A STOCHASTIC APPROACH FOR VEHICLE PEDESTRIAN INTERACTION ON TRAFFIC FLOW

A.Rajini devi[1], B.H. Nagendra Rao[2]

1P.G. student, Civil Engineering Department, Malla Reddy Institute of Technology, Telangana, India
2Professor, Civil Engineering Department, Malla Reddy Institute of Technology, Telangana, India

ABSTRACT

Several studies are there to understand the pedestrian movement and all the studies are based on fundamental diagrams only. These studies construct a base to characterize pedestrian flow. Several experiments have conducted to understand the pedestrian flow, some field observations have done to represent fundamental diagrams. Therefore, before going to analyze the data obtained from the observation, it is necessary to study the pedestrian flow parameters carefully.

The aim of the paper is to build up the base to study the fundamental diagrams and for characterization of pedestrian. Then derive the required flow diagrams and obtain results to suit the field observations. Field survey is conducted to know the vehicle pedestrian interaction, and this field data with respect to pedestrian crossing at signalized, unsignalized or at midblock sections is aimed to be observed. And the impact of vehicle pedestrian interaction at several intersections/midblock sections is to be studied. To do this, two places are chosen in Hyderabad.

It is aimed to observe whether the pedestrian fundamental diagram is different in alternate locations or not. In this study it can prove that fundamental diagrams are different in different locations in Hyderabad.

Keywords: *disturbed and undisturbed pedestrian crosswalk movement, signalized unsignalized and midblock sections, fundamental diagrams, vehicle pedestrian interactions*

---

1. 1. INTRODUCTION

Walking has always been the primary means of human motion. And that’s why we considered the pedestrians are the basic elements of transportation. In ancient ages there was a huge pedestrian walking take place and walking is the only mode of transportation. For every transport related to travel and journeys must begin and end in walking. This pedestrian walk is an effective mode of transportation for short trips. Walking is a major mode of transportation in Indian cities also. In order to provide the best design spaces for human motion or circulation like at airport corridors, shopping malls, subways etc. for that pedestrian motion is studied empirically in all aspects. It is carried away by two levels. At macroscopic level one can analyze the basic flow parameters like speed, density of pedestrian motion and at microscopic level one may track the paths followed by individual pedestrians while moving respectively. From this it is clear that the pedestrian may create own paths in their journey trip. People walk for many reasons: to go to a neighbor’s house, to run errands, for school, or to get to a business meeting. People also walk for recreation and health benefits or for the enjoyment of being outside. Some pedestrians must walk to transit or other destinations if they wish to travel independently. It is a public responsibility to provide a safe, secure, and comfortable system for all people who walk. In this lecture we will discuss about the pedestrian problems, pedestrian survey (data collection), characteristics, different level of services, and design principles of pedestrian facilities. There are many problems related to safety security of pedestrians. These are discussed below in brief.

Factors affecting pedestrian demand

1. The demand for pedestrian facilities is influenced by a number of factors of which some of the most important are, **The nature of the local community**- Walking is more likely to occur in a community that has a high proportion of young people.
2. **Car ownership** -The availability of the private car reduces the amount of walking, even for short journey.
3. **Local land use activities**- Walking is primarily used for short distance trips. Consequently the distance between local origins and destinations (e.g. homes and school, homes and shops) is an important factor influencing the level of demand, particularly for the young and elderly.
4. **Quality of provision**- If good quality pedestrian facilities are provided, then demand will tend to increase.
5. **Safety and security**- It is important that pedestrians perceive the facilities to be safe and secure. For pedestrians this means freedom from conflict with motor vehicle, as well as a minimal threat from personal attack and the risk of tripping on uneven surfaces.

2. VEHICLE PEDESTRIAN INTERACTIONS

This chapter presents an overview of literature related to the study of vehicular and pedestrian activity. Classification of topics indicates important categories and trends in research in the field. The contribution of this thesis ultimately is in the field of engineering. Earlier studies provide significant facts about pedestrian demographic characteristics (such as age, gender) and how these characteristics influence road crossing behavior. Such studies have focused on detailed experiments to find out the effect of age on road crossing decisions with effect of vehicle distance or speed of vehicle. Most of these studies have been carried out in a virtual environment. Road crossing behavior with respect to gender and baggage held has also been observed in various studies. Males have a tendency to show more hazardous road crossing behavior than females due to less waiting time. Few studies have also explored the importance of the pedestrian speed at different locations. Outline of these studies suggest that males walk significantly faster than females while crossing the roads. A recent study was focused on legal versus illegal pedestrian road crossing behavior at mid-block location.

Terminology:

1. **Pedestrian speed:** it is the average pedestrian walking speed, generally expressed in units of meters per second.
2. **Pedestrian flow rate:** it is the number of pedestrians passing a point per unit of time, expressed as pedestrians per 15 min or pedestrians per minute. Point refers to a line of sight across the width of a walkway perpendicular to the pedestrian path.
3. **Pedestrian flow per unit of width**: it is the average flow of pedestrians per unit of effective walkway width, expressed as pedestrians per minute per meter (p/min/m).
4. **Pedestrian density:** it is the average number of pedestrians per unit of area within a walkway or queuing area, expressed as pedestrians per square meter (p/m 2).
5. **Pedestrian space**: it is the average area provided for each pedestrian in a walkway or queuing area, expressed in terms of square meters per pedestrian. This is the inverse of density, and is often a more practical unit for analyzing pedestrian facilities.
6. **Platoon**: it refers to a number of pedestrians walking together in a group, usually involuntarily, as a result of signal control and other factors.

