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***Study of Pedestrians Flow Characteristics in Some
Congestion Area within Hilla City***

A Thesis

Submitted to the Department of Civil Engineering, College of Engineering,
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Master Degree in Engineering / Civil Engineering / Transportation

By

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Lamyaa Shaker Fadel

Dedication

Great thanks to Almighty Allah for his blessings and all the achievements in my life. I am grateful to my family for their support and patience throughout my studies and provided me with motivation and financial support. Without them, none of this achievement would be possible.

To:

My Mum and Dad

My Husband

My Sons and Daughters.

Every person supported me during my entire life.

Lamyaa Shaker Fadel

Abstract

In our modern life, walking and crossing have become an important means for pedestrians to reach their various goals. However, the processes of walking and crossing, require efficient and safe side walkways, walkway, stairway and other traffic facilities within congestion area in order to reduce the interference of activities between pedestrians and vehicles, which results in many types of traffic accidents. This calls for conducting the necessary studies and search for suitable solutions to ensure pedestrians safety factors in pedestrian movement to provide pedestrian paths that suit their activities in urban areas.

The study aims to achieve several goals such as evaluate the impact of pedestrian characteristics, traffic flow in addition to walking speed on the efficiency of pedestrian (Level of Service) (LOS) with the aided of statistical and traffic models to show the extended impact of variables and their effect on the efficiency of pedestrian traffic flow. To that purpose, the study chose five sites within the urban area of Hilla city.

Data collected for pedestrian walking and crossing according to field survey in order to estimate flow, average speed, density and spacing. Evaluation of lane width, number of lane, vehicle classification for each selected section included too.

The study conducting that the (Level of Service) (LOS) for the roadway sections ranges between (B-F) while the (LOS) for pedestrian's ranges between (B-F) that indicates the aggravation of the pedestrian problem in the study area. As well as according to the output of software program (PTV VISSIM) simulations, scientific analysis using (**HCM, 2010**) method with design of the crossing areas and sidewalks agree with (**AASHTO, 2011**) specifications, rustling in an increase in the level of service (LOS) for the sidewalks and crossing areas from (F to B & C).

Abstract

A statistical methods analysis has done with the aided of (SPSS) software program; by study the relationships between traffic flow, speed and density of pedestrians. The linear equation reflected the relationship between speed and density, while the Second order; equation reflected the relationship between traffic flow and pedestrian speed in most sections of the study area.

F- Test values, give a significant effect between the independent and the dependent variables led to accept the alternative hypothesis and reject null hypothesis as well as a significant value of the correlation coefficient (R), (coefficient of determination (R^2) and standard error of estimation (SE).

The study suggested a comprehensive transportation for pedestrian flow characteristic in Hilla city includes pedestrians environmental within roadways and intersections as networks to design an appropriate modern environment and safe crossing facilities to reduce traffic accidents that result in death, injury or disability.

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List of Abbreviations and Symbols

Abbreviations	Definition
AASHTO	American Association of State Highways and Transportation Officials
HCM	Highway Capacity Manual
HCS	Highway Capacity Software
PTV VISSIM	Planning Transport Verkehr-in German Language
SPSS	Statistical Package for the Social Sciences
R	Coefficient of Correlation
R²	coefficient of determination
SE	Standard Error of estimation

Chapter One

Introduction

CHAPTER ONE

1. INTRODUCTION

1.1. Background

Currently, pedestrians are the most susceptible road users because of their vast selection of freedom when picking a part specific walking and crossing pattern. This difference between pedestrians and driver's road users makes pedestrians considerably more divergent than driver's road users. In contrast to the many forms of vehicle movements, walkers are continually interacting with one another and the environment around them that causes frequent variations in the walking flow properties.

The distinct capabilities of pedestrians that make them much more complicated and distinct from the traffic generated by motor vehicles, include the following:

- The capability of a pedestrian to traverse another stream, walk in the opposite direction of a main flow, simply navigate without substantial conflict, and travel in many directions at once.
- The pedestrians flow, much like the flow of automobile traffic, does not follow correct lane discipline when there is a low amount of traffic activity.
- Lane creation and lane squeezing connections were two of the phenomena that might occur when there is a high flow level.

Federal Highway Administration (**FHWA**) ((**US**), **2006**) suggested some information about pedestrian's safety flow as well as safety tips for drivers they are:

- Always in every location, and on the lookout for pedestrians.
- Once turning or otherwise approaching a cross, reduce your speed and be prepared to come to a complete stop.

- Drive with increased care if you are in situations when it is difficult to see the road, including at night or during inclement weather.
- Give pedestrians in the crosswalk the right of way, and stop far back from the edge of the crosswalk to provide oncoming traffic the chance to observe people crossing and come to stop themselves if necessary.
- You should never go around a vehicle that is stopped at a crosswalk. It's possible that there are individuals crossing the street in areas that you can't observe.
- Always drive at or below the posted speed limit, particularly around pedestrians, in school zones, and in other areas of the neighborhood where children are present.
- While reversing, use extreme caution, and keep an eye out for pedestrians.

1.2. Pedestrian Flow Characteristics

Studies that were done on pedestrian flow characteristics focused primarily on determining the essential basic factors, finding correlations between those factors, and gaining a knowledge of the elements that influence the walking pace of pedestrians. The features of pedestrian traffic were determined to differ depending on the kind of facility, the breadth, the gender of the pedestrians, and the area (**Banerjee & Maurya, 2018**). The study conducted the following:

- Across walkway facilities in Saudi Arabia, Iraq, Bangladesh, Indonesia, and Sri Lanka, pedestrians walked noticeably more slowly than their counterparts in Canada, the UK, and America.
- Their physique (height), culture (clothing), attractions (availability of hawker's position along walkways), friction (since parked cars),

objective of the travel, and environmental situation all contributed to this slower walking pace.

- Furthermore, the maximum and minimum pedestrian speeding detected are (98 m/min.) and (52 m/min.), respectively.

1.3. Level of Service (LOS) Concept for Pedestrians

The level of service (LOS), defined as the pedestrian's quality movement and conceptually analogous to the levels A through F of traffic quality, illustrates the correlations between the speed, volume, and pedestrian flow density (Lahart et al., 2013).

It conveys a sense of ease of movement for individuals while they walk. It is assessed that, so as to the motion of the different sets of pedestrians on pavements to be as comfy as potential, the pavement width should be at least 1.50 meters wide. This determination is made not just on the basis of this pedestrian level motion quality, but also on the basis of other factors (without distance for safety purposes). The minimum pavement width seems to be usually 0.75 meters that also relates to one lane for pedestrian flow in single direction. However, there is no guarantee that pedestrians will be comfortable overtaking other pedestrians walking at a definite speeding, etc., because there is only one lane for pedestrian flow.

1.4. Study Problems

The main problems addressed by the research are the followings:

- Hilla city in general and the investigation zone in particular lacks an efficient traffic system that takes into account the provision of the necessary times and safety zones for pedestrian's movements and their crossing in a manner that guarantees efficiency, safety and convenience for road users.

- The absence of plans and strategies that take upon themselves the study of the condition, environment and growth of pedestrians, in order to avoid the conflict points between pedestrians and vehicles, which leads to the occurrence of different types of traffic accidents.
- The lack of facilities for pedestrian crossing, as well as the inadequacy of walkway and sidewalk, their lack of capacity to transfer pedestrian traffic volumes exacerbated the pedestrian problem and increased traffic accident rate within investigation zone.

1.5. Objectives of the Study

The study aims to reach the following goals and objectives within a scientific and statistical methodology, adopts the elements of scientific research as following:

- Evaluate the impact of pedestrian's characteristics, traffic flow also walking speed on the efficiency of pedestrian level of service (LOS) within investigation zone with the addition of PTV VISSM software.
- The use of statistical and traffic models to show the extended impact of variables and their effect on the efficiency of pedestrian traffic flow, through the outputs of the statistical standards used.
- Development and proposing some solutions for the existing designs of sidewalk and walkway used in the investigation zone, as well as studying the efficiency of grade and stairway crossing in other location of the investigation zone.

1.6. The Importance of the Investigation

The significance of this investigation lies in the facts that it is one of the few investigates that deal with pedestrian traffic flow and the facilities their crossing and movements, as most of the designs deal with the path of the road, the cross and longitudinal sections, and alignment, but pedestrian designs

largely neglected. This study sheds the light on the problem of pedestrians and tries to find some options and solutions that would contribute to improve safety, efficiency and convenes.

1.7. The Structures of Thesis

The current thesis consists of five chapters:

1. The first chapter presents a background to the investigation work and presents brief idea about Pedestrian characteristics, pedestrian flow characteristics, service level for pedestrians, factors affecting pedestrian movement, traffic safety in Iraq and Hila, the concept of simulation and advantages, The principles of sustainability for the street in the urban city, statement of the problem and objectives of the study, methodology and structure of the investigation.
2. Chapter two consists of literature review, describing surrogate safety measures, traffic conflict techniques, and microscopic simulation. Provide an overview of STATISTICA and VISSIM Software.
3. The research area, figures, tables, and specifics of all data that were gathered for this investigation have been covered in the third chapter.
4. Chapter three deals with conflict, geometric, crash, calibration, and traffic data collection and briefly presents the VISSIM methodology.
5. The fourth chapter provides an overview of the techniques and approaches employed in this study's analysis as well as some background information.
6. Finally, Chapter five concludes this thesis by providing summaries of the major findings of the research, summarizes the major recommendations to better enhance safety. Highlights future studies to treat cases that are not mentioned in this study. References are added at the end of the research.

1.8. Program of the Investigation

The investigation seeks to present the program and the steps according to traffic preference of pedestrian's characteristics within investigation zone as demonstrated in Figure (1.1).

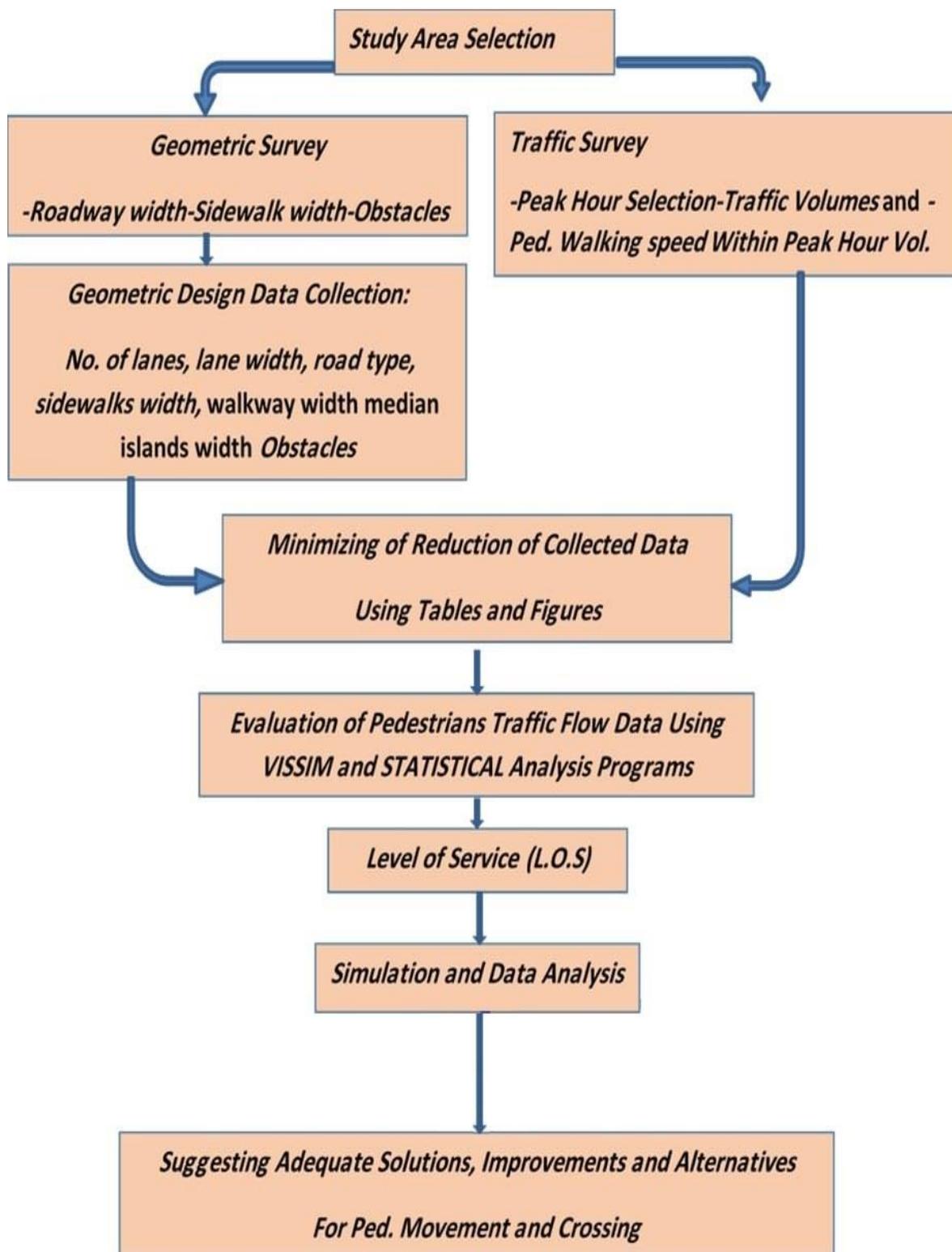


Figure 1.1: Investigation steps based on Pedestrian Characteristics within Investigation zone.

Chapter Two

Basic Concept and Literature Review

CHAPTER TWO

2. Basic Concept and Literature Review

2.1. Introduction

This chapter deals with the some geometric and methods of sidewalk, walkway, and stairway facilities as well as pedestrian characteristics in order to evaluate Service's level (LOS), as well as finding ways and basic rules that deal with pedestrian movements, movements, crossing and environment, because they represent an essential element of traffic elements within the urban area.

The results of researches and studies of pedestrian's movement and improvement are included within the study area.

2.2. Pedestrians Characteristics in the Urban Area

Pedestrian accustomed to follow some rules according to their behavior in the urban area, summarized as follows (AASHTO, 2011):

In order to successfully plan and develop pedestrian facilities, it is necessary to have a solid grasp of the average pedestrian. The average pedestrian would not walk more than 1.5 kilometers (one mile) to work, and they will not walk more than 1.0 kilometers (half a mile) to catch a bus. Moreover, approximately % of the distances that pedestrians travel will be less than 1.0 kilometers (half a mile).

- The average pedestrian seems to be a shopper around half of the time that they are a pedestrian, but the average pedestrian would be a commuter approximately just 11 % of the time. As a direct result of this, the busiest time of day for pedestrians occurs around mid day rather than at the busiest periods of day for commuters. The amount of foot

traffic in a certain area may be affected by fleeting variables such as the weather or, in some places, by deals that have been publicized.

- The behaviors of pedestrians may be more harder to anticipate than those of drivers. A significant number of people who walk perceive themselves to be exempt from the laws that govern transportation, therefore pedestrian prohibitions are sometimes only partially implemented. Because of this, it is challenging to build a facility that allows for the efficient flow of pedestrians.
- Pedestrians have a tendency to travel along a route that represents the shortest distance between two places. Hence, it is possible that some places might benefit from additional crossings in addition to those found at corners and signalized junctions. While crossing roads, pedestrians have a fundamental aversion to any variations in grade or elevation and, as a result, they prefer to avoid utilizing facilities specifically designed for pedestrians such as underpasses and overpasses. Moreover, pedestrian underpasses could be possible crime hotspots, which would discourage people from using them.
- The age of a pedestrian is a significant factor that might also describe behavior that leads to collisions between motor vehicles and pedestrians. This information is provided in a publication by the Federal Highway Administration ((FHWA), 2006) that is titled Informational Report on Lighting Design for Midblock Crosswalks. Young pedestrians are often careless in traffic due to either their lack of experience or their exuberance, whereas older pedestrians may be impacted by restrictions in their sensory, perceptual, cognitive, or motor skills. Very young pedestrians are often careless in traffic due to either their lack of experience or their exuberance. Accidents involving pedestrians may also be caused by a deficiency in the number of available sidewalks, which might also require pedestrians to walk along

the roadway alongside moving vehicles. As a result, the installation of sidewalks must to be taken into consideration as a component of every urban or suburban roadway renovation project.

2.3. Pedestrian Characteristic Studies

There are many studies of pedestrian characteristics within urban area, some of these showed that the idea of using an appropriate signs for pedestrian that can carry out the message directly without any confusion to prevent the misunderstanding of these signs by drivers. The survey was conducted by presenting a variety of signage to a number of people who used the roadway and posing a few questions to them. The feedback received from customers was crucial in the development of a sign system that may improve pedestrian safety (Ullman & Ullman, 2010).

Another study used a statically software called SPSS for the analysis of data. The data that were gathered were utilized to build the speed-flow-density-space connection of pedestrians, and this generated correlation may be used as a foundation for the creation of facilities for pedestrians that are more effective, adequate, and safe (Nazir et al., 2014).

The research done by (Jain et al., 2014) provided a descriptive description of the motions made by pedestrians on sidewalks. Both the variation rate in the pedestrian flow-area module curve and another criterion dependent on speed proportion density plot were used in the process of developing the level criteria for the service.

In another research, the characteristics of pedestrian design variables were the subject of investigation. Connectivity, the quality of the road network, and closeness were identified as the three most important characteristics of pedestrian movement. Connectivity was a representation of the state of the nodes and connections, the number of nodes, their density, the number of linkages, their density, and the overall length of the walking area. The quality

of the road network categorized the connections into categories according to the number of lanes and the amount of traffic. The proximity reading revealed not only the walking distance, but also the anticipated walking time for the individual (**Gori et al., 2014**).

One of the primary users of the public space in a city is a pedestrian. Once it comes to the organization of the urban environment, pedestrians are prioritized as a participant in road traffic based on the development plans of several smart cities, and the creation of pedestrian infrastructure is considered to be an aspect of the notion of smart mobility (**Sanseverino et al., 2016**). Since individuals often walk the last leg of their journeys inside the city, it is important that the city be equipped with a pedestrian infrastructure that is user-friendly. This will benefit the whole city's inheritance (**Kumar, 2015**). Because of this, ensuring the comfort and safety of pedestrians is a priority of the highest order.

Mixed traffic patterns are widespread in urban settings, particularly in nations that are still in the development stage (**Ni et al., 2016**). The actions of pedestrians and motorists alike have the potential to have a significant impact (**Suzuki & Ito, 2017**). For instance, pedestrians and cyclists may enter the roadway without proper caution, and they might be ignorant of, or less vigilant in relation to, the surrounding traffic, that increases the likelihood of an accident with a car.

