open)



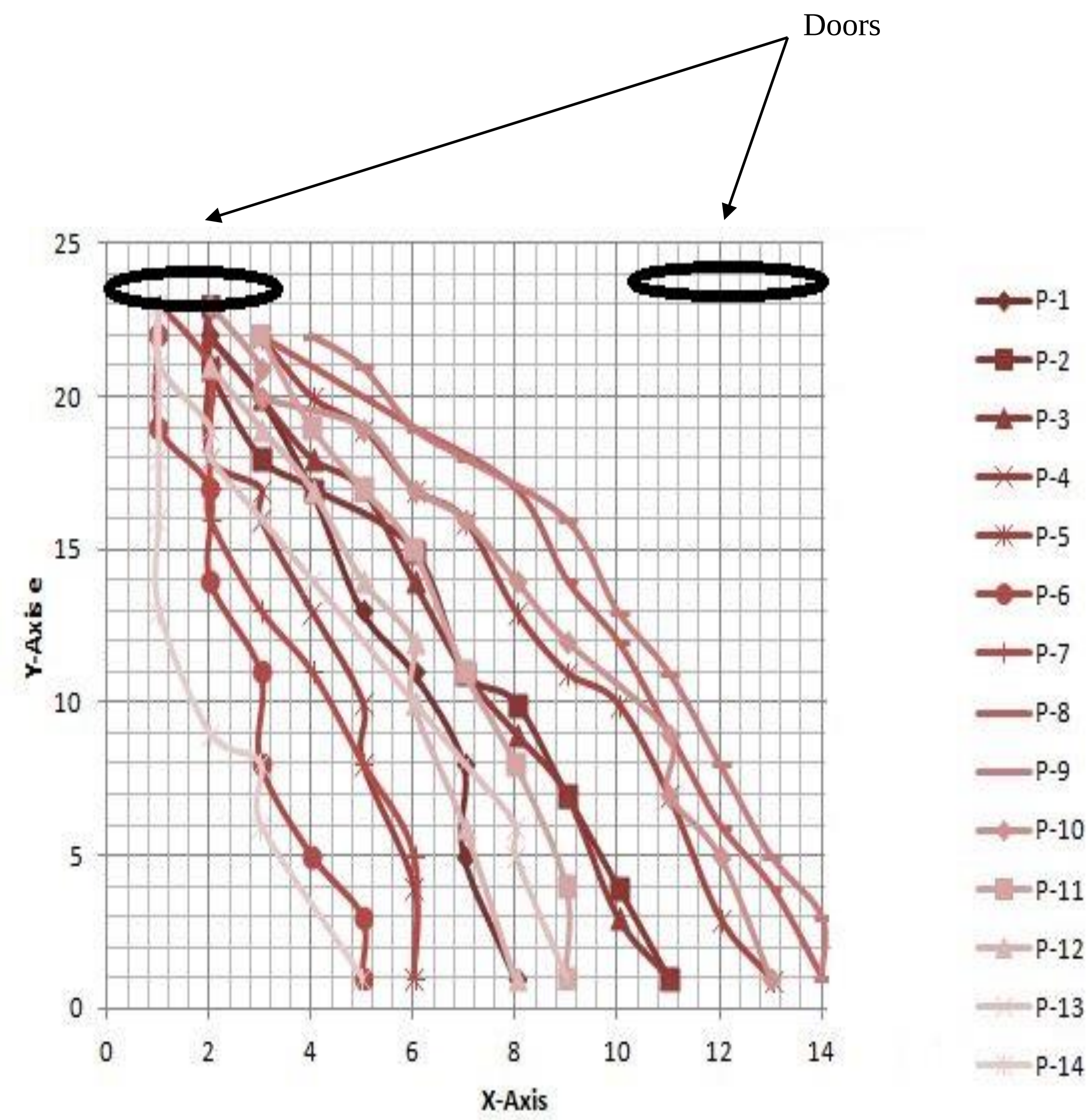
Sketch of flow space for evacuation when both the doors are fully open, Experiment is done with one set of experiments 14 people are used. Above graph represent total 14persons trajectories.