2.1 Types of Pedestrian Crossings

Pedestrian crossing can be broadly classified (IRC: 103-1988) as:

1. At-grade crossings,
2. Grade separated crossings

At grade crossings the pedestrians cross the carriageway at the same level as that of vehicular movement. It is very common in cities and towns. It may be controlled and uncontrolled. Uncontrolled crossings are those where the pedestrian cross walk is marked by studs or paint line but not controlled by any system of signals or a zebra form of crossing. With respect to locational aspects, such crossings can be classified as:

1. Pedestrian crossings at intersections,
2. Mid-block crossings.

These are the crossings where the pedestrians are required to cross the carriageway at a level different from that of vehicular movement. It may be in the form of a pedestrian subway or a foot over bridge across the road.

2.2 Crossing Behavior of Pedestrians

Previous researches have made theoretical and methodological contribution to a practical understanding of pedestrian's behavior and the interaction between the driver and the pedestrian at pedestrian crossings. Pedestrians arriving at the pedestrian crossing look for acceptable gaps between vehicles in the traffic stream. They either accept or reject such gaps. Rejection of prevailing gaps leads to longer waiting time at the curb side. Pedestrian crossing behavior is divided here into four categories namely "one stage", "two-stage", "perpendicular direction" and "oblique direction". Each of these serves to minimize crossing time while still providing a degree of safety.

2.3 Pedestrian Flow characteristics:

In many ways pedestrian flow are similar to those used for vehicular flow because it can be described in terms of familiar variables such as speed, volume, rate of flow and density. Other measures related specifically to pedestrian flow include the ability to cross a pedestrian traffic stream, to walk in the reverse direction of a major pedestrian flow, to manoeuvre generally without conflicts and changes in walking speed, and the delay experienced by pedestrians at signalized and unsignalized intersections. It is dissimilar to the vehicular flow in that pedestrian flow may be unidirectional, bidirectional, or multi-directional. Pedestrian do not always travel in clear "lanes" although they may do sometimes under heavy flow.

2.4 Fundamental diagrams of traffic flow:

The relation between flow and density, density and speed, speed and flow, can be represented with the help of some curves. They are referred to as the fundamental diagrams of traffic flow. They will be explained in detail one by one below.

Flow-density curve:

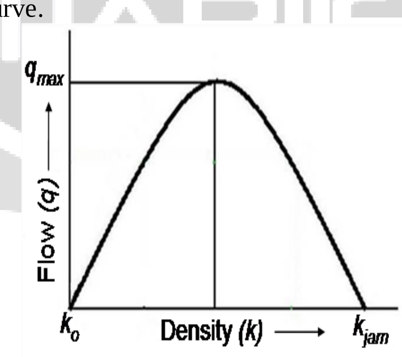
The flow and density varies with time and location. The relation between the density and the corresponding flow on a given stretch of road is referred to as one of the fundamental diagram of traffic flow. Some characteristics of an ideal flow-density relationship is listed below:

1. When the density is zero, flow will also be zero, since there are no vehicles on the road.

2. When the number of vehicles gradually increases the density as well as flow increases.

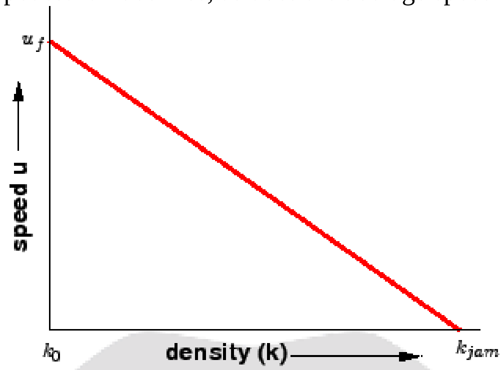
3. When more and more vehicles are added, it reaches a situation where vehicles can't move. This is referred to as the jam density or the maximum density. At jam density, flow will be zero because the vehicles are not moving.

4. There will be some density between zero density and jam density, when the flow is maximum. The relationship is normally represented by a parabolic curve.



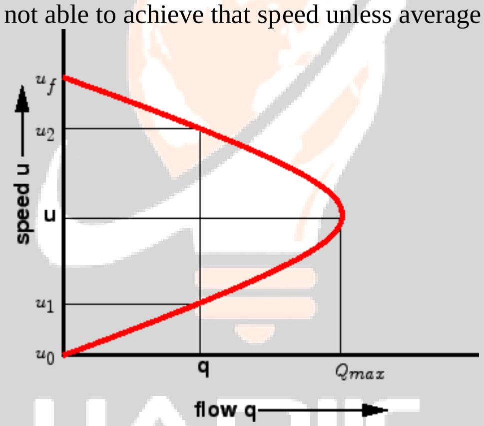
Pedestrian Speed-Density Relationships

Similar to the flow-density relationship, speed will be maximum, referred to as the free flow speed, and when the density is maximum, the speed will be zero. The most simple assumption is that this variation of speed with density is linear as shown by the solid line. Corresponding to the zero density, vehicles will be flowing with their desire speed, or free flow speed. When the density is jam density, the speed of the vehicles becomes zero. It is also possible to have non-linear relationships as shown by the dotted lines. These will be discussed later. The fundamental relationship between speed, density, and volume for pedestrian flow is analogous to vehicular flow. As volume and density increase, pedestrian speed declines. As density increases and pedestrian space decreases, the degree of mobility afforded to the individual pedestrian declines, as does the average speed of the pedestrian stream.