Due to the fact that they are not shielded from dangers on the road, pedestrians are among the most vulnerable road users (**Zheng et al., 2015**). It is believed that it is typical for walkers to shorten their path and choose the shortest route that frequently describes violations in the type of crossing in the incorrect location, which can be found in both scientific literature and suggestions on the organization of pedestrian infrastructure (**Mudron & Pachta, 2013; Zegeer et al., 2009**).

2.4. Pedestrian Capacity Terminology

The following is a list of significant phrases utilized while discussing pedestrian facility capacity and LOS major terms described as follows

(HCM, 2010):

- The term "pedestrian speed" refers to the normal walking pace of pedestrians and is often stated in terms of feet per second.
- The pedestrians' number that pass a certain site in a given period of time is referred to as the pedestrian flow rate and may be represented as pedestrians per 15 minutes or pedestrians per minute. The term "point" indicates to a line of sight that extends across the breadth of a pathway in a direction that is perpendicular to the route used by pedestrians.
- The average number of people moving through an area in relation to the width of a pathway is referred to as the pedestrian flow /unit of width, and it is measured in pedestrians/minute/foot (p/min/ft).
- The mean pedestrians number /unit of space inside a walkway or queue area is referred to as the pedestrian density, and it is stated as the number of pedestrians per square foot (p/ft²).
- The amount of space that is allotted to pedestrians in a given place, such as a walkway or a waiting area, is referred to as the pedestrian space and is measured in square feet /pedestrian. This is the opposite of density, thus being a frequently more useful metric for doing research on pedestrian amenities.
- Platoon is a term used to describe a number of pedestrians that travel together in a group, most of the time unintentionally, as a consequence of signal control and other parameter.

2.5. Principles of pedestrian flow

Comparatively, the qualitative measurements of pedestrian flow are analogous to those of vehicle flow; for example, freedom of choice in terms of travel

speeds and the ability to sidestep other pedestrians are two examples. The capacity to cross a pedestrian traffic stream, to walk in the opposite direction of a main pedestrian flow, to manoeuvre usually without any conflict points and variations in walking speed, and the delay experienced by pedestrians at unsignalized or signalized crossings are some other measures specifically related to pedestrian flow. Other environmental elements that contribute to the walking experience and perceived service level (LOS) include the economy, convenience, safety, and security of the walkway system as well as comfort and safety.

- Transit shelters, arcades, temperature control, weather protection, and other pedestrian facilities are all examples of things that contribute to comfort.
- Directory maps, directional signage, sidewalk ramps, slopes, route directness, walking lengths, and other elements that make pedestrian travel quick and uncomplicated are examples of factors that are considered to be convenient.
- The separation of pedestrians and vehicular traffic on the same horizontal plane, as is the case with malls and other places that are free of vehicles, as well as vertically above and below, as is the case with overpasses and underpasses, provides a safe environment for pedestrians. The passage of pedestrians and vehicles may be kept at a safe distance from one another, thanks to the use of traffic control devices. Lighting, clear lines of sight, the amount and kind of activity on the street, and other factors may all play a role in security.
- The pedestrian facilities economics relates to the user costs paid by traffic delays and inconveniences, as well as the effect that pedestrian access has on commercial magnitudes and retail development.

These additional characteristics have the potential to influence how pedestrians evaluate the high-level qualities of the street environment as a whole. While the person operating the car has some degree of influence over the majority of these circumstances, the person walking has almost no control over them.

2.5.1. Pedestrian Speed-Density Relationships

The essential link between the speed of the flow, the density of the flow, and the volume of the flow of pedestrians is equivalent to the flow of vehicles. The average walking pace of pedestrians slows down when there are more people in an area. When there are more people living in an area and fewer places for pedestrians to walk, the amount of mobility that is available to each individual pedestrian and the main speed of the pedestrian stream both drop. According to the research that was done, the link between speed and pedestrian density is shown in figure (2-1) for three different pedestrian categories.

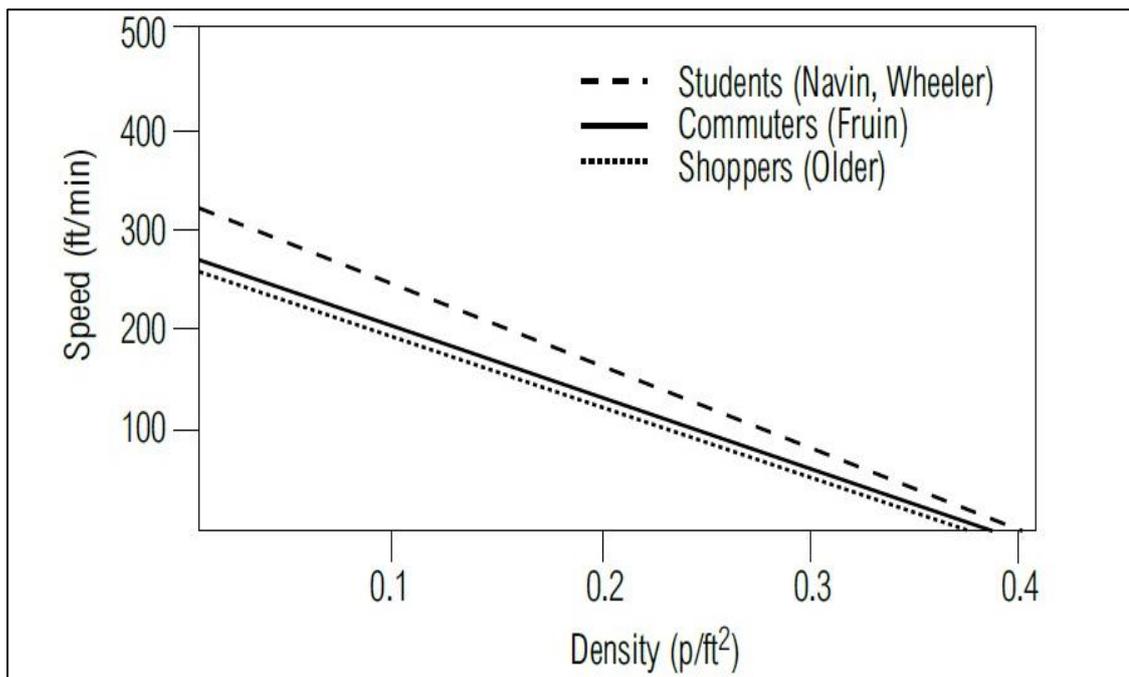


Figure 2.1: Associations Between Density and Pedestrian Speed
(HCM, 2010).

2.5.2. Flow-Density Relationships

The relationships between flow, speed, and density for pedestrians are analogous to those for automobile traffic streams, as given in formula (2-1).

$$V_{ped.} = S_{ped.} \times D_{ped.} \quad (2-1)$$

Whereas:

$V_{ped.}$ = unit rate of flow (p.min⁻¹.ft⁻¹),

$S_{ped.}$ = the speeding of pedestrian (ft.min⁻¹), and

$D_{ped.}$ = the density of pedestrian (p/ft²).

A different and more practical representation makes utilize the reciprocal of space, often known as density, as seen in the following:

$$V_{ped.} = \frac{S_{ped.}}{M} \quad (2-2)$$

Whereas:

M = the space of pedestrian (ft².p⁻¹).

The fundamental link that exists between space and flow, as shown by a number of scholars, is shown in figure (2-2).

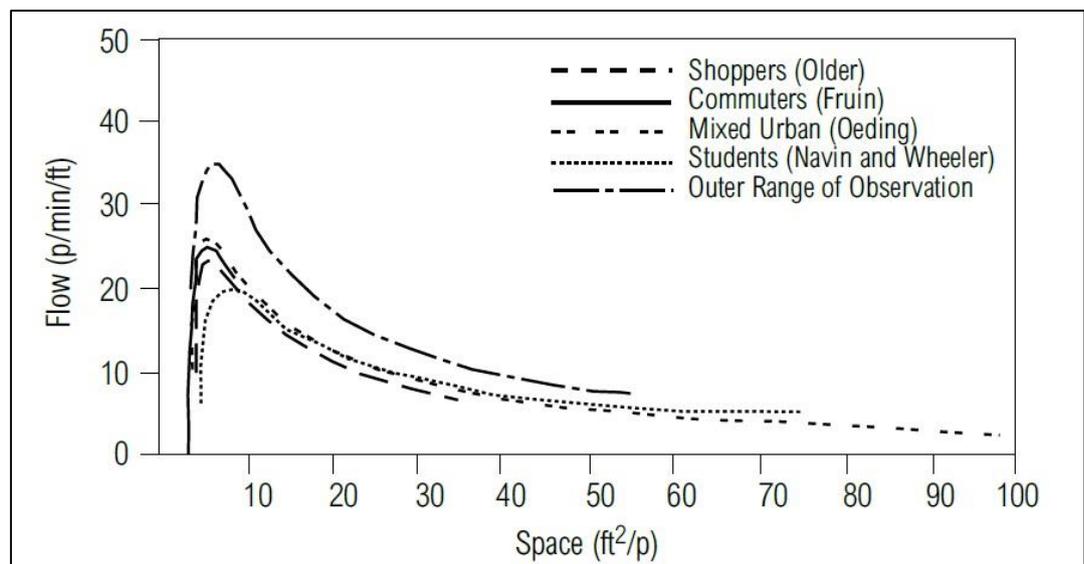


Figure 2.2: Associations Between Space and Pedestrian Flowing
(HCM, 2010).

The walkway facility capacity is represented by the circumstances when it is at its max flow. As can be seen in Figure (2-2), all of the findings of max unit flow fall within a rather limited range of density, with the mean space per pedestrian changing between 5 and 9 ft².p⁻¹. This information was gleaned from the graph. Even the extremes of these data point to this density as the point at which flow is at its maximum, despite the fact that the actual flow in this research is far larger than that the one seen in the other studies.

The flow rate drops dramatically once the available space is limited to an area of less than 5 ft².p⁻¹. When the minimal space allotment of 2 to 4 ft²/person is reached, all mobility is essentially halted. These connections demonstrate that qualitative analyses of pedestrian traffic may be conducted by using comparable ideas to LOS as are used in analyses of vehicle traffic. For flows that are almost equal to capacity, a mean of 5 to 9 ft².p⁻¹ is needed for every moving pedestrian.

2.5.3. Speed-Flow Relationships

The link between the flow of pedestrians and their pace is seen in figure (2-3) below. These curves, which are similar to those used to describe the flow of vehicles, demonstrate that there is more room to pick faster walking speeds when there are fewer people on a sidewalk (also known as when flow levels are low). When the number of pedestrians grows, the proximity of those walking together causes speeds to decrease. Once there is a critical amount of people in a certain space, it becomes more difficult to move about, and both speed and flow are reduced.

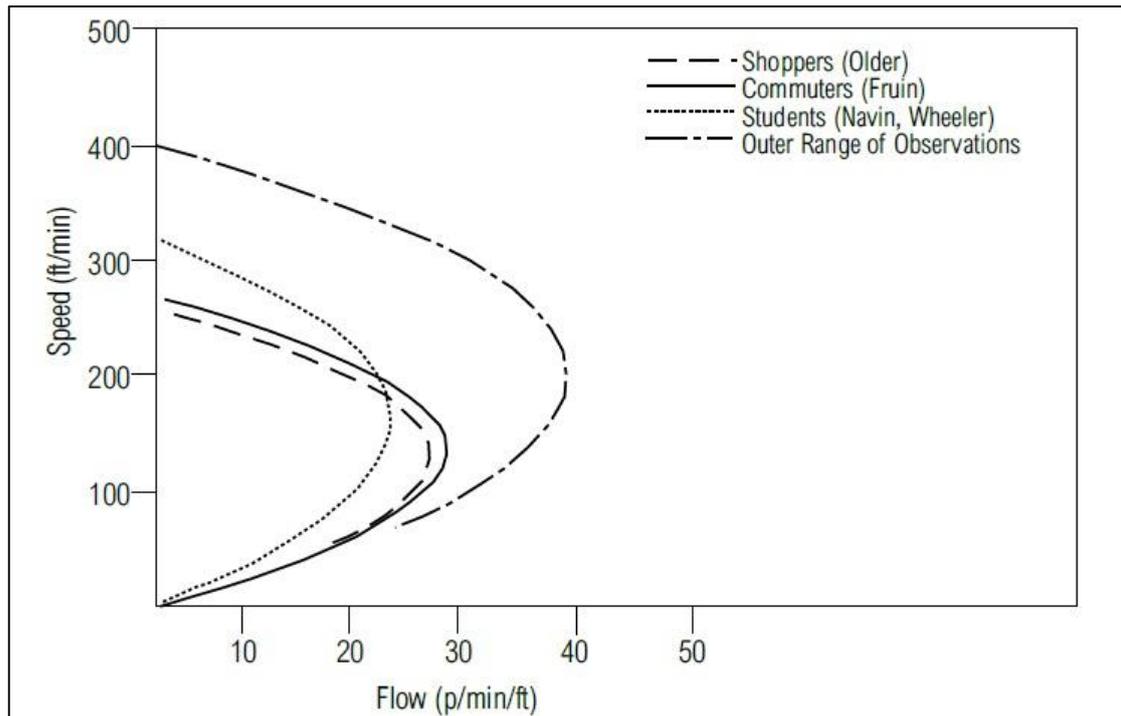


Figure 2.3: Associations Between Flow and Pedestrian Speeding
(HCM, 2010).

2.5.4. Speed-Space Relationships

The correlations between space available and walking speed are discussed in Figure (2-4), and the figure recommends several places of separation in order to establish (LOS) criterion. Due to the fact that the outside range of observations revealed an average spacing of less than $15 \text{ ft}^2 \cdot \text{p}^{-1}$, even the most sluggish walkers are unable to accomplish the walking speeds they seek. Pedestrians that walk at rates of up to 350 feet per minute are unable to reach that speed unless the average area available to them is at least 40 square feet per person.

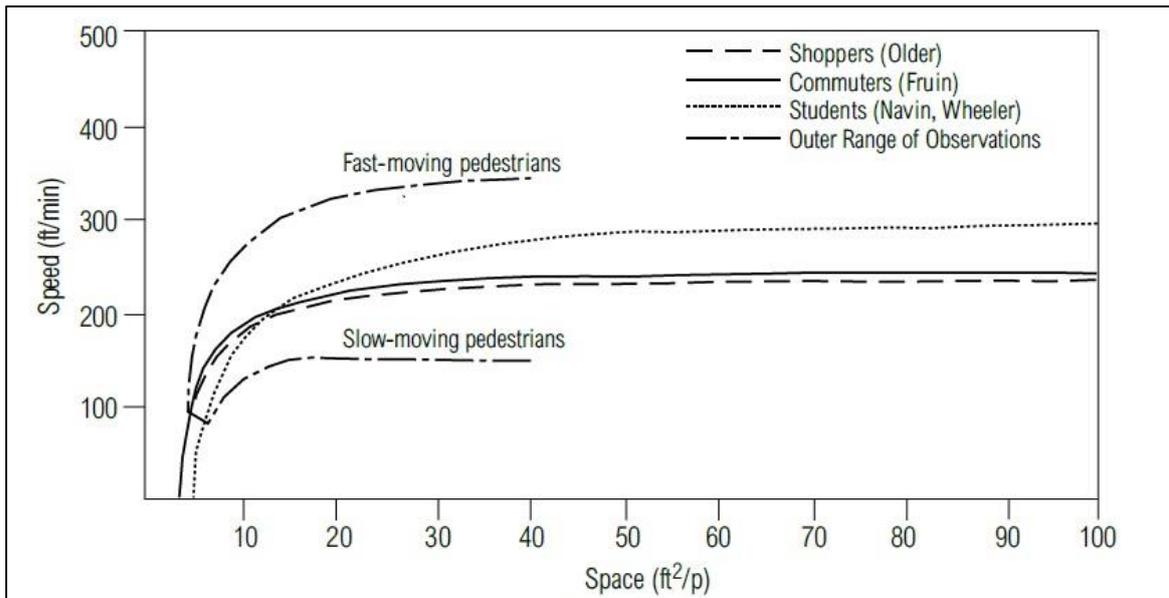


Figure 2.4: Associations Between Space and Pedestrian Speeding
(HCM, 2010).

2.6. Pedestrian Space Requirements

At the very least on an implicit level, pedestrian facility designers take into account body depth and shoulder width when determining minimum space guidelines. As illustrated in Figure(2-5), the fundamental amount of space required to accommodate a single pedestrian is calculated using a simplified body ellipse that has dimensions of 1.5 feet by 2.0 feet and a total area of 3 feet squared (2-5a). This reflects the bare minimum that may be reasonably expected for pedestrians standing. While doing an analysis of a pedestrian facility, a buffer zone for every pedestrian consisting of an area of 8 feet square is employed. A pedestrian who is walking has to have a particular amount of space in front of them.

This forward space is an important dimension since it determines the speed of the journey as well as the pedestrians number that seem to be capable of passing a location in a certain amount of time. The forward area in (2-5b) may be broken down into two distinct zones: a pacing region and a sensory region.