4.2.3 CASE-3 (Both Doors Half Open)



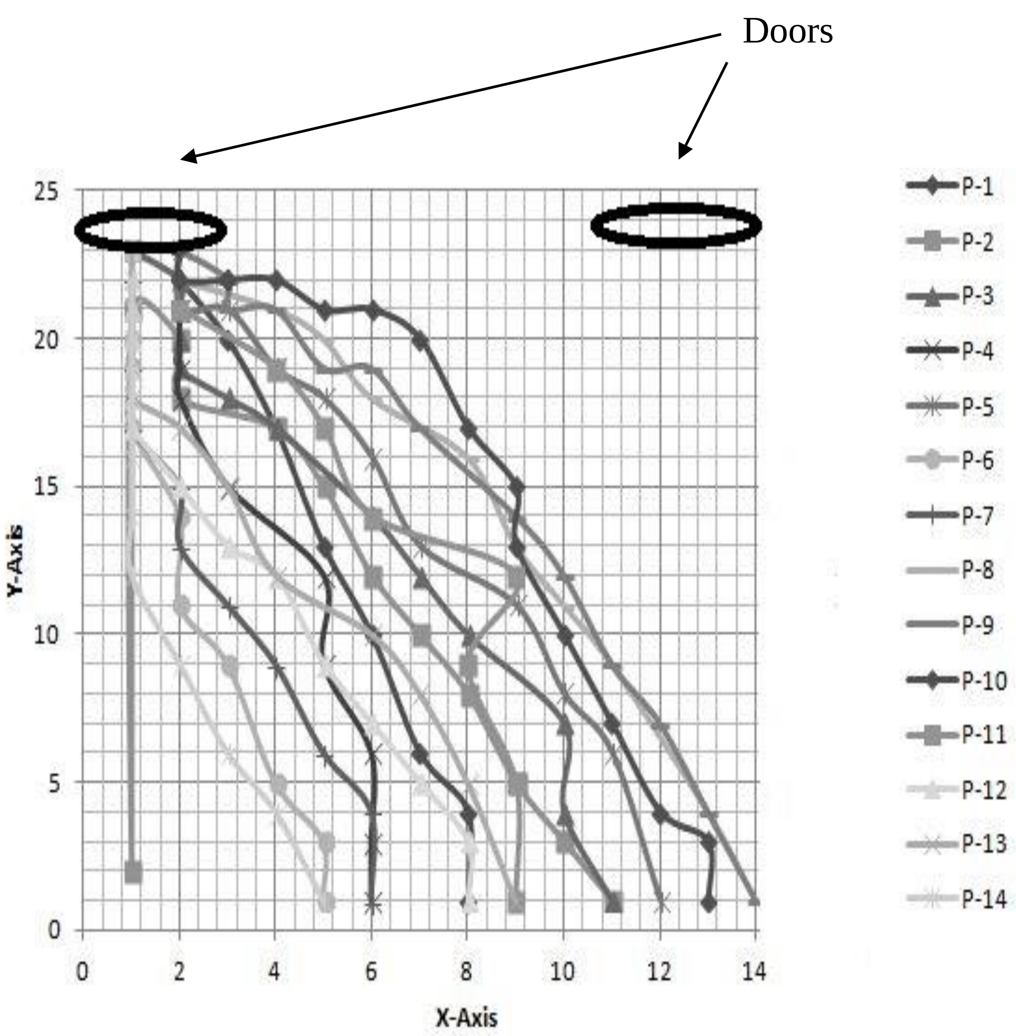
Sketch of flow space for evacuation when both the doors are Half open, Experiment is done with one set of experiments 14 people are used. Above graph represent total 14persons trajectories.