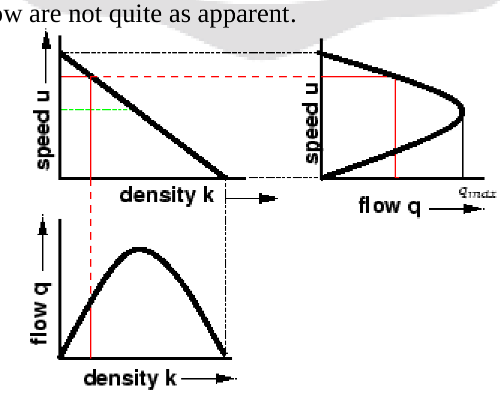
Speed-Flow Relation:

The following figure illustrates the relationship between pedestrian speed and flow. These curves, similar to vehicle flow curves, show that when there are few pedestrians on a walkway (i.e., low flow levels), there is space available to choose higher walking speeds. As flow increases, speeds decline because of closer interactions among pedestrians. When a critical level of crowding occurs, movement becomes more difficult, and both flow and speed decline. The Fig.3.3 confirms the relationships of walking speed and available space, and suggests some points of demarcation for developing LOS criteria. The outer range of observations indicates that at an average space of less than 1.5 m^2/p, even the slowest pedestrians cannot achieve their desired walking speeds. Faster pedestrians, who walk at speeds of up to 1.8 m/s, are not able to achieve that speed unless average space is 4.0 m^2/p or more.



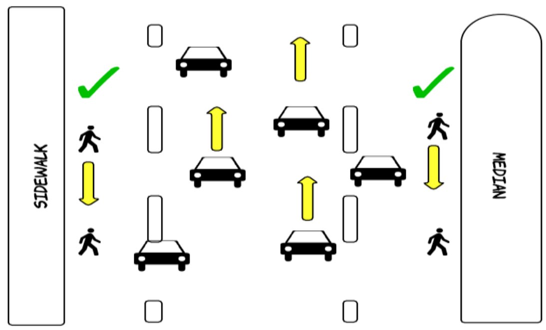
Combined diagrams :

The diagrams shown in the relationship between speed-flow, speed-density, and flow-density are called the fundamental diagrams of traffic flow. These are as shown in **figure 3.4.**Speed, flow, and density are all related to each other. The relationships between speed and density are not difficult to observe in the real world, while the effects of speed and density on flow are not quite as apparent.



2.5 Pedestrian Space Requirements:

All urban sidewalks require the following basic ingredients for success: adequate width of travel lanes, a buffer from the travel lane, curbing, minimum width, gentle cross-slope (2 percent or less), a buffer to private properties, adequate sight distances around corners and at driveways, shy distances to walls and other structures, a clear path of travel free of street furniture, continuity, a well-maintained condition, ramps at corners, and flat areas across driveways. Sidewalks also require sufficient storage capacity at corners so that the predicted volume of pedestrians can gain access to and depart from signalized intersections in an orderly and efficient manner. Sidewalks require a minimum width of 5.0 feet if set back from the curb or 6.0 feet if at the curb face. Any width less than this do not meet the minimum requirements for people with disabilities.



2.6 Factors Affecting pedestrian crossing behavior

Pedestrian crossing behavior is usually get influenced by various factors related to;

- pedestrian characteristics
- pedestrian movements
- traffic conditions
- road conditions and
- Environmental surroundings.

Rosenbloom et al. (2008) observed unsafe crossing behavior of children, like not stopping at the curb, not looking before crossing, attempting to cross when a vehicle is nearing and running across the road. Female pedestrians are observed accepting more gaps and less risk compared to male pedestrians. Oxley et al. (2005) have done experimental studies on the effect of age of a pedestrian in gap selection. They reported that, for all age groups, gap selection is primarily based on vehicle distance and speed.

2.7 Objectives of the Study

The main objectives of this study are:

- To study the crossing behavior pedestrians at uncontrolled intersections.
- To analyze and study the effect of various factors related to pedestrian characteristics, pedestrian movements, traffic conditions, road conditions, walking environmental surroundings and intersection conditions.

The problem of this thesis can be broadly stated as “understanding vehicular, pedestrian flow interactions in varied situations.” In some situations, pedestrian motion is observed empirically.

This describes the following

- Crossing time for pedestrian will be measured to evaluate the maximum pedestrian flow, crossing speed, density, and the adequacy of the geometry and location of signalized crosswalk. The signal timing for pedestrian and motorists will also be examined.
- To analyze and study the effect of various factors related to vehicle, pedestrian interactions like pedestrian characteristics, pedestrian movements, traffic conditions, road conditions.
- The signalized crosswalk performance will be examined if it can handle the pedestrians safely and efficiently.