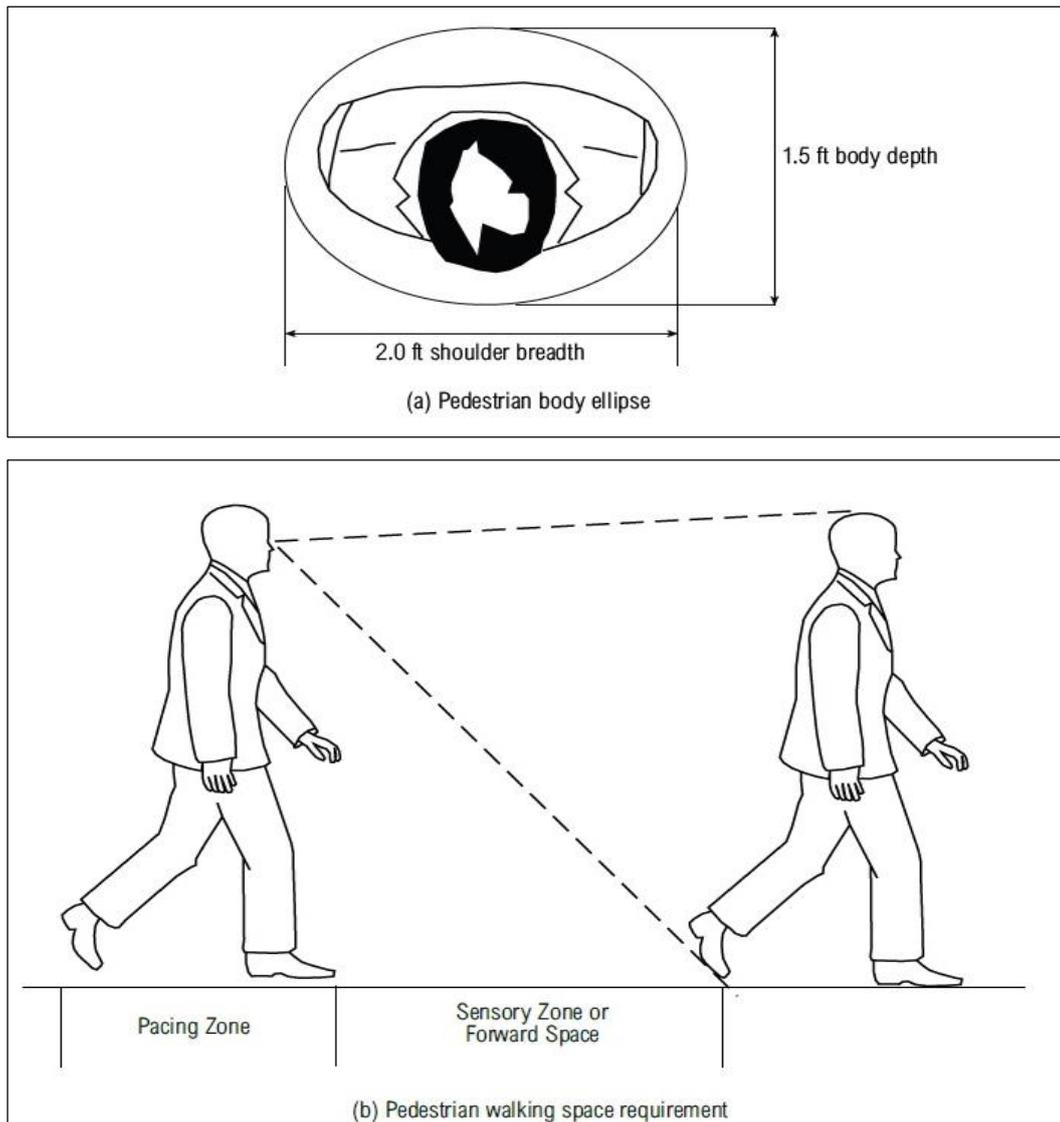


Figure 2.5: Pedestrian Body Ellipse for Standing Areas and Pedestrian Walking (HCM, 2010).

2.7. Pedestrian Walking Speed

The percentage of senior pedestrians (defined as those aged 65 or older) in a population of walkers has a significant impact on that population's average walking pace. On pathways, the average walking pace is 4.0 feet per second if only 0 to 20% of walkers are considered to be old. When senior adults make up to than 20 percent of all pedestrians, the mean walking pace drops to three feet per second. About 5.0 feet per second is the average pace at which people move freely along sidewalks.

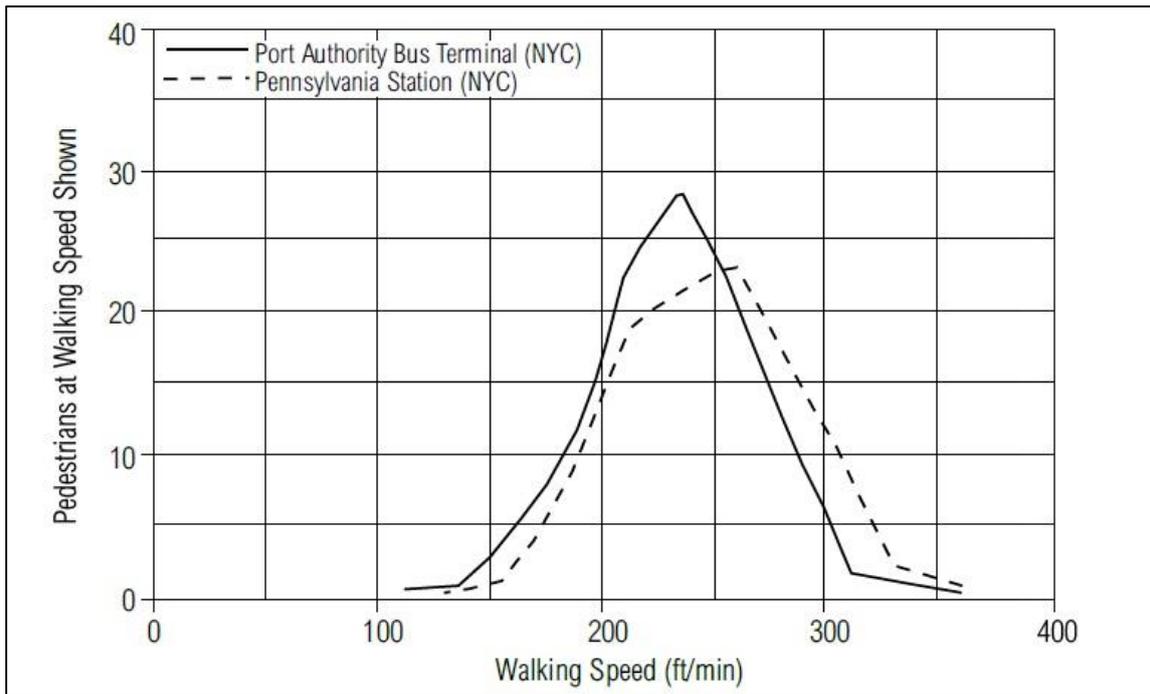


Figure 2.6: Typical Free-Flow Walking Speed Distributions (HCM, 2010).

2.8. Definition of some Parameters Use in Pedestrian Facilities.

There are many Parameters used in the evaluation and analysis of pedestrians movements in the urban area defined as follow (AASHTO, 2011):

2.8.1. Sidewalks

Sidewalks are an essential component of metropolitan roadways, but in rural locations they are far more uncommon to see. Nonetheless, the likelihood of being involved in an accident with a pedestrian is significantly increased in many rural regions as a consequence of the greater speeds and the usual lack of lights. According to the few data that is currently available, sidewalks in rural regions seem to be successful in lowering the number of pedestrian accidents. In rural and suburban settings, the construction of sidewalks next to or beside a roadway is typically justified at locations of development that produce pedestrian concentrations, including residential neighborhoods, schools, companies, and industrial facilities. In the process of developing suburban residential areas, basic highway amenities are required in order for the

community to operate properly; however, the building of sidewalks is often delayed during this phase of development.

In both suburban and urban settings, a border zone is often what stands between a highway and the residences and businesses that comprise a neighborhood. The creation of space for pedestrian walkways is the primary purpose of the boundary. Additional responsibilities include acting as a buffer strip and providing room for lighting, fire hydrants, and other pieces of street infrastructure as well as aesthetically pleasing plants. The width of a border may vary quite a little, but 2.4 meters (or 8 feet) is generally accepted as the minimum width that should be used.

2.8.2. Stairs, Ramps, and Escalators

These are required to provide passenger access between the levels of the motorway and the local streets. Access to public transportation facilities is a need for people with impairments. As a result, access to transport stations via the stairs alone needs to be authorized. The stairways and ramps at transit stations need to be straightforward to ascend and have a welcoming look. This effect is achieved in part by providing rails and adequate lighting both during the day and at night, as well as by supplying landings at every 1.8 to 2.4 meter (6 to 8 ft) change in height. A roof over the staircases, ramps, and platforms would also be beneficial. Stairways must be placed where climbing will be kept to a minimum, particularly between 5.4 and 6.0 meters. (18 to 20 ft).

2.8.3. Walkway Facility

The walkway represents a pedestrian facility positioned far away from motorized traffic and in recreational or retail areas where pedestrians can move about freely without the intrusion of motorized vehicles. The walkway was located where pedestrians could move freely without being bothered by motorized vehicles. The walkway has become distinct from the sidewalk

because it is not elevated and far broader than sidewalks. Additionally, it is completely separated from vehicular traffic.

2.8.4. Crosswalk and Crossing Facility

The at-grade facilities known as crossings are designed to make it simple and risk-free for pedestrians to cross from one side of the road to the other. Crossings are often located at intersections. These crosswalks and crossings may be found either at crossroads or in the middle of blocks, and they can either be signaled or unsignalized, with or without zebra crossings. They can also be positioned with or without zebra crossings. Crosswalks are more important than sidewalks because they allow for more contact between pedestrians and vehicle traffic. This is because people typically choose to cross the street at signalized and unsignalized junctions or at mid-block parts of the road. At signalized junctions, pedestrians must cross only throughout the pedestrian green signal period, whereas motorists must wait throughout the pedestrian red signal period.

2.8.5. Grade-Separated Pedestrian Crossings

Using a grade-separated pedestrian facility, walkers and automobiles can traverse a highway at various elevations by going over or under it. It offers pedestrians a protected haven from which they may across the road without coming into contact with any vehicles. Pedestrian separations must be given in areas where the amount of pedestrians, the volume of traffic, the capacity of the junction, and other factors support their usage; nevertheless, their precise position and design require individual research.

They may be needed to handle large peak pedestrian movements, including those that occur in areas with Central Business Districts (CBD), industries, schools, or sports fields, in conjunction with moderate to heavy traffic flow or in situations in which walkers may be subjected to extraordinary danger or be placed in an awkward position. At freeways or expressways,

pedestrian separations, often overpasses, might be required at the points where cross streets end.

2.9. Pedestrian Service's level (LOS) Studies

Many researches and studies have been conducted that deal with pedestrian activities, their movement and their crossing in the urban area, which concluded to find the necessary development and improvements in this regard, as follows:

(Polus et al., 1983) conducted a study to determine the characteristics of pedestrian flow on sidewalks. The researchers used a video recorder and a digital clock to gather the data and determine the walking speeds. The level of service was determined using linear models based on the link between speed and density. According to the findings, an inverse relation exists between speed and density.

Assessing sidewalks depends on two different aspects: first, the evaluation should be based on the actions of pedestrians, and second, the evaluation should be based on the opinions of pedestrians. The pedestrian density and sidewalk width were considered while determining the amount of service provided to pedestrians (Mōri & Tsukaguchi, 1987).

Several ideas about the process of adjusting the amount of pedestrian service. To calibrate the degree of service provided to pedestrians, several characteristics, including walkway width, median width, initialization parameters, and user perceptions, such as safety and convenience, were determined. A system that employs visual approaches was designed for the pedestrian level of service to assist in finding a solution to this issue (Miller et al., 2000).

Jaskiewicz explained in his study that the pedestrian safety and comfort should be paid a careful attention if walking needs to be encouraged as an alterante form of transportation (Jaskiewicz, 2000).

The safety of pedestrians in the roadside environment to provide a measure of pedestrian service's level. Thus, the researchers tried to identify the factors in the right of way which significantly affect the pedestrians' feeling. These factors due to the sidewalk capacity, quality, safety and comfort which help the designers for a better pedestrian facilities (**Petritsch et al., 2006**).

Techniques were utilized to analyze the degree of pedestrian service by establishing the significance of the features of the sidewalks. These characteristics include the pedestrians' flow rate, the sidewalk's width, the presence of barriers, and the crossing facilities. They concluded that the most important component in determining the amount of pedestrian service was the pedestrian flow rate, followed closely by the width of the sidewalk. On the other hand, an obstruction needed to be more significant to determine the degree of pedestrian service (**Muraleetharan et al., 2004**).

An investigation was conducted to determine the elements that influence the level of pedestrian service and to suggest a technique for determining the degree of pedestrian service. The researchers endeavored to collect responses from a sizeable number of pedestrians in various places before developing a regression model to determine how best to attain the desired level of service. An investigation was carried out in the field to gather data on crosswalks' geometric, operational, and traffic features. In the regression analysis, several independent factors that affect the degree of pedestrian service were found and examined. The issues, such as space, crossing facilities, turning vehicles, delay at signals, and pedestrian-vehicle interaction, are all critical considerations (**Muraleetharan et al., 2005**).

During 15 minutes, measurements of pedestrian volume and flow were obtained. All factors that may affect the quality of the service were measured. Several permanent things may impact access to and usage of sidewalks in addition to the width of the sidewalk itself. Examples of such objects include street furniture and plants. The effects of pedestrians who occupied the

sidewalks in the region were evaluated concerning how they impacted pedestrian traffic as well as the degree of service provided. **(Kim et al., 2006)**

The degree of services provided to pedestrians in metropolitan areas and the impact such services have on pedestrians' ability to choose the appropriate path are both under consideration. The research carried out by the geographic information system (GIS) revealed that pedestrian alters their paths depending on the distance and the service's level. This was discovered to be the case after it was determined that the service's level is connected to the sidewalk's operational and geometrical characteristics **(Muraleetharan & Hagiwara, 2007)**.

The walking behavior of pedestrians under varied conditions, such as climbing and descending stairways, one-way sidewalks, and two-way sidewalks. The characteristics of pedestrian flow, including pedestrian flow, density, and speed, and the correlations between pedestrian flow density and speed form the foundation for the data gathered. In addition, the researchers analyzed the flow characteristics of pedestrians walking owing to the flow-density and speed-density correlations **(Ye et al., 2008)**.

A model was constructed to provide an approximation of the quality of service provided by sidewalks from the point of view of pedestrians. The data acquired from the questionnaire survey, together with the features of the traffic flow, and the geometric data, served as the foundation for the model **(Bian et al., 2009)**.

(Christopoulou & Pitsiava-Latinopoulou, 2012) study service's level model for different conditions, dependent on a questionnaire survey. The developed model was compared with other existing models. They discovered that service's level varies with the approach they quantitative and qualitative parameters for better pedestrian movement situations.

(Nagraj & Vedagiri, 2013) described the level of crosswalks used by the pedestrian service and the elements influencing them. In developing the

model, we considered turning traffic through traffic, the total number of pedestrians, and pedestrian delay.

A method of pedestrians calls pedestrian crossing video simulation (PCVS) to compute the pedestrian service's level, the result found that the increase in delay and traffic volume had negative effect on service's level while the existence of refuge island improves the service's level (**Ling Suan & Mohd Nasurdin, 2014**).

A further investigation was conducted at the Malaysia'sersity of Technology (UTM) in M study aimed to assess and enhance the level of pedestrian service provided on campus. The study relied on pedestrian design indicators that depended on provided guidelines. These indicators were discussed in light of these guidelines. Finally, the research composed an approach that relied on all indicates the level of pedestrian service provided (**Asadi-Shekari et al., 2014**).

A research investigation was conducted to investigate issues concerning the level of pedestrian service provided at crosswalks. It was discovered that the evaluation of pedestrian servise places a greater emphasis on qualitative measurement than it doitative height. Additionally, a measure of effectiveness was utilized to evaluate pedestrian facilities; this measure of effec effectes depends on the kind of facility being evaluassessed example, the measure extent effectiveness of crossings depends on safety, accessible vehicle gaps, pedestrian delay, and behavior (**Kadali & Vedagiri, 2015**).

2.10. Pedestrian Counter measures, Factors and Crashes

More than one-fifth of people killed on the world's roads are pedestrians; in certain countries, this percentage can reach as high as two thirds. These facts are represented in the data that are compiled on car accidents across the globe, (**Organization, 2013**). One of the causes is that pedestrians are placed in a more precarious position. They have the greatest ratio of fatalities to injuries among

all groups of individuals wounded by motor vehicles: almost twice as many as motorcyclists, and more than four times as many as passengers of motor vehicles (**Patargias et al., 2001**). In accordance with the World Health Organization (**Organization, 2013**), there are a number of variables that contribute to pedestrian accidents, the most prominent of which are the speed of the vehicle, the use of alcohol by both drivers and pedestrians, the absence of safe infrastructure for pedestrians, and poor visibility of pedestrians. The following table provides many instances that have been organized according to the Haddon matrix. These examples are based on (**Bates, 2013; Bouwen, 2009; Martin & Sunley, 2006; Organization, 2013**).

Table 2.1: Show Pedestrian crashes factors (**Ambros et al., 2017**)

Factor groups	Crash factors	Available countermeasures
Road user	speeding, alcohol, crossing behaviour, age	reducing vehicle speeds, improving pedestrian and motorist safety awareness and behaviour, education and enforcement
Vehicle	unforgiving vehicle fronts	improving vehicle design for pedestrian protection, under-run protection, improving laws for pedestrian protection
Environment	lack of dedicated pedestrian facilities, insufficient lighting, insufficient trauma care services	crossing facilities, reducing exposure, traffic re-routing, pedestrians separation, reducing road width, improving sight distance and/or visibility, offering early rehabilitation services

2.11. Type of Pedestrian Crossing

Pedestrian crossing are safer places for pedestrians to cross the roadway and the most commonly used in the world when urban area, they are (**Department for Transport, 2005**):

2.11.1. Zebra Crossing

- Road markings as well as specifics on the studies and materials.
- Flashing rates, the photometric performance of globes, and the requirements for both building and electrical work.
- The Highways (Road Humps) rules 1990 do authorize the installation of a road hump in conjunction with a Zebra crossing, but not in the Zebra zig-zag region, provided that the placement of the road hump would adhere to the other criteria of the rules. This is the case only if the road hump is installed in a manner consistent with the laws. There is a benefit to installing a road hump in areas where these conditions can be satisfied. Vehicle speeds are going to be slowed as they approach the hump, and pedestrians can cross the roadway at the same level as the footway.
- Zebra crossings are an option for usage when combining refuge islands. (but see the section on signal-controlled crossings).
- It is essential to maintain the areas leading up to the zebra crossing free of obstructions, just as it is with refuges and signal-controlled crossings. Street furniture and trees present a risk to pedestrians, particularly those with impairments (**Iraqi Highway Design Manual, 2005**) . Plate 2.1



Plate 2.1: Zebra Crossing Facilities

2.11.2. Signal Controlled Crossing

- Once approaching the stop line and while they are stopped there, drivers are required to ensure they have a clear view of at least one of the signal heads. When the view of the vehicular signals is obscured, either because of the vertical or horizontal alignment of the road or other circumstances, including signal masking under heavy traffic conditions or overhanging trees, the visibility of the signals must be made clearer.
- In order to facilitate navigation for pedestrians with impaired vision, posts might be outfitted with either one white or one yellow band, as specified in the relevant General Directions.
- The principal push button and indication panel must usually be situated on the right-hand side of the crossing to aid pedestrians who are blind or partially sighted as they approach the crossing. This will help pedestrians navigate the crossing more safely. They must be encouraged to face

incoming traffic by the orientation of the road. It is recommended that the center of the push button be between 1.0 and 1.1 meters above the level of the footway. Plate 2.2



Plate 2.2: Show the Signal Controlled Crossing Facilities

2.11.3. Pelican Crossing

The pelican crossing has pedestrian signal heads on the far side and a flashing amber/flashing green crossings time that is of a predetermined length and is desired gradually by pushing the button. At a Pelican crossing, pedestrians are required to press the button to activate the device. Once the red figure appears, it's important to be patient and wait till the green light comes on before proceeding.