4.2.4 CASE 4 (Left Door Fully Open)



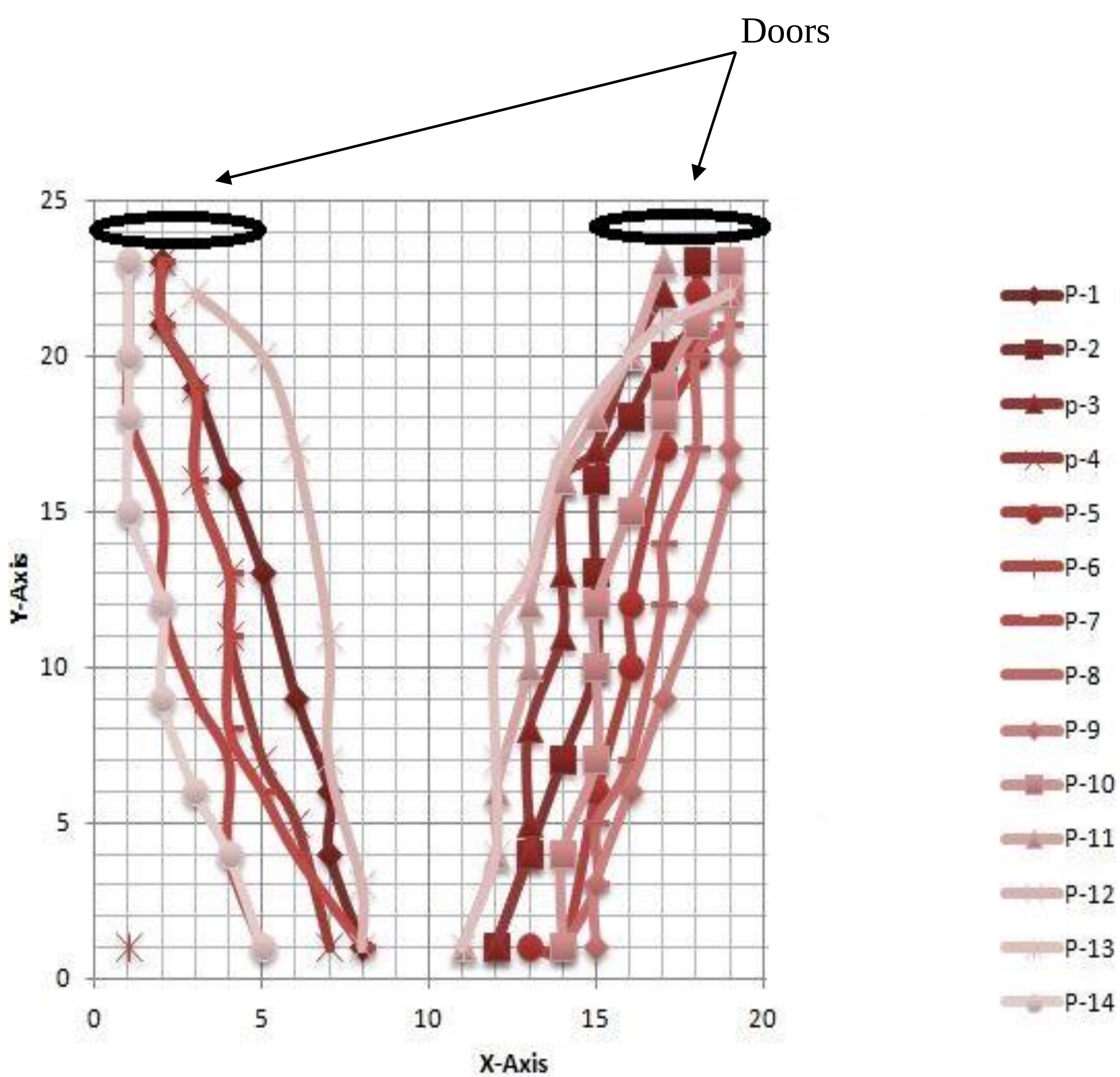
Sketch of flow space for evacuation when both the doors are Half open, Experiment is done with one set of experiments 14 people are used. Above graph represent total 14persons trajectories.