2.8 Types of Traffic Counts

It is essential to know the magnitude of traffic c data required or to be collected, which will then determine its quality and type of vehicle classification to be adopted. Trafficcounting falls in two main categories, namely; manual counts and automatic counts. There is no distinct difference between the two methods however, the economic use or selection of an appropriate method of traffic counting is a function of the level of traffic flow and the required data quality. This difference can be deduced from the discussions of the respective methods below, and in the subsequent chapters.

Manual Counts :

The most common method of collecting traffic flow data is the manual method, which consist of assigning a person to record traffic as it passes. This method of data collection can be expensive in terms of manpower, but it is nonetheless necessary in most cases where vehicles are to be classified with a number of movements recorded separately, such as at intersections.

At intersection sites, the traffic on each arm should be counted and recorded separately for each movement. It is of paramount importance that traffic on roads with more than one lane are counted and classified by direction of traffic flow.

Automatic Counts

The detection of vehicular presence and road occupancies has historically been performed primarily on or near the surface of the road. The exploitation of new electromagnetic spectra and wireless communication media in recent year, has allowed traffic detection to occur in a non-intrusive fashion, at locations above or to the side of the roadway. Pavement-based traffic detection currently relatively inexpensive will be met with fierce competition in the coming years from detectors that are liberated from the road surface.

The most commonly used detector types are:

1. **Inductive loops.**

Inductive loop detector consists of embedded turned wire from which it gets its name. It includes an oscillator, and a cable, which allows signals to pass from the loop to the traffic counting device. The counting device is activated by the change in the magnetic field when a vehicle passes over the loop. Inductive loops are cheap, almost maintenance-free and are currently the most widely used equipment for vehicle counting and detection. Single loops are incapable of measuring vehicular speed and the length of a vehicle. This requires the use of a pair of loops to estimate speed by analyzing the time it takes a vehicle to pass through the loops installed in series. An inductive loop can also, to a certain degree, be used to detect the chassis heights and estimate the number of axles.

1. **Weigh-in-Motion Sensor types.**

A variety of traffic sensors and loops are used world-wide to count, weigh and classify vehicles while in motion, and these are collectively known as Weigh In Motion (WIM) sensor systems. Whereas sensor pads can be used on their own traffic speed and axle weighing equipment, they are trigged by “leading” inductive loops placed before them on the roadbed. This scenario is adopted where axles, speed and statistical data are required.

2. **Micro-millimeter wave Radar detectors.**

Radar detectors actively emits radioactive signals at frequencies ranging from the ultra-high frequencies (UHF) of 100 MHz, to 100 GHz, and can register vehicular presence and speed depending upon signals returned upon reflection from the vehicle. They are also used to determine vehicular volumes and classifications in both traffic directions.

Radar detectors are very little susceptible to adverse weather conditions, and can operate day and night. However, they require comparatively high levels of computing power to analyses the quality of signals.

3. **Video camera**

Video image processing system utilize machine vision technology to detect vehicles and capture details about individual vehicles when necessary. A video processing system usually monitors multiple lanes simulations.

3. DATA COLLECTION & EMPIRICAL OBSERVATION

The locations for carrying out the pedestrian study are decided based on the combination of land uses, width of the road and the type of intersection. Data were collected from the following locations in Hyderabad city:

1. JNTU junction:

The following represents the picture of JNTU junction at peak traffic time. A survey has shown that 50,000 motorists use this stretch per hour. Having witnessed unprecedented growth in traffic, the Kukatpally corridor right till Miyapur on the Mumbai Highway is chaotic on the main thoroughfare throughout the day.The Comprehensive Transportation Study has recorded the high pedestrian movement at the JNTU junction at Kukatpally.

2. Forum mall intersection:

Commuters from the West-eastern corridor of the city, that is, from forum mall to Mind Space, the stretch infamously known for its acute traffic issues, are set to get a breather. Here is a pictorial representation of forum mall unction in figure.

Some facts that affect the pedestrian movement are the interactions of the other pedestrian motion, geometry of the road facilities, and alternate ways of the pedestrian has to choose their trip in a multiple ways. The pedestrian flow may take place in a unidirectional, bidirectional, or multi-directional. They do not prefer travel in extreme clear path/lanes although they may do sometimes under heavy traffic. To do that recorded data or experimental/field data is to be taken to extract the pedestrian speed, density and several parameters which are very useful for the study.

There are several experiments were conducted at intersections and midblock. The first experiment was conducted at JNTU junction on disturbed pedestrian movement intended to study the impact of motorized vehicles on the pedestrian. From daily market undisturbed pedestrian movement was recorded to compare with the disturbed data set. The yield of this study is to show the fundamental difference between speed and density of the pedestrians. The study locations chosen for the present study, satisfies the following criteria:

- The pedestrian traffic is enough.
- The traffic flow is continuous.
- The effective width of the road is uniform throughout the length considered.
- For video recording of pedestrian flow, the road width considered should be easily accessed from vantage point.

3.1 Data Collection Techniques

There are different methods for data collection. These are given below:

- 1. Direct observation methods,
- 2. Video observation methods,
- 3. Time Lapse Photography,
- 4. Pedestrian opinion surveys.