2.11.4. Puffin Crossing

Puffin crossings use a near-side pedestrian signaling head and an extending all-red crossing duration, both triggered by a push button request in conjunction with a pedestrian detecting demand. In addition, these crossings have an extensible all-red crossing duration. The Puffin operating cycle is

planned to become the regular crossing style for pedestrians at stand-alone crossings and intersections.

2.11.5. Toucan Crossing

The toucan crossing utilizes the same method of identifying vehicles as the pelican and puffin crossings, and its pedestrian on-crossing detector is often identical to that of the puffin crossing. It is planned to build detectors that can be placed at the curbsides. It is expected that the approach that is now utilized for the puffin crossings to become standard after the development of the Toucan has reached a sufficient level of completion. The way that is described in this paper is an intermediate mode of operations. Plate 2.3



Plate 2.3: Show the Toucan Crossing Facilities

2.12. Pedestrian Movement Observation Methods

The main point which is to understand the pedestrian data collection needs based on age distribution, walking distance and in what period of the day. The study also compared between three pedestrian data collection method; manual count method, recording with push button method and video camera recording method (**Cottrell & Pal, 2003**).

Another investigation of the diverse ways of counting at ten various crossroads. The findings demonstrated that both manually counting pedestrians and using clickers generated a lower observational yield than the real situation. (**Diogenes et al., 2007**).

Infrared sensors were used to develop a mechanism for capturing shifts in pedestrian volume that occurred at different times of the day, in different locations, and as a result of different types of weather. The manual counts over a period of two hours, in conjunction with the adjustment variables, were used in order to arrive at an estimate of the weekly pedestrian volumes that were then utilized in the traffic safety study (**Schneider et al., 2009**).

A comprehensive analytic approach for pedestrian data collecting that makes use of passive infrared sensors and temperature sensors. It has come to everyone's attention that the thermal sensors' assessment of pedestrians was far more realistic and included less mistake (**Ozbay et al., 2010**).

Another research on the use of the global positioning system (GPS) for data collecting to determine the route chosen, as well as the beginning and ending places of a pedestrian journey (**Bolbol & Cheng, 2010**).

2.13. Traffic Condition in Urban Area

Congestion is a condition where roadway traffic space requirements surpass the existing provided roadway space. It is the resistance that vehicles carry out on one another, When the utilization of a transportation facility comes close to capacity. Congestion basically a comparative occurrence that is

connected to the variance between how users expect the transportation facility to perform and the actual facility performance (**Chakrabarty et al., 2015**).

There are two main forms of traffic congestion:

Recurring Congestion: This type of congestion can be predicted to happen in an identical period each day as a result of large traffic demand of travelers using roadways which are at or close to their roof capacity

Non-Recurring Congestion: This type of congestion happens as a consequence of an unpredictable or unusual incident. Some sources of a congestion of this type involves vehicle accidents, vehicle collapses, road construction, Security points checks, unplanned pedestrian passing, climate changes, and extra volumes consequential to special events or holidays (**Kelbaugh, 2019**).

2.14. Evaluation and Comparing Methods LOS for Pedestrian

According to (**Sisiopiku et al., 2007**) movement pedestrian activities in urban area, which is included movement, crossing and walking. There are some methods use to evaluate and compare service's level that can be defined as follow:

2.14.1. Highway Capacity Manual

LOS is "a qualitative measurement describing the operational situation within a traffic stream, according to service parameters including speed and duration of travel, comfort, traffic interruptions, freedom to maneuver, as a convenience," as defined by the American Society of Civil Engineers (**HCM, 2010**). The approach for calculating pedestrian LOS comprises criteria for assessing uninterrupted facilities, joint pedestrian-bicycle facilities, staircases, crossings pedestrian streams, signalized pedestrian facilities, and queue spaces for crossing traffic streams. It determines the level of service (LOS) for sidewalks by using the service measurement of space in conjunction with the supplemental criteria of unit flow rate, speeding, and volume/capacity (v/c)

proportion, in addition to the influenced side walk width (W_e), as illustrated in Table (2-2).

2.14.2. Australian Method

The Australian method bases LOS calculation on factors that fall into three categories: physical characteristics, location, and user factors. Among the physical characteristics considered is the path width, the quality of the surface of the sidewalk, the number of obstructions to consider obstacles that reduce the effective sidewalk width, crossing opportunities, and support facilities such as signage, lane markings, and rest areas.

The location factors such as connectivity, path environment and potential for vehicle conflict. User factors include pedestrian volume, mix of path users such as bicycles, elderly and personal security which includes lighting, path visibility, and other measures of the surrounding area.

After these factors have been evaluated, each factor is scored using the criteria. These factors are each weighed based on relative importance and a Level Of Service (LOS) scale is developed to describe the a Level Of Service (LOS) of pedestrian routes

2.14.3. Trip Quality Method

This method combines urban design architectural principles with practical safety and capacity considerations to generate nine evaluation measures for analyzing pedestrian sidewalks for their safety, and functionality.

The method consists of measures that are independent of pedestrian and vehicle flows; it evaluates qualitatively, the following nine measures: enclosure/definition, building articulation, complexity of spaces, overhangs, shade trees, buffer, transparency, complexity of path network, and physical components/condition. Enclosure indicates how well the building and surrounding environment encloses the walking path. Building articulation is a

measure of how well the buildings flow in relation to one another. Both of these measures work along with the complexity of spaces as well as transparency and complexity of path network. Transparency refers to the ability of a pedestrian to move from public to private spaces such as from the walking path to building lobby. This method rewards areas that have low speeds. An area with a low speed is one that cannot be fully evaluated via motorized vehicle. Characteristics of such areas include a complex path network and a complexity of spaces which allow more opportunities for pedestrians to explore rather than motorists. Each measure is assessed and given a score ranging from 1 to 5, with 1 being very poor and 5 being excellent. This method gives poor ratings to facilities that are not conducive to pedestrians. The literature did not provide much information about assigning values for each factor, an issue that greatly depends upon the observers' opinions. Taking these factors and the proposed rating system under consideration, the Trip Quality method can be used to calculate an average score for the facility under consideration and relate this score to a LOS based on the criteria. One advantage to this method is the ability to use the system to describe each measure separately rather than just determining LOS. This, in turn, can be used to recommend specific actions to improve a corridor's pedestrian attractiveness. **(Jaskiewicz, 2000)**

2.14.4. Landis Method

The Landis method concentrates on factors that significantly influence the safety and comfort of the pedestrian users. This method is a good attempt to quantify objectively a pedestrians' perception of safety and comfort in the roadside environment. This quantification provides a measure of how well roadways accommodate pedestrian travel. Also known as, the Florida Department of Transportation, this method is based on a statistical evaluation of perceptions of the effects of motorized traffic on the safety and comfort of pedestrians. **(Steiner 2002)** The Landis Method considers sidewalk capacity

and the quality of the walking experience as measures of quality of pedestrian facilities operation. It does this by quantifying the perception of safety and comfort that a pedestrian experiences. Also recently, the Landis Method has been expanded to include intersections, instead of sidewalk segments only.

2.14.5. Conjoint Analysis

Usually, a user survey is used to carry out the Conjoint Analysis.

2.15. PTV Vissim Software Program

Cities around the world are studying how digitization can improve traffic flow. PTV VISSIM (Planning Transport Verkehr-in German Language) is one of the most famous digitization and used across the globe simulation software to evaluate traffic problems such as safety, delay, emissions and pedestrian movement. PTV VISSIM allows with simulating different modes of transport, and pedestrians, it is owned by PTV Group. VISSIM simulation platform was used in this study to simulate the traffic interaction at signalized intersection locations

The main advantages of VISSIM over contemporary software are:

- Flexibility in dealing with interactions between two vehicles in the same lane. lateral movement of vehicles, and gap acceptance controls **(Habtemichael & de Picado-Santos, 2013)**.
- Allows calibration of different parameters that include the driver's behavior to reach real traffic situations.
- VISSIM has many routing decisions for vehicles, allowing many scenarios

Thus, companies and cities save money and time, enhance road safety and reduce the impact on the environment with VISSIM. So VISSIM is a valuable and effective tool for transportation engineering **(Atamo, 2012)**.

2.16. Micro-Simulation Technique

Micro-simulation has been a widely applied technique in many fields of transportation (**Essa & Sayed, 2016**).

The micro-simulation technique can be regarded as a potent alternative for traditional studies (**Wang & Stamatiadis, 2013**).

Recently, researchers have been motivated to explore the potentials of using the micro-simulation technique for evaluating traffic safety, which is more difficult to quantify directly (**Gettman & Head, 2003**).

(**Mehmood et al., 2001**) provided essential insights into used micro-simulation-based methods with regard to modeling relationships among highway traffic flow changeable, geometric characteristics, and highway safety (**HCM, 2010**).

Which is the PTV VISSIM simulation model where many researchers used the micro-simulation VISSIM to evaluate safety at different traffic facilities (**Cunto & Saccomanno, 2008; Ghanim & Shaaban, 2019; Vasconcelos et al., 2014**).

2.17. Summary

The chapter deals with the basic characteristics of pedestrians based on their reactions, behavior and interaction with the basic elements of traffic, speed, traffic volume and density. There are many studies and researches conducted that deal with the service's level for pedestrians with a study of the current status of their transportation and the transit facility available in the study area and the existing traffic facilities. The studies also dealt with a study other pedestrian facilities within urban area such as walkway, stairway and escalator facilities.

In order to find the possible solution and improve pedestrians condition to ensure the efficiency, safely and comfort for their movements and crossing, several methods that have been addressed to identify the service level for pedestrians, including the study found the Highway Capacity Manual (**HCM, 2010**) is the majority broadly accepted technique of quantifying pedestrian LOS.

The most accepted method of quantifying pedestrian LOS is the HCM method, it has a simple and easy to follow approach to finding variables. The HCM defines LOS as a qualitative measure describing operational conditions within a traffic stream based on the service measure of space, unit flow rate, speed, and volume/capacity (v/c) ratio. (**HCM, 2010**)

Chapter Three

Data Collection and Methodology

CHAPTER THREE

3. Data Collection and Methodology

3.1. Introduction

This chapter deals with the methods of collecting pedestrian traffic data for the locations of the study area in the city of Hilla, using field techniques consistent with the scientific methodology, in proportion to the importance of the data that will be extracted from the study area.

The surveys in the study area adopted accuracy and efficiency in collecting, organizing and preparing them within appropriate Tables and Figures to reflect the behavior of the sample, reflects to some extent the study population for the purpose of conducting a statistical and engineering analysis of the data in order to reduce the negative effects of the pedestrian problem and find effective solutions and improvements to this traffic problem within study area.

3.2. Pedestrian Problems in Hilla City

The city of Hilla is considered one of the main cities in Iraq due to its historical, cultural, religious and economic importance, as it is located to the south of the capital, Baghdad, at a distance of 100 km. That exacerbates the problem of pedestrians as a result of the conflict of their activities movement with the vehicles heavy traffic volumes, resulting in a decrease in the level of service (LOS) for pedestrians and an increase different types of traffic accidents specially (vehicle / pedestrian).

Conducting the traffic studies are conducted providing safety zones for pedestrians and their movements according to the approved technical specifications as well as providing suitable crossings for them, ensuring the provision of sufficient time and space to reduce the pedestrian problem in the roads and intersections of Hilla city in general and the urban area in particular.

Therefore, it requires taking into account the pedestrians problems in the study area, conducting comprehensive reviews and studies to evaluate the efficiency of crossing and pedestrian mobility, as well as using modern software based on conducting engineering and statistical analysis to find appropriate traffic solutions, safely, efficiently and conveniently.

3.3. Data Collection

The process of collecting field data to evaluate traffic volume of vehicles and pedestrians in the study area is very important and complicated because it's a variable element from one period to another, therefore the survey operations included the following stages:

3.3.1. Reconnaissance phase

In this survey, a reconnaissance survey was conducted for the five sites studied in Hilla city, where the roadways condition, sidewalks, pedestrian activities, stairway and pedestrian crossing facilities was observed, the focus was on determining the A.M. & P.M. peak hour's volume and how to obtain them.

The roadways were inspected for a period of three months (30/10/2021 – 30/01/2022) where the most traffic hours were observed in the weeks, then the highest days, and thus the highest peak hours per day, with the assistance of traffic policeman as well as road users. Therefore, the critical peak hours were studied for the study area, noting that the traffic data was collected on working days (Monday, Tuesday, and Wednesday). It was excluded holidays and inappropriate weather conditions, as they do not give an appropriate idea about traffic flow within study area.

3.3.2. Field Measurement

At this stage, engineering and traffic measurements were done for the roadway sections within study area. The engineering survey included lane width, No. of lanes, median width, and sidewalks width.

Traffic survey contend, traffic volumes of vehicles and classification (on the basis of AASHTO method), which are Passenger car (PC) and Heavy vehicles (HV), divided into (Truck T) and (Buses B).

Pedestrian's traffic volume, average speed, stairway condition, at grade crossing and density included too. As well as the effective sidewalk width (W_E) and the obstacle width (W_O) in order to evaluate the exist (LOS).

Manual count method was used to collect traffic data using a video camera with the aid of the resident engineer department for the cameras project in order to determine all-important parameters needed to be evaluated and analysed in this study.

3.4. Definition of Study Area

The study chose five sites in Hilla city. In order to identify the pedestrian problems, the selection based on the following considerations:

- The variety of pedestrian's activities in the study area.
- The variety of land uses in the urban area, including commercial, educational and residential according to Hilla master plan.
- Studying pedestrian movements and their crossing in various areas such as at grade crossing and by using stairs.

The study seeks to find this variety in the study area to clarify the importance of this traffic problem in order to conduct the necessary assessment based on the collection and analysis of field data within traffic studies that adopt the effects of overlapping random activities between pedestrians and vehicles. Thus solutions are provided that assist to reduce the effects of Pedestrian problem as shown in Figure (3.1) in which the study area marked on Al-Hilla master plan.

The five sites studied as follows:

- Hilla-Najaf Roadway (Babylon University Gates) Section Length.
- Muhrmat Shat Al- Hilla.

- AL-Mahdi AL-Muntazar Street (60).
- Abed Alkarim Kassem Street (Al Jamia)
- Al Jabal Street.

3.4.1. Hilla-Najaf Roadway (Babylon University Gates) Section Length.

It is characterized as arterial multi lane highway with two directions, each direction have five lanes , lane width (3.70) m, as well as the width of the median (6.0) m. The roadway section in front of the gates of the University of Babylon was studied (from The southern garage gate to the Al-Mustaqbal University). It is provided with steel structure of two bridges for pedestrian crossing, one of them is equipped with an electric ladder to transfer the traffic volumes of pedestrians across between two sides of the roadway .

The road section that was studied is accured with the lack of sufficient side walks for pedestrians, as well as the lack of adequate facilities for their crossing and movement.

The roadway section length seem with unincrease in vehicles and pedestrians traffic volumes, as well as many hazardes conflict points during official working hours, especially in the a.m & p.m.peak hour volume.

The current situation of traffic data have been collected for pedestrians. Listed in Figure (3-2), (3-3) and Tables (3-1), (3-2), (3-3) and (3-4) and Plate (3-1) show the characteristics of study area.

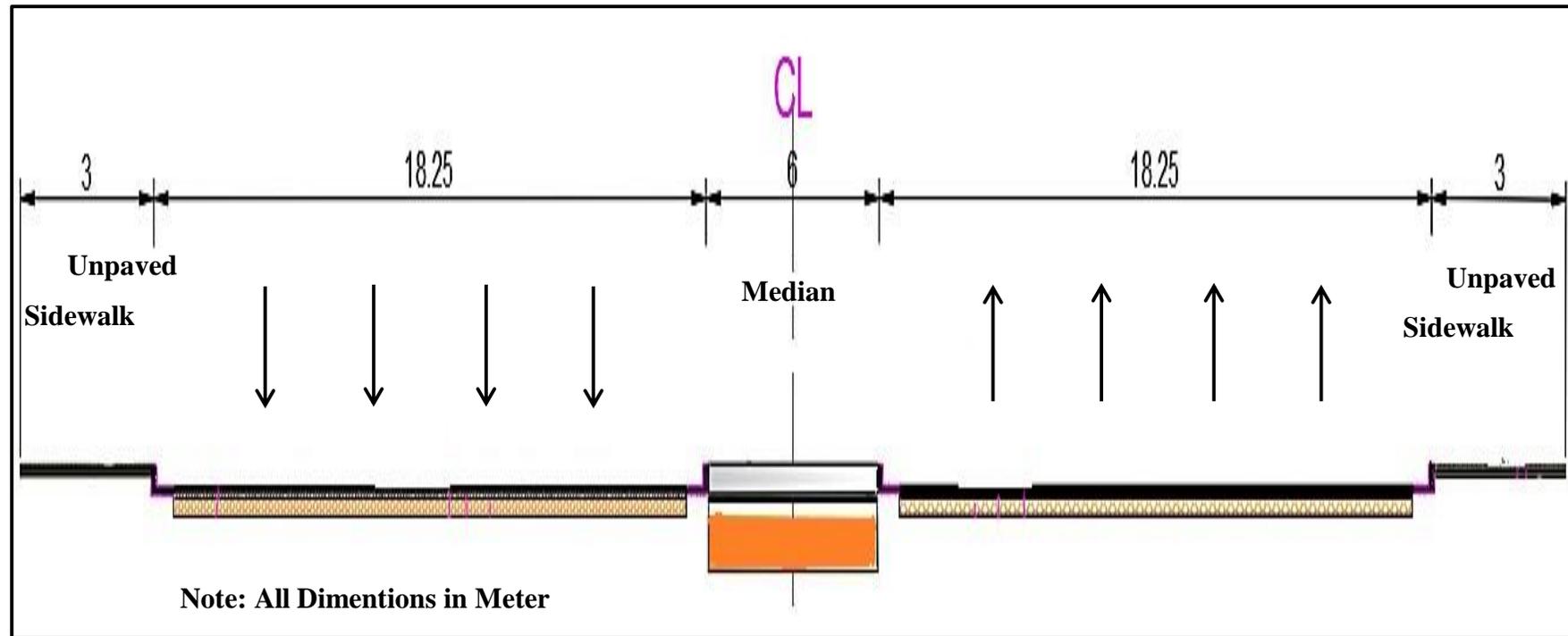


Figure 3.2: Hilla-Najaf Roadway Cross Section .