4.2.5 CASE 5 (Left Door Half Open & Right Fully Close)



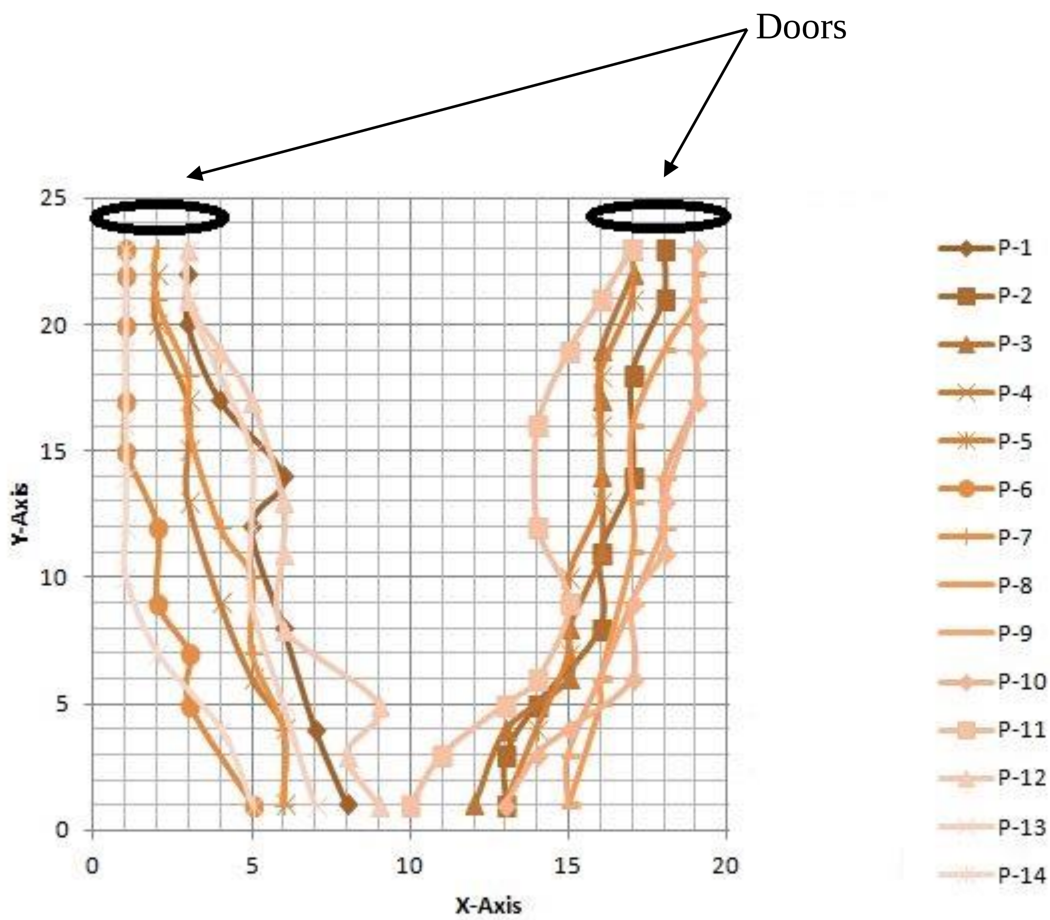
Above graph represent flow space evacuation when left door half open and right door closed. Experiment is done with one set of experiments 14 people are used. Above graph represent total 14persons trajectory