Out of the above, **video graphic method and direct observation methods** are used in the present study. The camera was fixed in an elevated position so as to obtain an overall view of the selected test locations. Recording was done for about 60 minutes at a time, during morning (10.00 am to 12.00 noon) and evening peak periods (4.00 pm to 6.00 pm) on a normal working day. And direct observations are made by origin-destination survey.

3.2 Methodology for Data Analysis

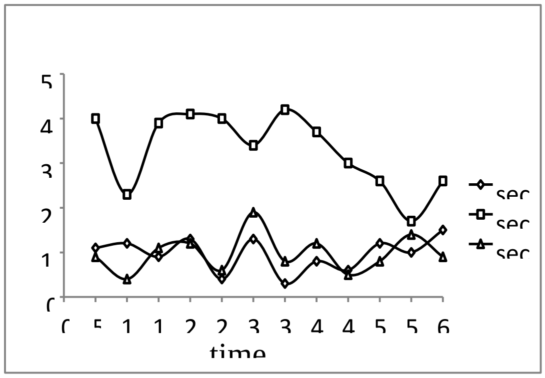
Recorded video is used to extract data. The values of pedestrian waiting time and crossing time are observed from the videos and recorded in MS-Excel work sheets for further processing of the data. Based on the above recorded information and using the value of road width sections, pedestrian speeds are estimated. Behavioral aspects like gap acceptance, safety margins etc. are also calculated and examined using the data. Variation in speed with respect to pedestrian personal characteristics like age and gender and effect of carrying baggage while moving on the speeds of the individuals are also studied. The manual counts are typically used for periods less than a day.

Key Steps to a Manual Count Study:

A manual count study includes three key steps:

1. Perform necessary office preparations.
2. Select proper observer location.
3. Label data sheets and record observations

The lane density is inversely proportional to the width of the section, which is clearly confirmed by observing three different data sets from Hyderabad. Those are JNTU junction Forum mall intersection. And these 2 locations are approximately 2.9 km apart from each other. That is a 20m lane is divided into two equal parts and the flow varies. Maximum flow was observed at these locations during 6.00pm – 7.00pm. If we observe the graph represented in **fig.** it is clear that the middle of the section has higher flow than the other two sections. The width of the section provided is 20m and most of pedestrian using center part of the section i.e. setion2.



3.3 Pedestrian Crossing Behavior

Pedestrian Crossing Behavior patterns are observed which can be classified as
(a) One step/two step;
(b) Perpendicular.

The proportion of pedestrians estimated within these different during the analysis of recorded data from crossing patterns are shown in **Table 1** for different study locations, two major crossing all study locations.

Location	**Crossing Patterns**	**Perpendicular Crossing**		**Oblique Crossing**	
		Waiting Time in sec	**Crossing Time in sec**	**Waiting Time in sec**	**Crossing Time in sec**
Overall	**One step**	**1.5 (0-3.5)**	**6.0 (5.0-7.0)**	**1.5 (0-3.0)**	**8.0 (5.0-11.0)**
	Two step	**4.5 (2.0-7.0)**	**7.5 (3.0-12.0)**	**5.0 (0-10.0)**	**9.5 (5.5-13.0)**

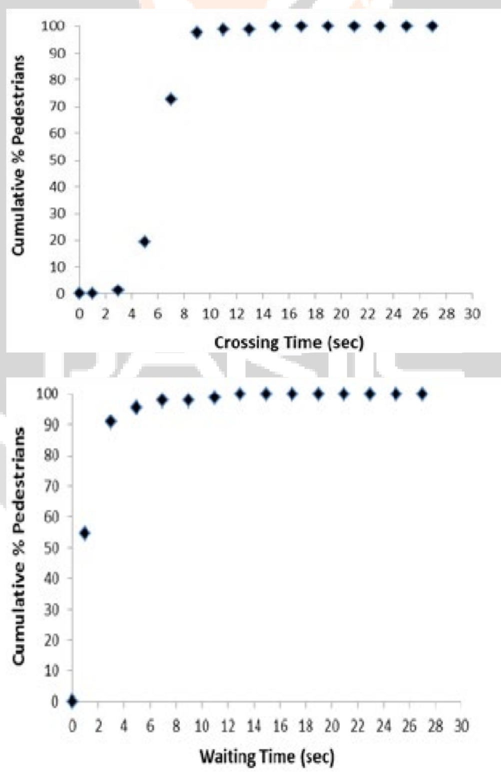
3.3 Study on vehicle, pedestrian interaction:

In this section results from the experiments on the mixed traffic flow are shown in the speed-density and flow-speed relationships. Due to the impact of vehicle motion some disturbance caused in pedestrian flow and speed, it leads to delay both the vehicle and pedestrian motion. The pedestrian flow behavior at these sections was observed to develop the pedestrian characteristics.