Table 3.1: Classification of Vehicle and Traffic Volume Variation. Hilla-Najaf Roadway According to A.M. Peak Hour

Study area	Time	vehicles classification			Total	Percentage of Heavy vehicles %
		PC*	T**	B***		
Hilla-Najaf Roadway (Babylon University Gates) Section Length.	8:00 - 8:15	1415	70	30	1515	6
	8:15 - 8:30	987	65	32	1084	8.9
	8:30 - 8:45	1083	50	21	1154	6
	8:45 - 9:00	991	52	22	1065	6

PC* = Passenger car unit.

T** = Truck.

B*** = Buses.

Table 3.2: Classification of Vehicle and Traffic Volume Variation. Hilla-Najaf Roadway According to P.M. Peak Hour

Study area	Time	vehicles classification			Total	Percentage of Heavy vehicles %
		PC	T	B		
Hilla-Najaf Roadway (Babylon University Gates) Section Length.	1:00 - 1:15	1580	21	19	1620	2.4
	1:15 - 1:30	961	29	16	1006	4.4
	1:30 - 1:45	1240	13	16	1269	2.2
	1:45 - 2:00	699	18	12	729	4.1

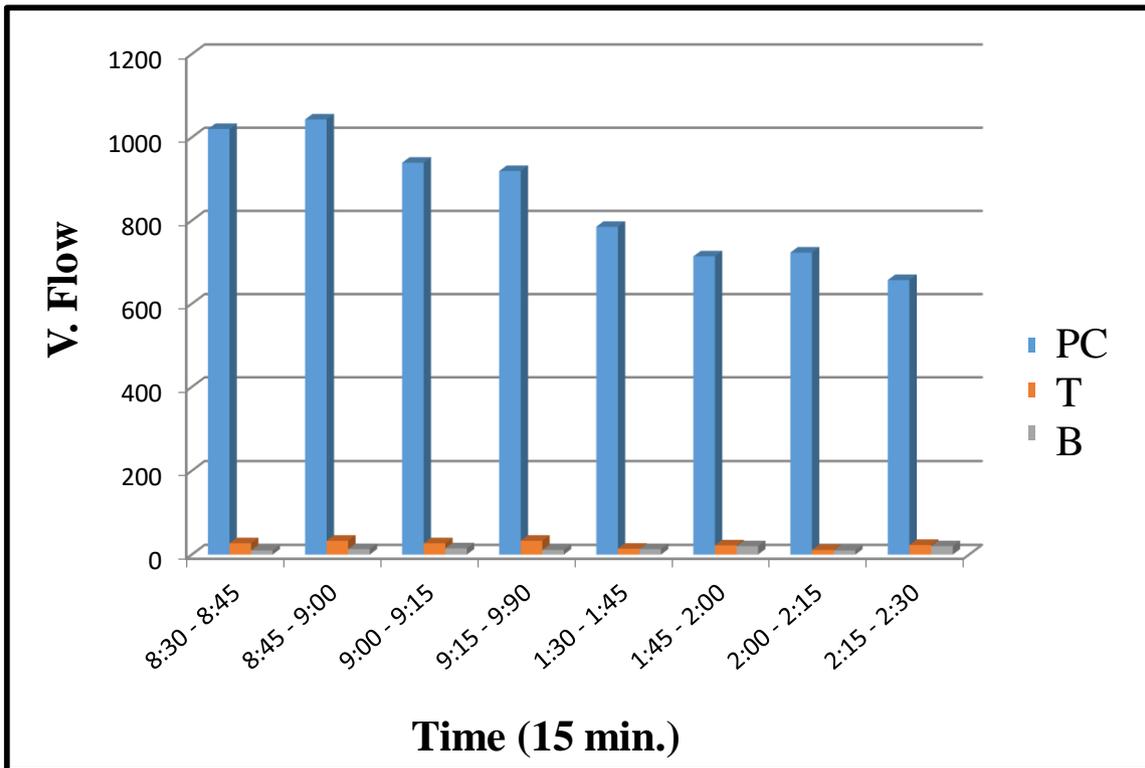


Figure 3.3: Classification of Vehicle and Traffic Volume Variation. Hilla-Najaf Roadway According to A.M. & P.M. Peak Hour

Table 3.3: Traffic Parameters for Pedestrian Movement. Hilla-Najaf Roadway
According to A.M. Peak Hour

Study area	Time	Pedestrian Traffic Volume (Ped. / 15 min.)	Pedestrian Average Walking Speed (ft. /min.)	Pedestrian Density (Ped. /ft ² .)
Hilla-Najaf Roadway (Babylon University Gates) Section Length.	8:00 - 8:15	250	180	1.38
	8:15 - 8:30	311	168	1.851
	8:30 - 8:45	386	150	2.573
	8:45 - 9:00	299	204	1.465

Table 3.4: Traffic Parameters for Pedestrian Movement. Hilla-Najaf Roadway
According to P.M. Peak Hour

Study area	Time	Pedestrian Traffic Volume (Ped. / 15 min.)	Pedestrian Average Walking Speed (ft. /min.)	Pedestrian Density (Ped. /ft ² .)
Hilla-Najaf Roadway (Babylon University Gates) Section Length.	1:00 - 1:15	115	240	0.479
	1:15 - 1:30	135	228	0.592
	1:30 - 1:45	201	174	1.155
	1:45 - 2:00	228	210	1.085

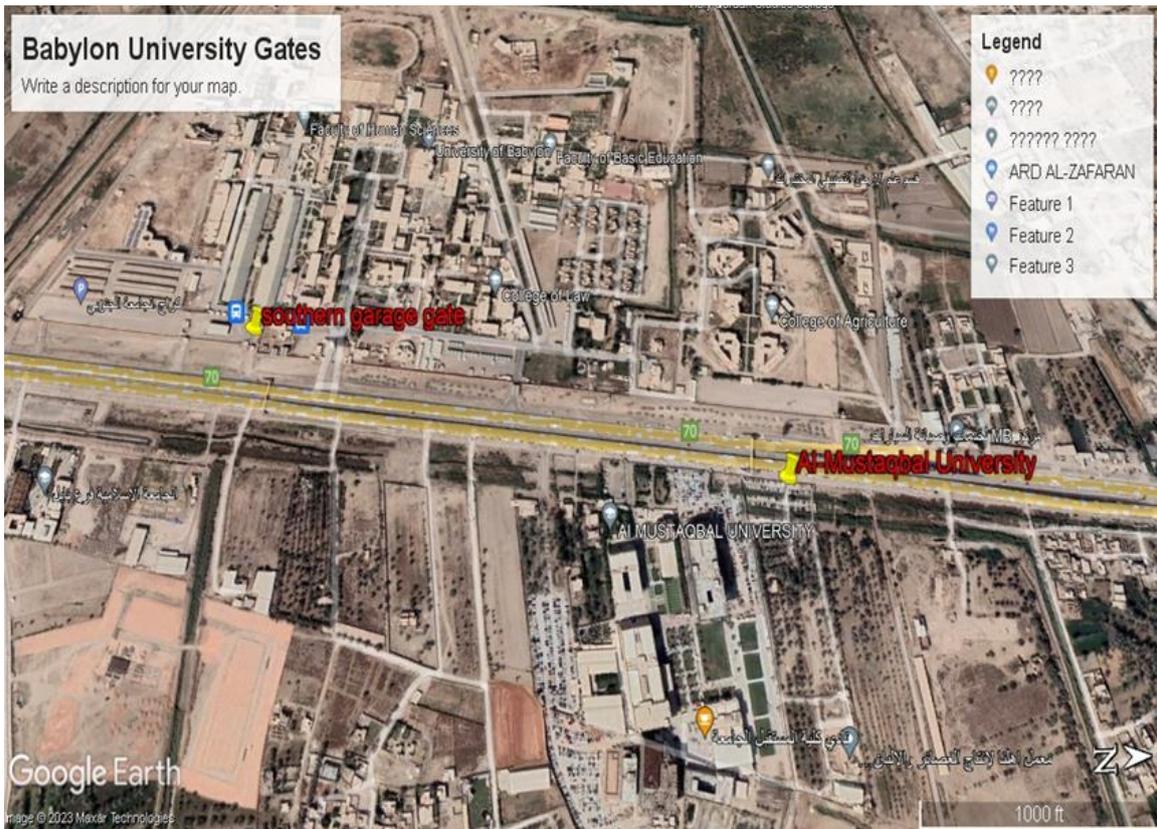


Plate 3.1: Hilla-Najaf Roadway .

3.4.2. Muhrmat Shat Al- Hilla Street

It is a multi-lane road with one direction traffic, it's width (11.25) m. Side walks width on both sides(1.5) m.

This road extends from Al-Hadidey Bridge in the north to the Imam Ali Street Bridge in the south. The roadway length is (1) km, it is characterized by an increase in traffic volumes and densities of pedestrian activities. It represents a great diversity in their effectiveness and provides shopping, medical, residential, commercial and educational.

while the width of the side walkways does not accommodate these many activities in order to reach their different goals. The inefficiency of pedestrian traffic and crossing facilities led to a decrease in the safety and convenience factors as a result of the increase in the critical points between vehicles and pedestrians. The characteristics of study area are shown in Figure (3-4), (3-5) and Tables (3-5), (3-6), (3-7) and (3-8) and Plate (3-2).

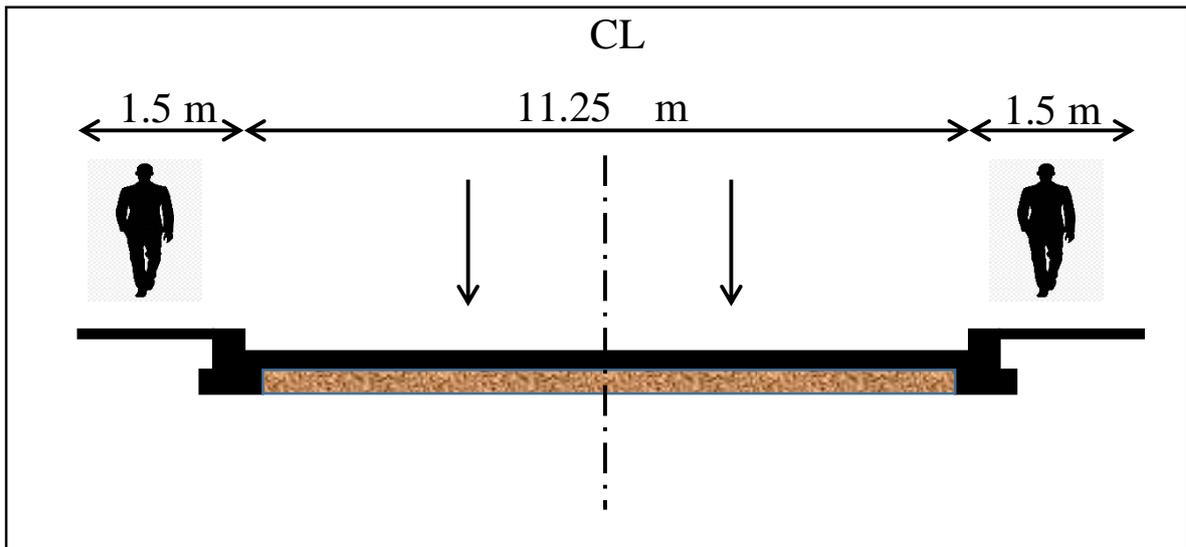


Figure 3.4: Muhrmata Shat Al-Hilla Cross Section Street.

Table 3.5: Classification of Vehicle and Traffic Volume Variation. Muhrmat Shat Al- Hilla According to A.M. Peak Hour

Study area	Time	vehicles classification			Total	Percentage of Heavy vehicles %
		PC	T	B		
Muhrmat Shat Al- Hilla Street	9:30 - 9:45	425	5	2	432	1.6
	9:45 - 10:00	401	2	7	410	2.19
	10:00 - 10:15	311	1	5	317	1.89
	10:15 - 10:30	222	2	6	230	3.47

Table 3.6: Classification of Vehicle and Traffic Volume Variation. Muhrmat Shat Al- Hilla According to P.M. Peak Hour

Study area	Time	vehicles classification			Total	Percentage of Heavy vehicles %
		PC	T	B		
Muhrmat Shat Al- Hilla Street	12:30 - 12:45	317	3	5	325	2.46
	12:45 - 1:00	388	2	2	392	1.02
	1:00 - 1:15	212	1	1	214	0.93
	1:15 - 1:30	235	6	2	243	3.29

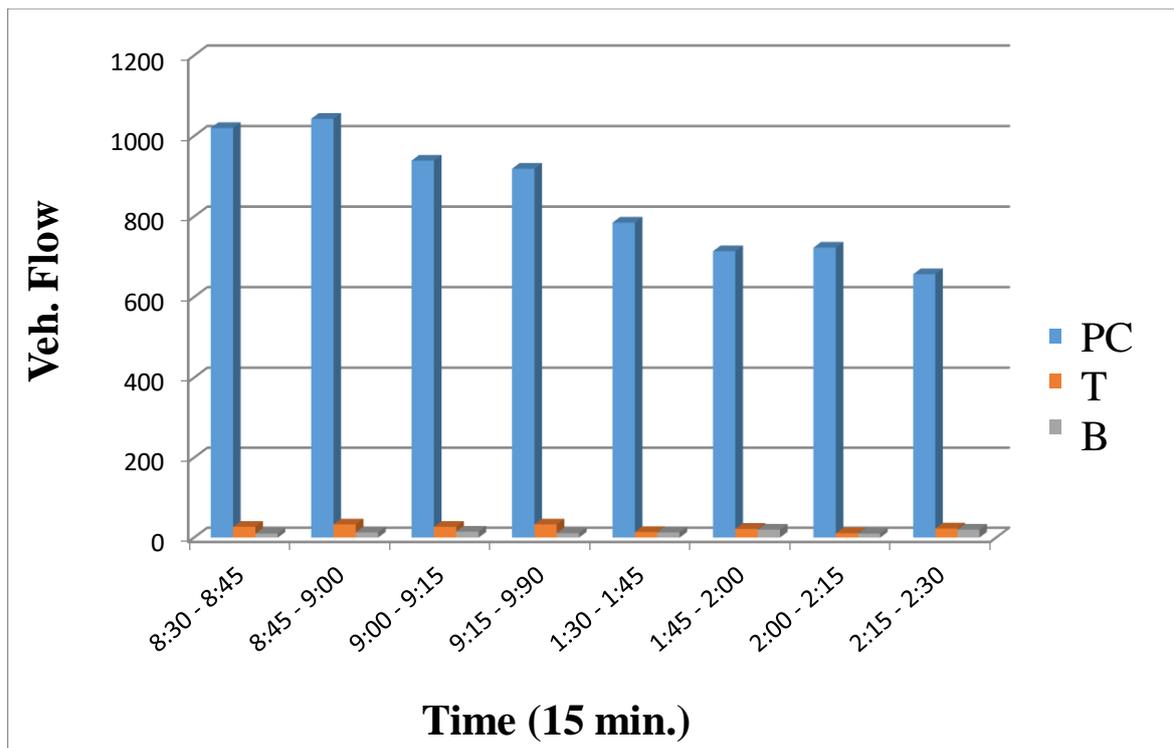


Figure 3.5: Classification of Vehicle and Traffic Volume Variation. Muhrmat Shat Al- Hilla According to A.M. & P.M. Peak Hour

Table 3.7: Traffic Parameters for Pedestrian Movement. Muhrmat Shat Al-Hilla According to A.M. Peak Hour

Study area	Time	Pedestrian Traffic Volume (Ped. / 15 min.)	Pedestrian Average Walking Speed (ft. /min.)	Pedestrian Density (Ped. /ft ² .)
Muhrmat	9:30 - 9:45	600	138	4.347
Shat Al- Hilla Street	9:45 – 10:00	550	150	3.666
	10:00 - 10:15	500	162	3.086
	10:15 - 10:30	400	180	2.222

Table 3.8: Traffic Parameters for Pedestrian Movement. Muhrmat Shat Al-Hilla According to P.M. Peak Hour

Study area	Time	Pedestrian Traffic Volume (Ped. / 15 min.)	Pedestrian Average Walking Speed (ft. /min.)	Pedestrian Density (Ped. /ft ² .)
Muhrmat Shat Al- Hilla Street	12:30 - 12:45	500	162	3.086
	12:45 - 1:00	400	180	2.222
	1:00 - 1:15	325	204	1.593
	1:15 - 1:30	300	198	1.515

3.4.3. AL-Mahdi AL-Muntazar Street (60 Section length)

It is defined as multi-lane main arterial roadway, with two lanes in each direction, separated by a median width (4 m) to ensure complete separation of movements between the two directions.

The width of the road in one direction is (7.5) m, while the lane width is (3.75) m. The roadway suffers from unpaved sidewalks, which exacerbates the problem of pedestrians crossing, movement, and crossing maneuver.

The main problem that pedestrians face, is the unsafe crossing process, especially if we take into consideration the speed of vehicles that reach (80) km/hr., in addition to the lack of safety zones and safe crossing areas, especially in the section of the roadway in front of the main garage in the city (from Al-Muwahid garage to Al-Batool bridge). The characteristic of study area are shown in Figure (3-6), (3-7) and Tables (3-9), (3-10), (3-11) and (3-12) and Plate (3-3).