4.2.6 CASE 6 Both Doors Fully Open (Rectangular obstacle in the form of a barrier)



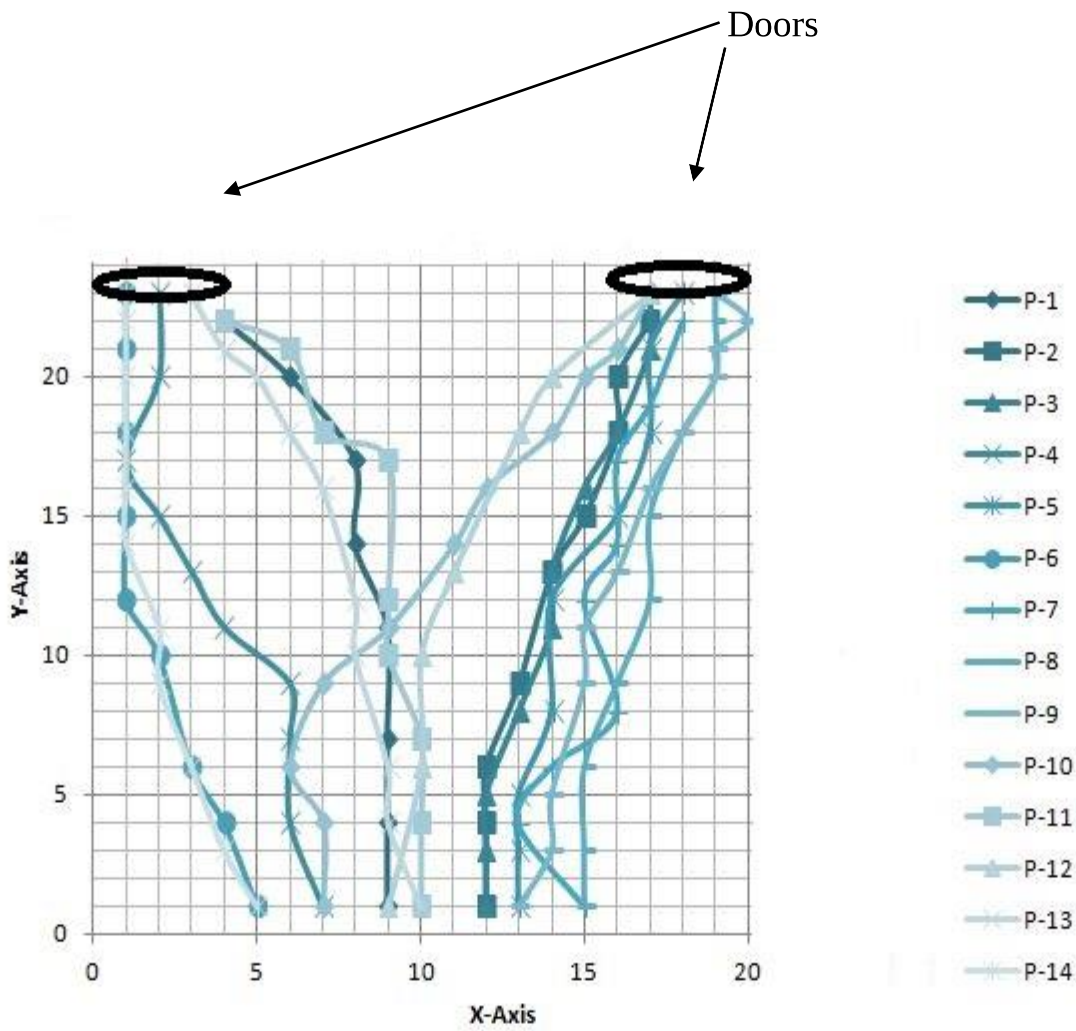
Above graph represent flow space evacuation when both doors fully open (Rectangular obstacle in the form of a barrier).Experiment is done with one set of experiments 14 people are used. Above graph represent total 14persons trajectories.

4.2.7 CASE 7: Both Doors Fully Open (Obstacle near initial position of pedestrians)



Above graph (5.7) represent flow space evacuation when Both Doors Fully Open (Obstacle near initial position of pedestrians).Experiment is done with one set of experiments 14 people are used. Above graph represent total 14persons trajectories.

4.2.8 CASE 8: Both Doors Fully Open (Rectangular obstacle near left door)



Above graph(5.8) represent Sketch of flow space for evacuation when both the doors are fully open (Rectangular Obstacle near left Door).in set of experiment 14 persons are used and there trajectories show in the above graph.

Chapter 5

Results & Discussion

Results & Discussion

As the initial bit of pedestrian increase the total evacuation time, increase because of the fact that at higher density, pedestrian, movement get obstructed frequency, and

i. In this study find a trajectories of the pedestrian.
ii. The collective effective observed in the motion of pedestrian
iii. In this study Results may help in designing enclosed space geometry and Exits.
iv. In this study experiments on evacuation from a hall are conducted to understand the impact of issues and the geometry of the flow space on pedestrian flow.

Conclusion

These experiments on pedestrian motion in a closed space with varying number and width of exit Locations and different obstacle position, size and shape yield among other things information On:

(i) Pedestrians are how to choose an exit and bears upon their movement,
(ii) The effect of obstacles on pedestrian movements, and
(iii) In this pedestrian evacuation process discuss how exit geometry (width) affects.

"It needs to be mentioned that these types of experiments help in understanding pedestrian motion inside enclosed spaces, which is essential for design of those spaces"

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