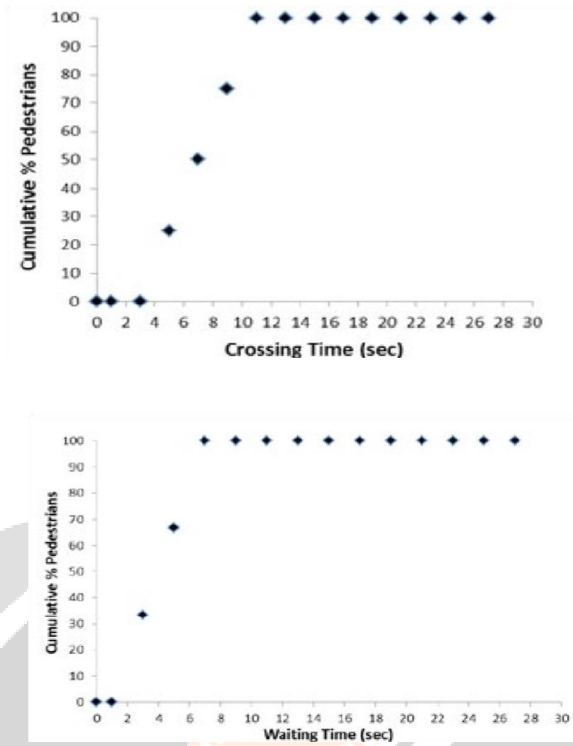
To understand the impact of vehicle pedestrian interaction, the geometry of the section is considered, i.e. the lane width and the width of the crosswalk and several parameters like road conditions, traffic conditions i.e. signalized or unsignalized. It affects the pedestrian flow and speed. To overcome from those problems zebra crossings, foot bridges, traffic signals etc. is designed. But it is difficult to provide signals and zebra crossings at midblock sections. In that case thorough study is needed to design a foot bridge. Parameters like pedestrian behavior, collisions, vehicle speed, vehicle flow, pedestrian flow in peak hour durations was considered.

3.4 Crossing Time and Waiting Time

After collecting the data from study location using video graphic technique, the analysis of pedestrian crossing speeds with respect to certain pedestrian characteristics is usually desired. For that purpose, firstly the pedestrian crossing time and waiting time is observed from the video of study locations. The crossing and waiting time is observed for perpendicular and oblique crossing condition separately. The analysis of crossing time and waiting time is done for one step crossing and two step crossing separately. The analysis presented here uses data of all study locations. The combined cumulative frequency curves of pedestrian crossing time and waiting time for the crossing patterns are given in the following figures. The general range of crossing time and waiting time.
The following is representing the graphs for the cumulative frequency curves for perpendicular movements in one step pedestrian crossing and represents the two step pedestrian crossing as well as the cumulative curves of oblique movement in one step and two step pedestrian crossing are shown in fig and respectively.



cumulative frequency curves for perpendicular movements in one step pedestrian crossing



Cumulative Frequency Curves for Perpendicular Movements in two Step Pedestrian Crossing

4. RESULTS & DISCUSSIONS

In this chapter data was analyzed and the result shows the fundamental relation between the speed-density and speed-distance headway of pedestrian flow. As referring U Chattaraj et al. (2009) for comparison of fundamental diagrams across cultures. And the differences between the disturbed and undisturbed pedestrian flow is shown by hypothesis testing. Regression analysis has been conducted to get the statistical results. Simple linear regression analysis is well known statistical technique for fitting mathematical relationship between dependent and independent variables.

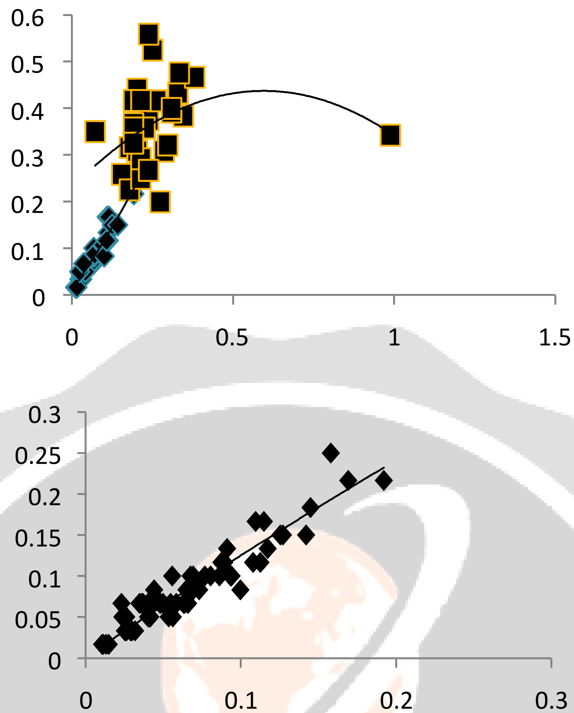
From the manual count method pedestrian flow is calculated for every 5minutes. From this it is noted down that the pedestrian flow varies from section to section and from place to place. The size of the data collection depends on the length of the counting period, the type of count being performed, crosswalks being observed and the road conditions.

Every 5min data was noted down in a sheet. The graph shows the undisturbed pedestrian flow, i.e. impact of vehicle was absent. And the three sections are apart from 400m-500m. The number of pedestrian crossing the road was observed and represented in the graph with time for each 5min interval.