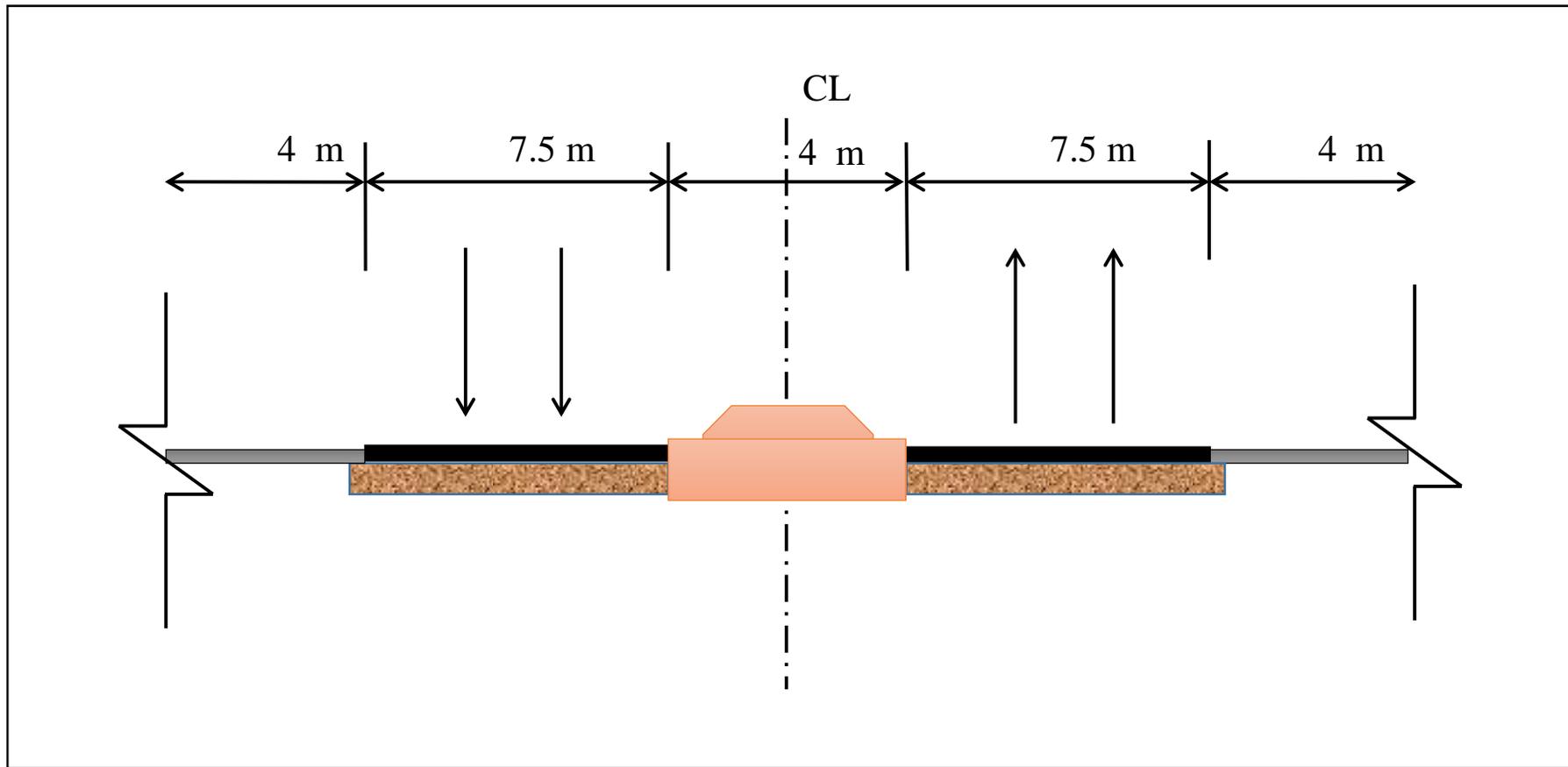


Figure 3.6: AL-Mahdi AL-Muntazar Street (60) Cross Section

Table 3.9: Classification of Vehicle and Traffic Volume Variation. AL-Mahdi AL-Muntazar(60) Street According to A.M. Peak Hour

Study area	Time	vehicles classification			Total	Percentage of Heavy vehicles %
		PC	T	B		
AL-Mahdi AL-Muntazar Street (60 Section length)	8:30 - 8:45	1020	27	10	1057	3.5
	8:45 - 9:00	1043	33	13	1089	4
	9:00 - 9:15	939	27	15	981	4.3
	9:15 - 9:30	919	33	11	963	4.5

Table 3.10: Classification of Vehicle and Traffic Volume Variation. AL-Mahdi AL-Muntazar(60) Street According to P.M. Peak Hour

Study area	Time	vehicles classification			Total	Percentage of Heavy vehicles %
		PC	T	B		
AL-Mahdi AL-Muntazar Street (60 Section length)	1:30 - 1:45	785	14	13	812	3
	1:45 - 2:00	714	22	20	756	5.5
	2:00 - 2:15	723	11	10	744	2.8
	2:15 - 2:30	657	23	20	700	6

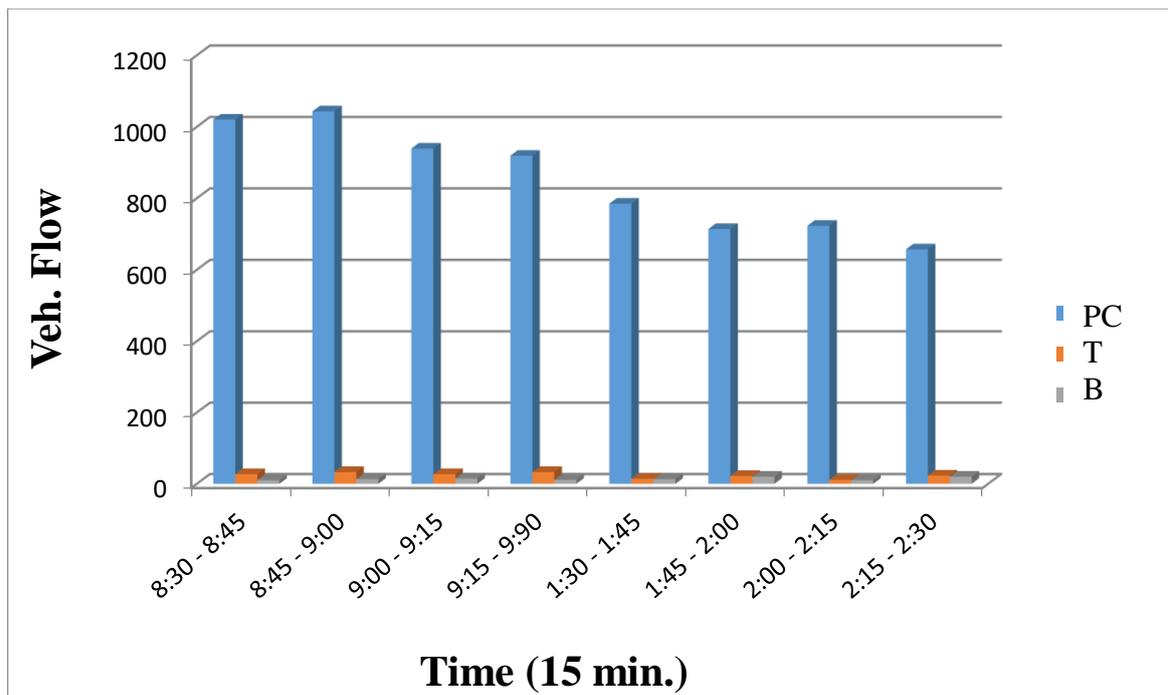


Figure 3.7: Classification of Vehicle and Traffic Volume Variation. AL-Mahdi AL-Muntazar(60) Street According to A.M. & P.M. Peak Hour

Table 3.11: Traffic Parameters for Pedestrian Movement. AL-Mahdi AL-Muntazar(60) Street According to A.M. Peak Hour

Study area	Time	Pedestrian Traffic Volume (Ped. / 15 min.)	Pedestrian Average Walking Speed (ft. /min.)	Pedestrian Density (Ped. /ft ² .)
AL-Mahdi AL-Muntazar Street (60 Section length)	8:30 - 8:45	75	186	0.403
	8:45 - 9:00	80	198	0.404
	9:00 - 9:15	65	174	0.373
	9:15 - 9:30	70	180	0.388

Table 3.12: Traffic Parameters for Pedestrian Movement. AL-Mahdi AL-Muntazar(60) Street According to P.M. Peak Hour

Study area	Time	Pedestrian Traffic Volume (Ped. / 15 min.)	Pedestrian Average Walking Speed (ft. /min.)	Pedestrian Density (Ped. /ft ² .)
AL-Mahdi AL-Muntazar Street (60 Section length)	1:30 - 1:45	45	210	0.214
	1:45 - 2:00	49	216	0.226
	2:00 - 2:15	50	223	0.224
	2:15 - 2:30	43	220	0.195

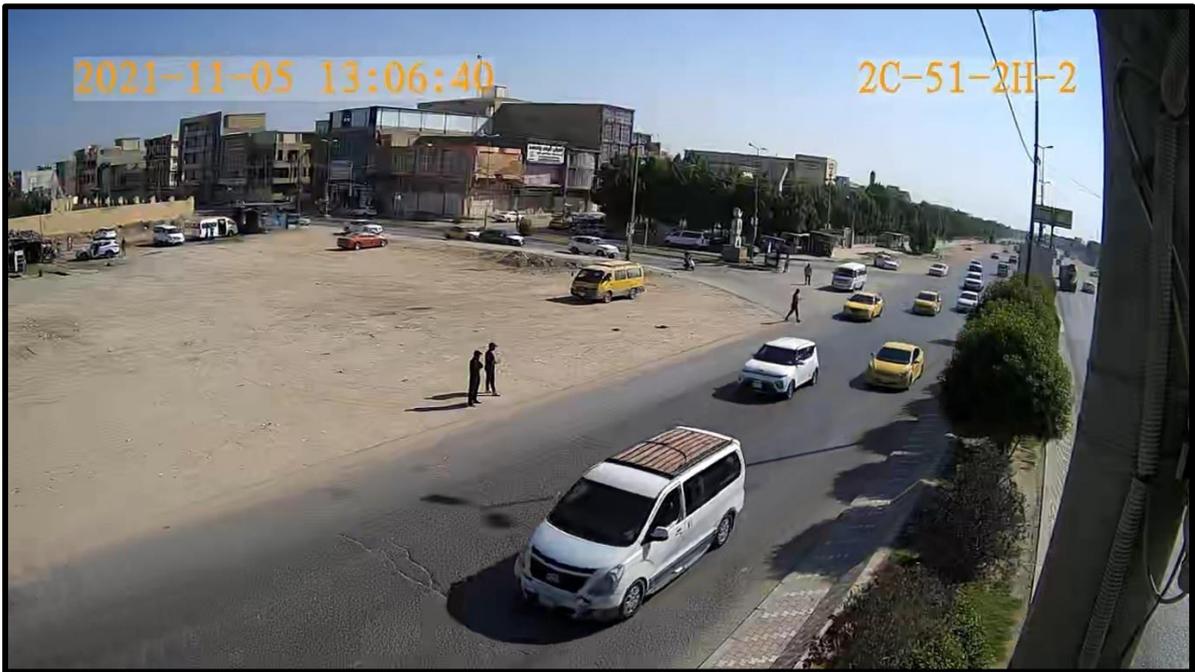


Plate 3.3: AL-Mahdi AL-Muntazar Street (60).

3.4.4. Abed Alkarim Kassem Street (Al Jamia Section Length)

The roadway is dominated by its commercial and residential as well as educational features, which made the road crowded with pedestrian movements, especially in the A.M. & P.M. peak hours volume. The roadway is also characterized by multiple uturns movements, in addition to not having specific areas for pedestrian crossing, which decrease the discomfort and safety factors for road users.

There is also no necessary times for pedestrian crossing in succession with the movement of vehicles. The length of the road is (1.5) km (from Al-Fayhaa hospital to 40 Street), it is a divided multi-lane roadway with six lanes, total width of (22.0) m by (1.0) m, the width of the median, while the width of the side walkway is (4.0) m in each direction.

The study noticed, through the field survey of the data, the presence of many violations on the path of pedestrian movement in the side walks.

As a result, led to overlapping activities are occurred and become random in most cases, in addition to the inefficiency of the level of service and Inappropriatnees for pedestrians along the road segment. The charactristic of study area are shown in Figure (3-8), (3-9) and Tables (3-13), (3-14), (3-15) and (3-16) and Plate (3-4).

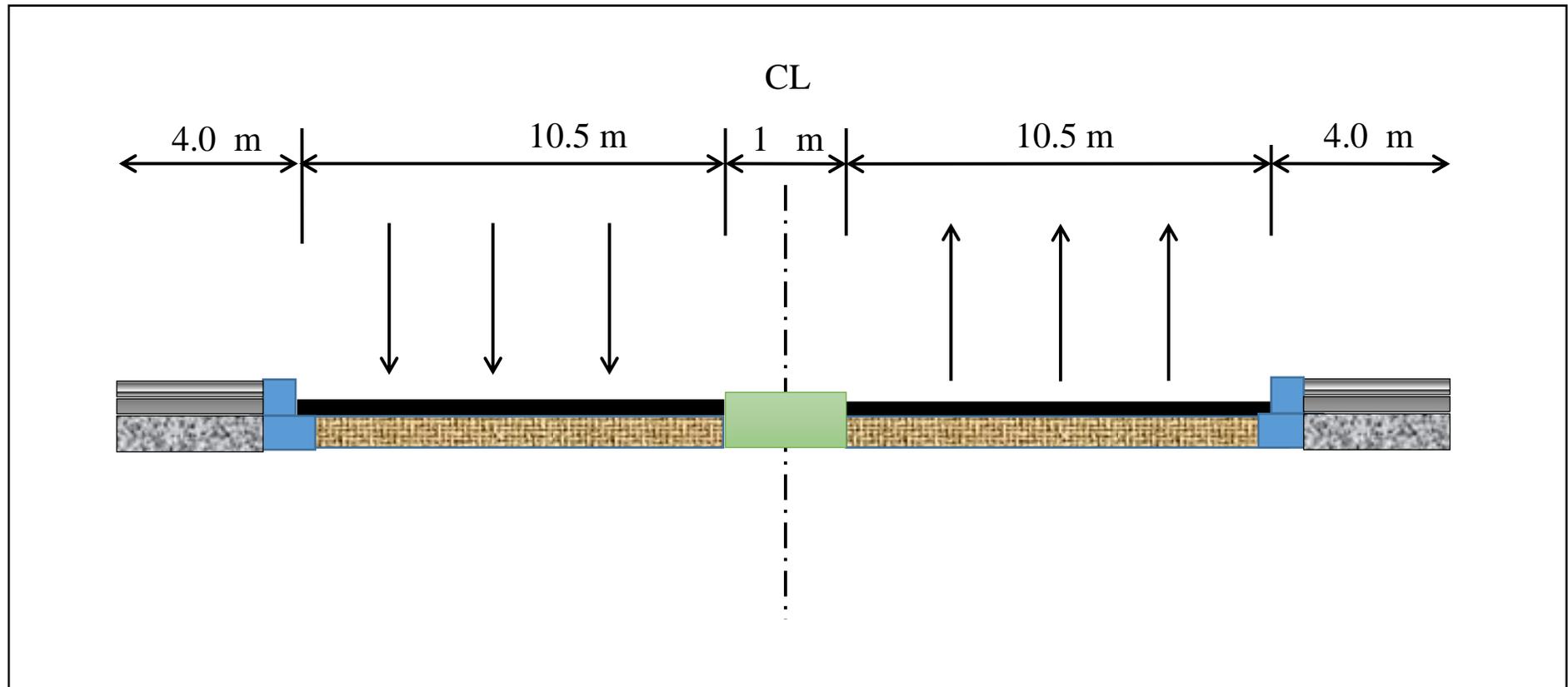


Figure 3.8: Abed Alkarim Kassem Street (Al Jamia) Cross Section.

Table 3.13: Classification of Vehicle and Traffic Volume Variation. Abed Alkarim Kassem Street (Al Jamia) According to A.M. Peak Hour

Study area	Time	vehicles classification			Total	Percentage of Heavy vehicles %
		PC	T	B		
Abed Alkarim Kassem Street (Al Jamia Section Length)	10:00 - 10:15	610	3	7	620	1.6
	10:15 - 10:30	442	6	9	457	3.2
	10:30 - 10:45	430	7	10	447	3.8
	10:45 - 11:00	394	5	13	412	4.3

Table 3.14: Classification of Vehicle and Traffic Volume Variation. . Abed Alkarim Kassem Street (Al Jamia) According to P.M. Peak Hour

Study area	Time	vehicles classification			Total	Percentage of Heavy vehicles %
		PC	T	B		
Abed Alkarim Kassem Street (Al Jamia Section Length)	6:30 - 6:45	744	2	9	755	1.4
	6:45 - 7:00	601	1	13	615	2.2
	7:00 - 7:15	380	2	2	384	1
	7:15 - 7:30	299	2	7	308	2.9

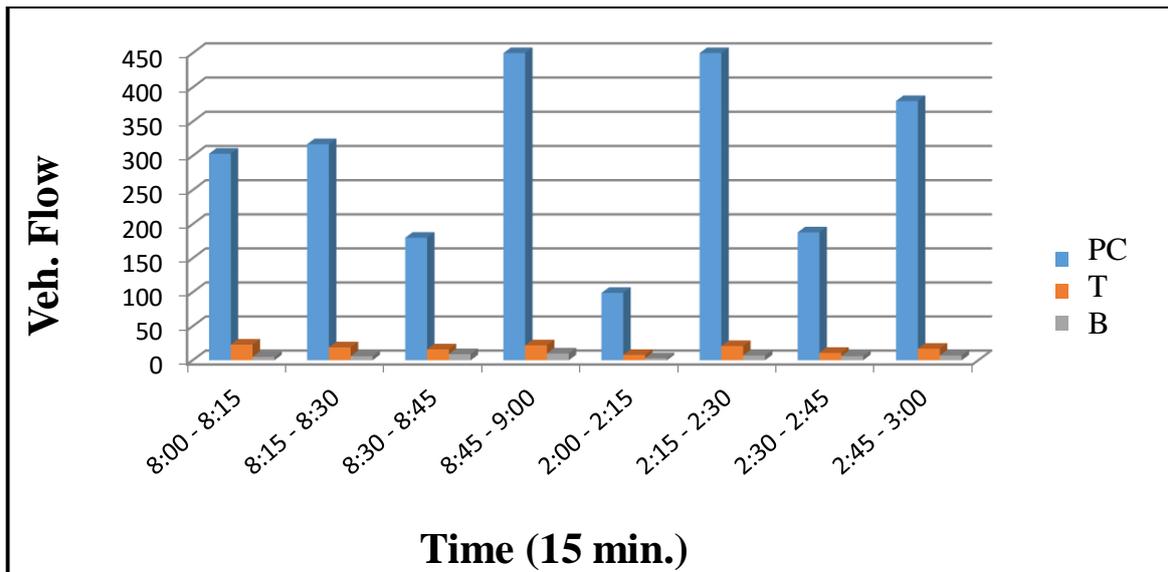


Figure 3.9: Classification of Vehicle and Traffic Volume Variation. . Abed Alkarim Kassem Street (Al Jamia) According to A.M. & P.M. Peak Hour