4.1 Flow-density relation:

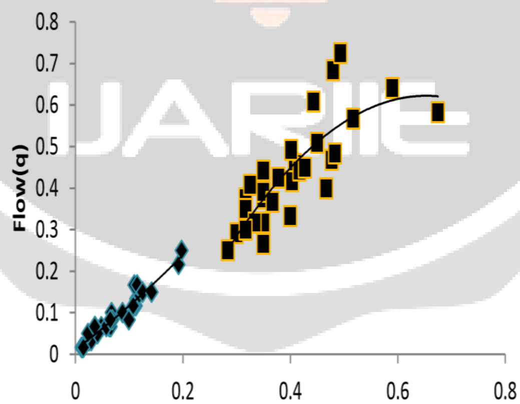
Flow and density relation of pedestrian is similar to that of the vehicular traffic stream. And it can be expressed as

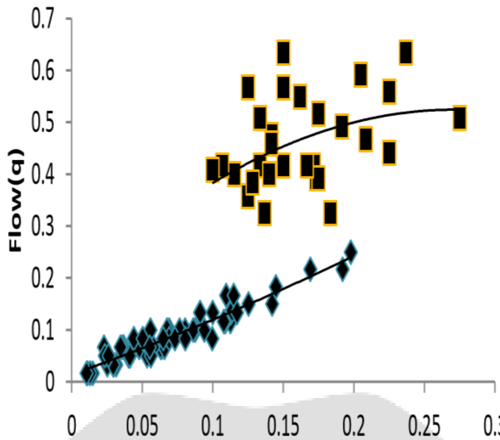
$$q = u*k$$



fundamental relationships between flow and density at different junctions

The above figure shows the flow and density relationship of JNTU junction and forum mall intersection Hyderabad. When the speed of the traffic flow decreases the density attains the maximum value. Whereas flow decreases, then becomes zero.



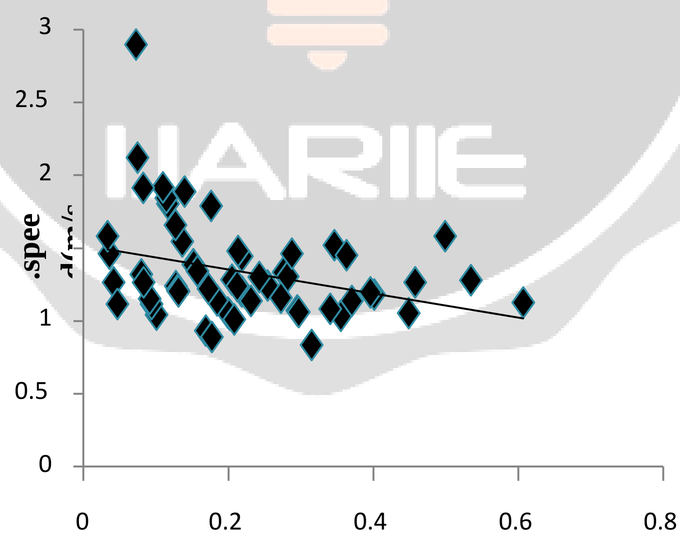


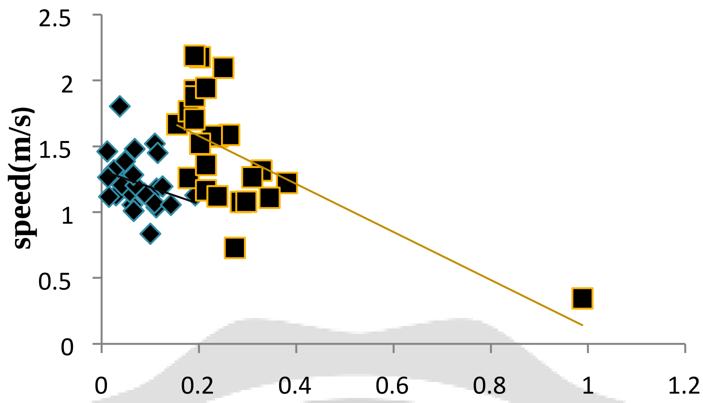
fundamental relationships between flow and density

In a hypothetical case, when flow approaches to zero at very high speeds, the density also approaches zero. With an increase in speed, the flow increases up to a certain limit and then decreases as shown in **fig .** Thus, at the optimum values of speed and density, the flow is maximum achievable capacity flow. From the regression statistics r^2 value was observed and it is equal to 0.9112. P value is 0.0244 which is less than 0.05, i.e. the test results were significant.

4.2 speed-density relation:

The relation between speed and density is linear. And speed is the basic input for the fundamental diagram. Practically it is not possible in all cases like zero density and free speed on the road. From the beginning one set of data was taken from jntu to set the fundamental diagrams of pedestrian flow.



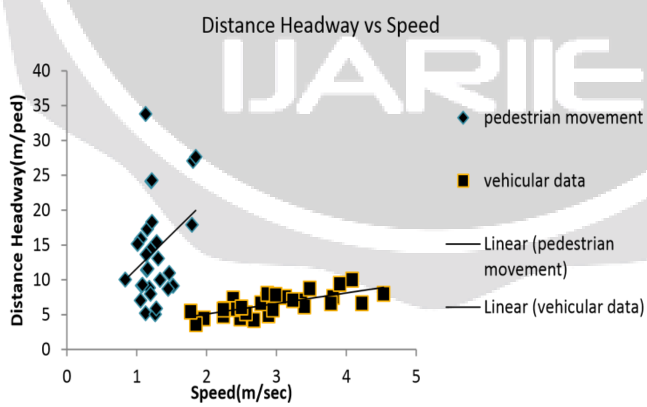


fundamental relationships between speed and density at jntu and forum mall intersection

The above **figure** shows the speed and density relationship of vehicle and pedestrian motion at jntu junction and forum mall intersection. To improve the test results number of experiments were conducted. The above graph which show the linear relationship between speed and density of pedestrian flow**.** The data were collected in the peak hour period. From the figure with increase in speed of a stream of vehicles on a roadway, the density per unit length decreases. This is because gap or spacing between vehicles is increasing with increase in speed.

4.3 **Distance headway- Speed relationship:**

Data was collected here to compare the disturbed and undisturbed pedestrian movement, by using the hypothesis testing it is concluded that the two data sets are different each other. That is impact of motorized vehicles is affects the pedestrian movement at the signalized intersections. Speed-distance headway relationship is crucial to know the space required for a pedestrian from two different locations. Here we can observe the difference of distance headway-speed relationship for disturbed and undisturbed pedestrian movement**.**



5. CONCLUSIONS

Based on the studied literature, it can be concluded that many researchers have conducted various studies on pedestrian's behavior at different parts of the world. Indian traffic is a mixed traffic including heavy vehicles, four wheelers, and Motorized& Non–Motorized two wheelers. Researchers have studied many criteria such as gap acceptance by pedestrian, their crossing patterns, age, gender, crossing time, handling baggage and crossing speed etc., Interaction of pedestrians with this mixed traffic and their behavior will have to be studied in detailed manner. In order to study the pedestrians comfort under Indian situation we must study their walking behavior and crossing behavior.

In this study, several experiments were conducted in different locations (jntu junction and forum mall intersection) to compare the disturbed and undisturbed pedestrian movement, interaction of motorized vehicles with pedestrian and to establish the fundamental diagrams between speed-flow, speed-density and speed-distance headway.

The pedestrian crosswalk data were collected from different locations; entry time and exit time were recorded using the video camera to get the speed and flow of a particular pedestrian stream. Using the manual count method pedestrian flow was determined and this undisturbed data is very useful to compare with the disturbed data and how it is different from this undisturbed pedestrian flow. For that hypothesis test difference was determined.

In this thesis two types of experiments were collected from the field. The first one experiment intended to study the fundamental relationship between speed, flow and density. Distance headway speed was also observed in pedestrian motion. Second one is an approximate data set to know the direction of pedestrian movement and desired details of pedestrian volume count by the time.

For better and easy way for pedestrian crossing is by implementing pedestrian safety interventions for road geometry. Following are some key reasons give the brief about pedestrian safety interventions:

(i) Reduce pedestrian exposure to vehicular traffic
Examples of interventions like providing sidewalks install and upgrade traffic and pedestrian signals, constructing the pedestrian refuge islands, raised medians, enhanced marked crossings, overpasses/underpasses and improving the mass transit route design.

(ii) Reduce vehicle speed
Examples of interventions like reduce speed limit, implementing area wise lower speed limit, install speed management measures at intersections.

Among the crossing patterns more pedestrians crosses the roads in perpendicular direction and very few of them crosses the roads in two stages. The average crossing speeds at different study locations are varied with respect to various pedestrians' characteristics like gender, age category, and baggage handling condition, volume and composition of traffic moving on road. Among them males and children have the higher crossing speeds. There is no significant variation in pedestrian's speeds due to handling of baggage. The majority of pedestrian are not inclined to take risks since the safety margins and time gaps were not very high but some pedestrians are there who take very high risks while crossing the roads. Approximately one out of five pedestrians has the safety margins of 0 sec.

The pedestrian crossing behavior analysis is the important factor for deciding the assurance of pedestrian safety on roads and the pedestrians waiting time can be used to decide the need of pedestrian facility in the area.

5.1 recommendations

- Design to minimize conflicts between vehicles and pedestrians.
- Consider separating bicycle and pedestrian paths from vehicular traffic.
- Consider linking open spaces so that they form an uninterrupted network of vehicle-free areas.
- Consider traffic calming strategies to slow down vehicles within the intersections.
- Constructing skywalks, pedestrian underpasses.
- Providing zebra-crossings for the safety of pedestrians.

5.2 Scope for the future research

- The Survey can be validated at other intersections of city and thus can help transport planners and officials for assuring safety of pedestrians.
- The National Highway and Public work Department shall review signal, intersection, FOB and underpass projects in the transportation Improvement to evaluate and recommend pedestrian enhancements that could be incorporated into the project to improve pedestrian travel.

- In order for people to reclaim the urban environment overrun by motor vehicles strategies must be incorporated.
- Policies and investments provide a momentum to transform Indian cities, encourage pedestrianization and allow people to enjoy better mobility and quality of life.

References

1. Fruin et al (1971) stated that pedestrian service standards.

2. Pushkarev and Zupan et al(1975) flow rate and speed.

3. Gregory Benz et al (1986) LOS calculations.

4. Young-In Kwon, Shigeru Morichi, and Tetsuo Yai et al (1989) occupancy index.

5. Venkata Chilukuri et al (2000) pedestrian delay at signalized intersections.

6. Muraleetharan Thambiah, et al(2004) calculation of pedestrian levels of service.

7. Gianluca Antonin (2006) problem of pedestrian walking behavior modeling.

8. Hubbard et al., (2009) statistical analysis using a binary logit model

9. S.K Khanna and C.E.G Justo “Highway Engineering “2008.