Table 3.15: Traffic Parameters for Pedestrian Movement. . Abed Alkarim Kassem Street (Al Jamia)According to A.M. Peak Hour

Study area	Time	Pedestrian Traffic Volume (Ped. / 15 min.)	Pedestrian Average Walking Speed (ft. /min.)	Pedestrian Density (Ped. /ft ² .)
Abed Alkarim Kassem Street (Al Jamia Section Length)	10:00 - 10:15	180	138	1.304
	10:15 - 10:30	190	150	1.266
	10:30 - 10:45	265	204	1.299
	10:45 – 11:00	220	192	0.114

Table 3.16: Traffic Parameters for Pedestrian Movement. . Abed Alkarim Kassem Street (Al Jamia)According to P.M. Peak Hour

Study area	Time	Pedestrian Traffic Volume (Ped. / 15 min.)	Pedestrian Average Walking Speed (ft. /min.)	Pedestrian Density (Ped. /ft ² .)
Abed Alkarim Kassem Street (Al Jamia Section Length)	6:30 - 6:45	390	192	2.031
	6:45 - 7:00	399	201	1.985
	7:00 - 7:15	504	264	1.909
	7:15 - 7:30	465	240	1.937

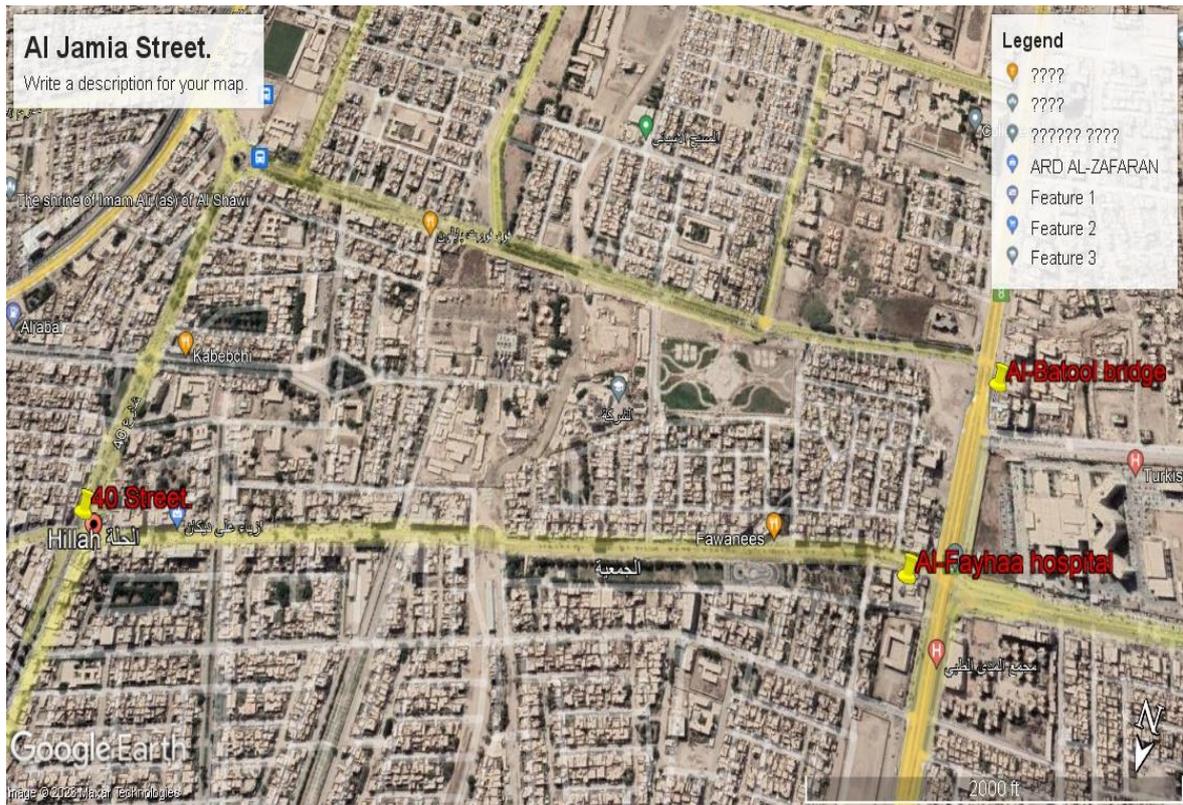


Plate 3.4: Abed Alkarim Kassem Street (Al Jamia)

3.4.5. Al Jabal Street Section Length

The roadway located in the central business district (CBD) area of Hilla city, it is characterized by commercial as well as religious events.

The dominant feature on the road is the excesses in the sidewalks of the road, which contradict to a large extent the pedestrians paths and expose them to multiple dangers as a result of the inadequacy of those walkways, forcing them to descend into the roadway section. As well as the lack of specific places for pedestrian crossing.

The road is classified as one of the main roads in the city (from 40 Street to Hussein Ibn Idriis), it's separated by a median width of (1) m. It has two lanes in each direction with four lanes and sidewalks. The width of the road in one direction is (7.5) m and the width of the sidewalkway is (4) m.

The roadway suffers from the lack of safe facilities for pedestrian crossing, so that traffic obstructions for pedestrian movement have become its dominant feature, therefore pedestrians are unable to reach their goals efficiently and appropriately.

Field survey help the study to evaluate the current situation of pedestrian movements and conduct the necessary analysis in order to find some solutions that help in Finding a pattern of pedestrian movement that ensures non-interference between pedestrian and vehicle activities, resulting in an increase level of service for pedestrians within the study area. The characteristics of study area are shown in Figure (3-10), (3-11) and Tables (3-17), (3-18), (3-19) and (3-20) and Plate (3-5).

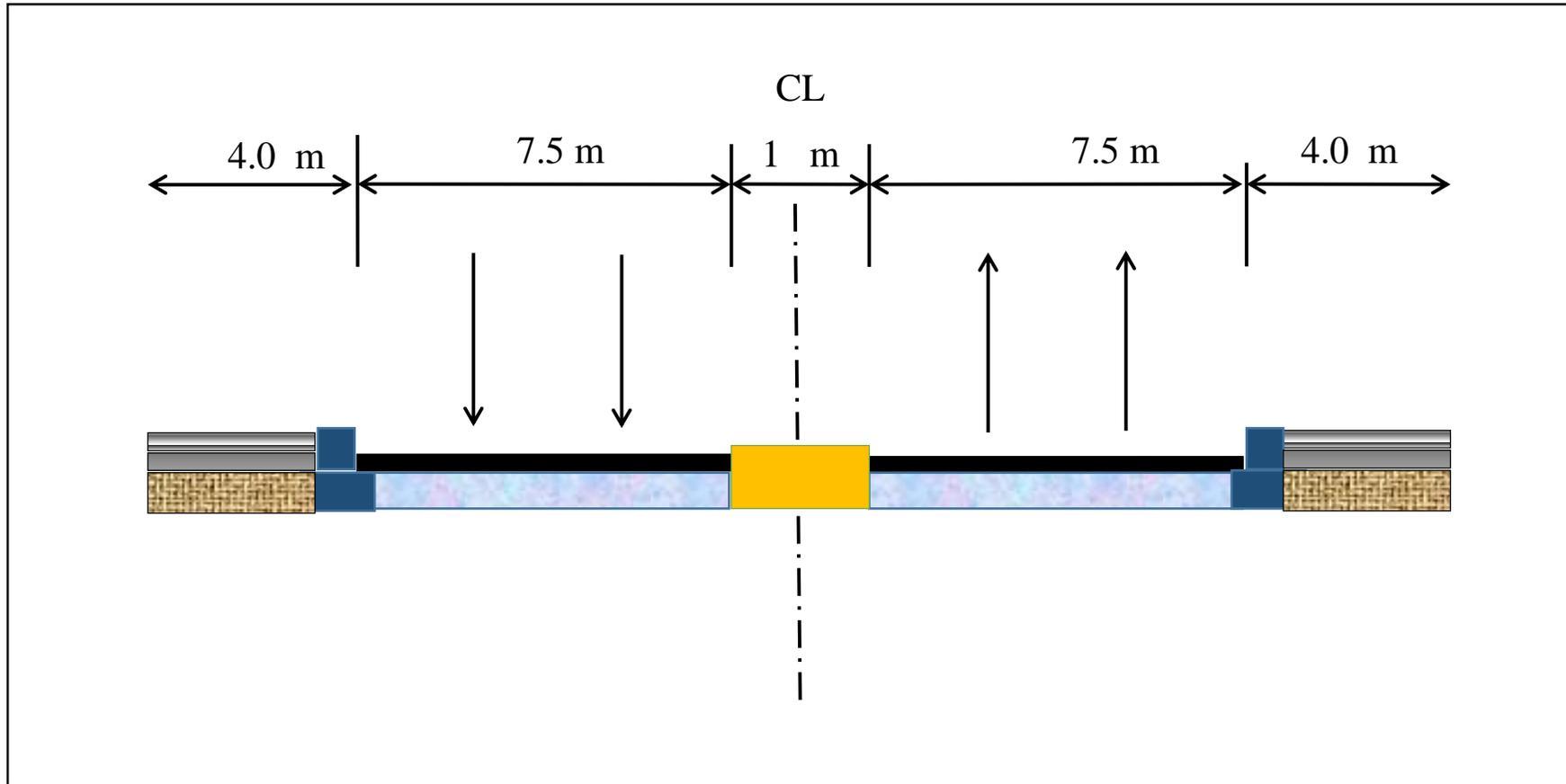


Figure 3.10: Al Jabal Street Cross Section.

Table 3.17: Classification of Vehicle and Traffic Volume Variation. Al Jabal Street According to A.M. Peak Hour

Study area	Time	vehicles classification			Total	Percentage of Heavy vehicles %
		PC	T	B		
Al Jabal Street Section Length	8:00 - 8:15	303	23	5	331	8.4
	8:15 - 8:30	317	19	6	342	7.3
	8:30 - 8:45	180	16	9	205	12.1
	8:45 - 9:00	450	22	10	482	6.6

Table 3.18: Classification of Vehicle and Traffic Volume Variation. Al Jabal Street According to P.M. Peak Hour

Study area	Time	vehicles classification			Total	Percentage of Heavy vehicles %
		PC	T	B		
Al Jabal Street Section Length	2:00 - 2:15	99	8	3	110	1.0
	2:15 - 2:30	450	21	7	478	5.8
	2:30 - 2:45	188	11	6	205	8.2
	2:45 - 3:00	380	17	7	404	5.9

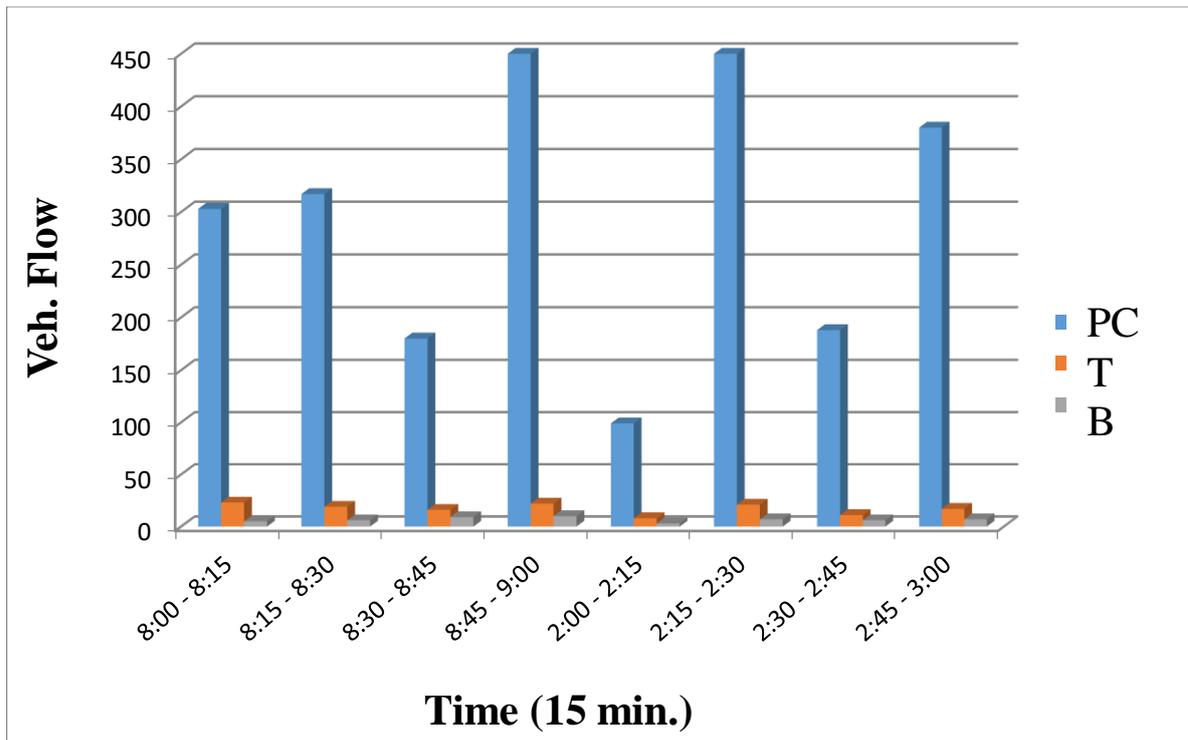


Figure 3.11: Classification of Vehicle and Traffic Volume Variation. Al Jabal Street According to A.M. & P.M. Peak Hour

Table 3.19: Traffic Parameters for Pedestrian Movement. Al Jabal Street
According to A.M. Peak Hour

Study area	Time	Pedestrian Traffic Volume (Ped. / 15 min.)	Pedestrian Average Walking Speed (ft. /min.)	Pedestrian Density (Ped. /ft ² .)
Al Jabal Street Section Length	8:00 - 8:15	145	138	1.05
	8:15 - 8:30	150	150	1
	8:30 - 8:45	190	174	1.091
	8:45 - 9:00	205	195	1.051

Table 3.20: Traffic Parameters for Pedestrian Movement. Al Jabal Street
According to P.M. Peak Hour

Study area	Time	Pedestrian Traffic Volume (Ped. / 15 min.)	Pedestrian Average Walking Speed (ft. /min.)	Pedestrian Density (Ped. /ft ² .)
Al Jabal Street Section Length	2:00 - 2:15	145	138	1.05
	2:15 - 2:30	150	150	1
	2:30 - 2:45	135	127	1.062
	2:45 - 3:00	125	119	1.5



Plate 3.5: Al Jabal Street

3.5. Software Programs Used in the Study

The main software used in this study as follow:

3.5.1. VISSIM Software

VISSIM is one of the software packages launched and developed by PTV Group Planning Transport Verkehr at the University of Karlsruhe in Germany, which means in English language (Planning Transport Traffic). It was initially designed to simulate traffic in cities, but the mode for freeway simulation is also added later (Tettamanti & Horváth, 2015).

Recent software updates have allowed simulated pedestrian flows besides public transportation such as transportation by rails and planes. In this study, PTV VISSIM 2021- Student license was used.

It is an efficient program that was used to find a simulation that includes the pattern of pedestrians crossing and their movement patterns in the sidewalks of the studied areas.



Plate 3.6: VISSIM Simulation Software Program

3.5.2. SPSS Statistical Software Program

SPSS defined as (Statistical Package for the Social Sciences). Statistics is the world's leading statistical software used to solve business and research problems hypothesis testing and predictive analytics (**Norman et al., 1975; Spss, 2010**). Organizations use IBM SPSS Statistics to understand data, analyze trends, forecast and plan to validate assumptions and drive accurate conclusions.

The study used version (26.0) in order to find the logical relationships between the basic traffic elements, and their effect on pedestrian movements, sidewalks, and crossing facilities through the outputs of the statistical parameters.

Chapter Four

Analysis, Results and Discussion

CHAPTER FOUR

4. Analysis, Results and Discussion

4.1. Introduction

The current chapter related to data analysis that is collected according to field survey, with the aid of highways manual capacity (**HCM, 2010**) technique.

The study seeks to evaluate the exist service level (Level of Service) for the pedestrian movement, walking and crossing within five sites study in urban area then suggested some solution to improve pedestrians' safety and convenience factors.

4.2. Pedestrians Flow Characteristics in the Study Area

(Level of Service)(LOS) based on pedestrian flow rate and sidewalk space adopted by highway capacity manual (**HCM, 2010**) which integrates pedestrian speed volume and density similar to the vehicle.

The service level (Level of Service) scale for different pedestrian facilities, including sidewalks, walkways, crosswalks, stairs, and escalators, is explained by pedestrian flow features including jam density, space, density, flow, and speed. Essential relationships (between density and speed) have been detected over various facilities and have been detected to be expressively various.

Pedestrian flow features investigate could be additionally extended to analyze the pedestrian service level (Level of Service) of the facilities in consideration.

Pedestrian flow in urban area is very important, due to provide suitable facilities as well as safety and convenience movement to avoid traffic accidents and arrive within the specified travel time while reducing the delay time.

The pedestrian traffic flow rate in the study area suffers from the following problems:

- The presence of large violation, on the sidewalks contributed to a large extent in the occurrence of obstacles and traffic accidents for pedestrians, as shown in Plates (3-2), (3-4) and (3-5).
- The inadequacy of the side walkways in terms of dimensions and paving contributed to reduce capacity, thus the inefficiency of the service level, as shown in Figures (3-2), (3-4) and (3-6). Plates (3-1), (3-2) and (3-3).

The study determines the useful geometric design details which are needed in the service level (Level of Service) analysis within the investigation zone, as shown in Table (4-1).

Table 4.1: Geometric Design for Roadway Section within Study Area.

Location	Roadway Width (Direction) (ft.)	Roadway Type	No. of Lanes (Direction)	Median Width (ft.)	Sidewalk Width (Direction) (ft.)	Lane Width (ft.)
Hilla-Najaf Roadway (Babylon University Gates) Section Length.	60.225	Divided	4	19.8	9.9	12.375
Muhrmat Shat Al- Hilla.	37.125	One Direction	2	-	4.95	18.56
AL-Mahdi AL- Muntazar Street (60).	24.75	Divided	2	3.3	13.48	12.375
Abed Alkarim Kassem Street (Al Jamia).	34.65	Divided	3	3.3	13.48	11.55
Al Jabal Street	24.75	Divided	2	13.48	13.48	12.375

4.3 Evaluate (LOS) for Roadway Section within Study Area

The study conducted an assessment of the service level in the studied road sections. (HCS, 2010) is used for the purpose of showing the extent of its impact on the features of pedestrian crossing and the flow of traffic in the investigation zone. Table (4-2) shows the findings of the analysis.

Table 4.2: Service's level (Level of Service) Criteria within Study Area

	Study Area	LOS Type	Note
1	Hilla-Najaf Roadway (Babylon University Gates) Section Length.	D	-
2	Muhrmat Shat Al- Hilla.	E	Form Observation
3	AL-Mahdi AL-Muntazar Street (60).	F	-
4	Abed Alkarim Kassem Street (Al Jamia).	C	-
5	Al Jabal Street	B	❖

❖ From observations the roadway with Level of Service less than (C), because the requirements of the software program is that the vehicle speed is not less than (45) miles / hour, while the actual roadway speed does not exceed (25) miles / hour.

Table (4-3), (4-4), (4-5) and (4-6) show Level of Service analysis within the study area.

Table 4.3: Level of Service Analysis for Hilla-Najaf Roadway (Babylon University Gates) Section Length.

		VOLUME	
Direction		1	2
Volume, V		4818 vph	4800 vph
Peak-hour factor, PHF		0.90	0.90
Peak 15-minute volume, v15		1338	1333
Trucks and buses		25 %	25 %
Recreational vehicles		0 %	0 %
Terrain type		Level	Level
Grade		0.0 %	0.0 %
Segment length		0.0 mi	0.0 mi
Number of lanes		3	3
Driver population adjustment, fP		1.00	1.00
Trucks and buses PCE, ET		1.5	1.5
Recreational vehicles PCE, ER		1.2	1.2
Heavy vehicle adjustment, fHV		0.889	0.889
Flow rate, vp		2007 pcphpl	2000 pcphpl
		RESULTS	
Direction		1	2
Flow rate, vp		2007 pcphpl	2000 pcphpl
Free-flow speed, FFS		60.0 mph	60.0 mph
Avg. passenger-car travel speed, S		57.1 mph	57.2 mph
Level of service, LOS		E	D
Density, D		35.1 pc/mi/ln	35.0 pc/mi/ln

Table 4.4: Level of Service Analysis AL-Mahdi AL-Muntazar Street (60).

VOLUME				
Direction	1		2	
Volume, V	4090	vph	3900	vph
Peak-hour factor, PHF	0.89		0.89	
Peak 15-minute volume, v15	1149		1096	
Trucks and buses	17	%	15	%
Recreational vehicles	0	%	0	%
Terrain type	Level		Level	
Grade	0.00	%	0.00	%
Segment length	0.00	mi	0.00	mi
Number of lanes	2		2	
Driver population adjustment, fP	1.00		1.00	
Trucks and buses PCE, ET	1.5		1.5	
Recreational vehicles PCE, ER	1.2		1.2	
Heavy vehicle adjustment, fHV	0.922		0.930	
Flow rate, vp	2493	pcphpl	2355	pcphpl
RESULTS				
Direction	1		2	
Flow rate, vp	2493	pcphpl	2355	pcphpl
Free-flow speed, FFS	60.0	mph	60.0	mph
Avg. passenger-car travel speed, S	mph		mph	
Level of service, LOS	F		F	
Density, D	pc/mi/ln		pc/mi/ln	

Overall results are not computed when free-flow speed is less than 45 mph.

Table 4.5: Level of Service Analysis for Abed Alkarim Kassem Street (Al Jamia)

VOLUME				
Direction	1		2	
Volume, V	1936	vph	1900	vph
Peak-hour factor, PHF	0.89		0.89	
Peak 15-minute volume, v15	544		534	
Trucks and buses	13 %		13 %	
Recreational vehicles	0 %		0 %	
Terrain type	Level		Level	
Grade	0.00 %		0.00 %	
Segment length	0.00 mi		0.00 mi	
Number of lanes	3		3	
Driver population adjustment, fP	1.00		1.00	
Trucks and buses PCE, ET	1.5		1.5	
Recreational vehicles PCE, ER	1.2		1.2	
Heavy vehicle adjustment, fHV	0.939		0.939	
Flow rate, vp	772	pcphpl	757	pcphpl
RESULTS				
Direction	1		2	
Flow rate, vp	772	pcphpl	757	pcphpl
Free-flow speed, FFS	60.0	mph	60.0	mph
Avg. passenger-car travel speed, S	60.0	mph	60.0	mph
Level of service, LOS	C		C	
Density, D	12.9	pc/mi/ln	12.6	pc/mi/ln

Overall results are not computed when free-flow speed is less than 45 mph.

Table 4.6: Level of Service Analysis for Al Jabal Street

VOLUME				
Direction	1		2	
Volume, V	1360	vph	1330	vph
Peak-hour factor, PHF	0.90		0.90	
Peak 15-minute volume, v15	378		369	
Trucks and buses	25 %		25 %	
Recreational vehicles	0 %		0 %	
Terrain type	Level		Level	
Grade	0.00 %		0.00 %	
Segment length	0.00 mi		0.00 mi	
Number of lanes	2		2	
Driver population adjustment, fP	1.00		1.00	
Trucks and buses PCE, ET	1.5		1.5	
Recreational vehicles PCE, ER	1.2		1.2	
Heavy vehicle adjustment, fHV	0.889		0.889	
Flow rate, vp	850	pcphpl	831	pcphpl
RESULTS				
Direction	1		2	
Flow rate, vp	850	pcphpl	831	pcphpl
Free-flow speed, FFS	46.0	mph	45.0	mph
Avg. passenger-car travel speed, S	46.0	mph	45.0	mph
Level of service, LOS	B		B	
Density, D	18.5	pc/mi/ln	18.5	pc/mi/ln

Overall results are not computed when free-flow speed is less than 45 mph.

4.3.1 The Determination of Effective Sidewalk Width (W_E)

It's described as segment of a sidewalk which may be utilized successfully by pedestrians as shown in Figure (4-1) and Table (4-7), (HCM, 2010).

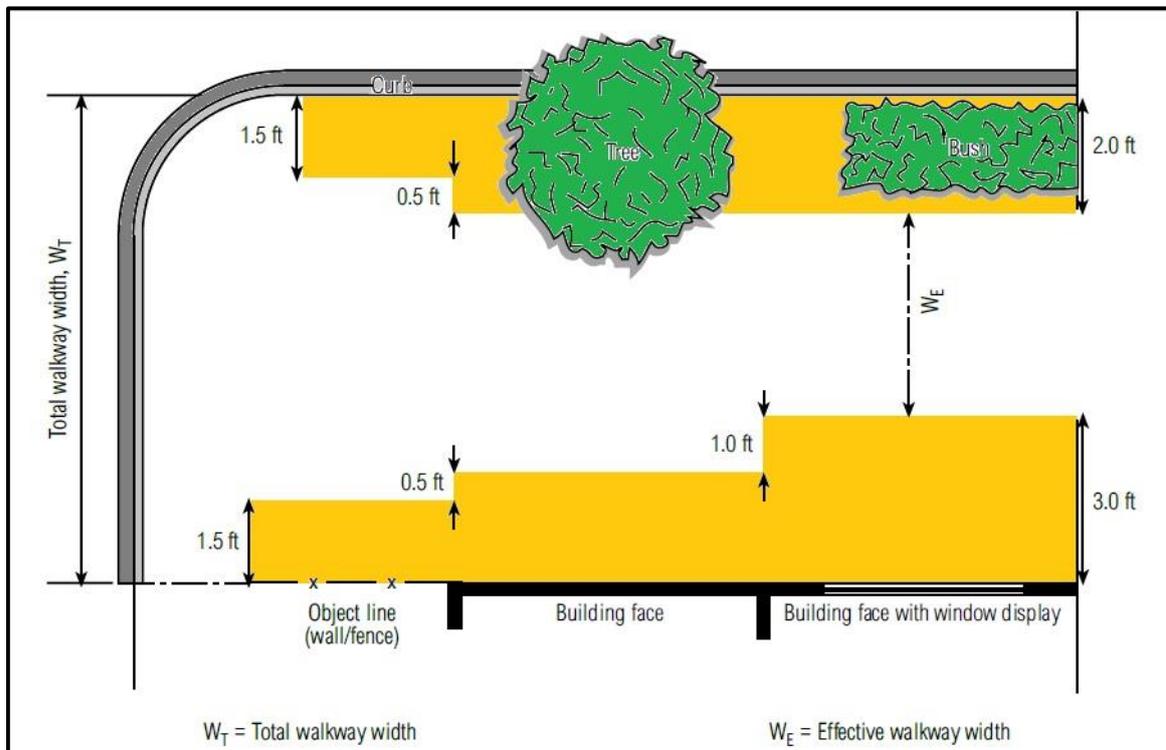


Figure 4.1: Sidewalk Effective Width

The study determines sidewalk effective width for each section within the study area. The information is listed in Table (4-8).

Table 4.7: Obstacles Description of Walkway Width

Obstacle	Approx. Width Preempted (ft)
Street Furniture	
Light pole	2.5–3.5
Traffic signal poles and boxes	3.0–4.0
Fire alarm boxes	2.5–3.5
Fire hydrants	2.5–3.0
Traffic signs	2.0–2.5
Parking meters	2.0
Mail boxes (1.7 ft x 1.7 ft)	3.2–3.7
Telephone booths (2.7 ft x 2.7 ft)	4.0
Waste baskets	3.0
Benches	5.0
Public Underground Access	
Subway stairs	5.5–7.0
Subway ventilation gratings (raised)	6.0+
Transformer vault ventilation gratings (raised)	5.0+
Landscaping	
Trees	2.0–4.0
Planter boxes	5.0
Commercial Uses	
Newsstands	4.0–13.0
Vending stands	variable
Advertising displays	variable
Store displays	variable
Sidewalk cafes (two rows of tables)	7.0
Building Protrusions	
Columns	2.5–3.0
Stoops	2.0–6.0
Cellar doors	5.0–7.0
Standpipe connections	1.0
Awning poles	2.5
Truck docks (trucks protruding)	variable
Garage entrance/exit	variable
Driveways	variable

Table 4.8: Sidewalk Obstacle and Effective Width within Study Area

Study Area	Sidewalk Total Width (W_T) (ft.)	Obstacle Type	Obstacle Width (W_O) (ft.)	Effective Sidewalk Width (W_E) (ft.)
Hilla-Najaf Roadway (Babylon University Gates) Section Length.	9.00	Light Pool Trees	7.5	1.5
Muhrmat Shat Al-Hilla.	4.95	Vending stands	4.0	0.95
AL-Mahdi AL-Muntazar Street (60).	13.2	Vending stands Trees Parking meters	10.0	3.2
Abed Alkarim Kassem Street (Al Jamia).	13.2	Store displays Trees Garage entrance/exit	10.0	3.2
Al Jabal Street	13.2	Store displays Light Pool Garage entrance/exit	12.2	1

The determination of pedestrian flow rate (p/min/ft) for each section of the study area selected is calculated by the equation (4-1) as follow:

$$V_P = \frac{V_{15}}{15 \times W_E} \quad (4 - 1)$$

Whereas:

V_P =pedestrian rate of flow (p.min⁻¹. ft.).

V_{15} =peaks 15 minutes' rate of flow (p.15min⁻¹).

W_E =effectiveness width of walkways (ft.).

According to the flow rate of pedestrian studies with respect to the sidewalks characteristics, the service level (Level of Service) was calculated for each investigation area section then included in Table (4-9)

Table 4.9: Service's level Cratria for Pedestrians Sidewlak within Study Area

Location	Flow Rate V_P (p/min/ft.)	Pedestrians Sidewalk LOS
Hilla-Najaf Roadway (Babylon University Gates) Section Length.	17.15	E
Muhrmat Shat Al- Hilla.	42.1	F
AL-Mahdi AL-Muntazar Street (60).	1.6	B
Abed Alkarim Kassem Street (Al Jamia).	10.5	D
Al Jabal Street	13.6	D

From Table (4-9), it is clear that the service level in the sidewalks for pedestrians is very low, which explains the increase in violation and the overlapping between activities, so that pedestrian movements became obstructed and dominated by randomness.

The increase in the service level does not represent the reality of pedestrian crossing and movement in area No. (3) as well as the lack of sufficient crossing facilities in that area.

The study evaluates walkway for pedestrian in order to determine Level of Service for their walking within the study area. The criteria determined the pedestrian space (M) (ft²./ped.) are listed in Figure (4-2) and Table (4-10).

Table 4.10: Pedestrian Walkway Level of Service within Study Area

Location	V_P (p/min/ft.)	($S_{ped.}$) (ft./min.)	(M) (ft ² ./ped.)	Pedestrian walkway LOS
Hilla-Najaf Roadway (Babylon University Gates) Section Length.	17.15	195	11.494	E
Muhrmat Shat Al- Hilla.	42.1	172	4.098	F
AL-Mahdi AL- Muntazar Street (60).	1.6	201	126.588	A
Abed Alkarim Kassem Street (Al Jamia).	10.5	198	18.867	D
Al Jabal Street	13.6	149	10.989	E

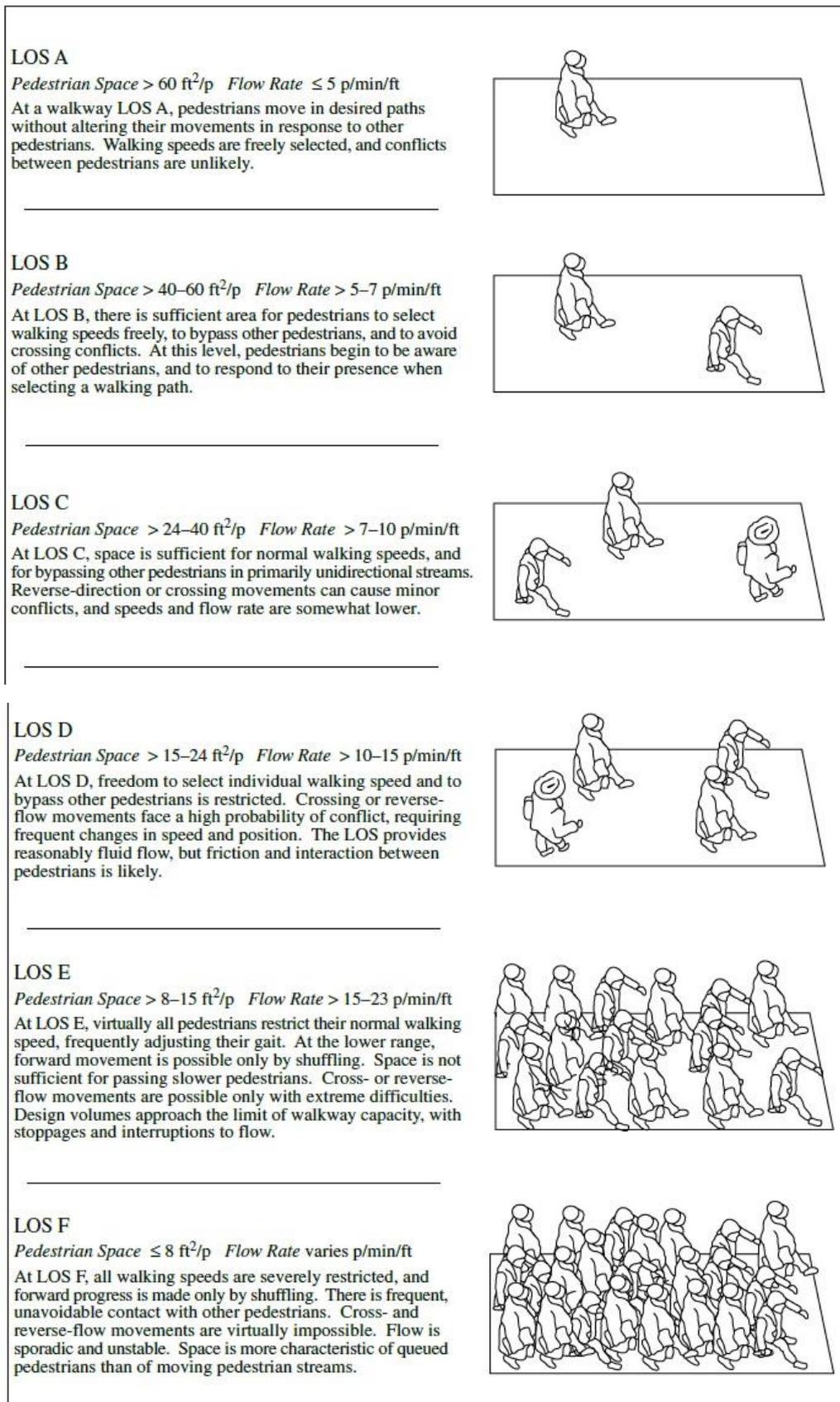


Figure 4.2: Pedestrian Walkway Level of Service (HCM, 2010)

4.4 Some Suggested Alternatives to Improve Pedestrian Movements

For the low service level for the sidewalks and pedestrian crossing services, the study proposed some solutions and alternatives to improve their environment and provide safety factors, convenience and efficiency, that may lead to increase service level for the study area, and result in reducing the rate of traffic accidents and increasing the efficiency of walking and crossing.

The study suggested the following alternatives:

4.4.1 Hilla-Najaf Roadway (Babylon University Gates) Section Length .

Due to the fact that this road has multiple lanes (five lanes in each direction), with traffic speed (80.0) km / hr. It is very difficult for pedestrians to cross the roadway based on the current situation that does not allow pedestrians the appropriate times and places to cross. Therefore, the study proposes construction of stairway with electric elevators and suitable stairs in accordance with specific standards, as shown in Figure (4-3).

The characteristics describe alternative No. (1) as follows :

- Easy and flexible construction.
- Increase LOS for pedestrian crossing to C.
- Reduce traffic accident to about (80%). On the condition of preventing at grade pedestrian crossing.
- The width of one step is (30) cm and its height is (15-18) cm, which is in accordance with the technical specifications approved by (AASHTO, 2011)

4.4.2 Muhrmat Shat Al- Hilla .

- The study suggested increasing the width of the sidewalk in order to face the increase in pedestrian traffic volumes.

- Separating pedestrian traffic from the edge of the road by using green area width (0.60) m to increase safety factors, avoid traffic accidents and provide a suitable environment for pedestrian movement.
- The use of fences that prevent random pedestrian crossing, while providing specific crossing areas designed to allow suitable times for pedestrians to cross and move around, as shown in Figures (4-4) & (4-5).

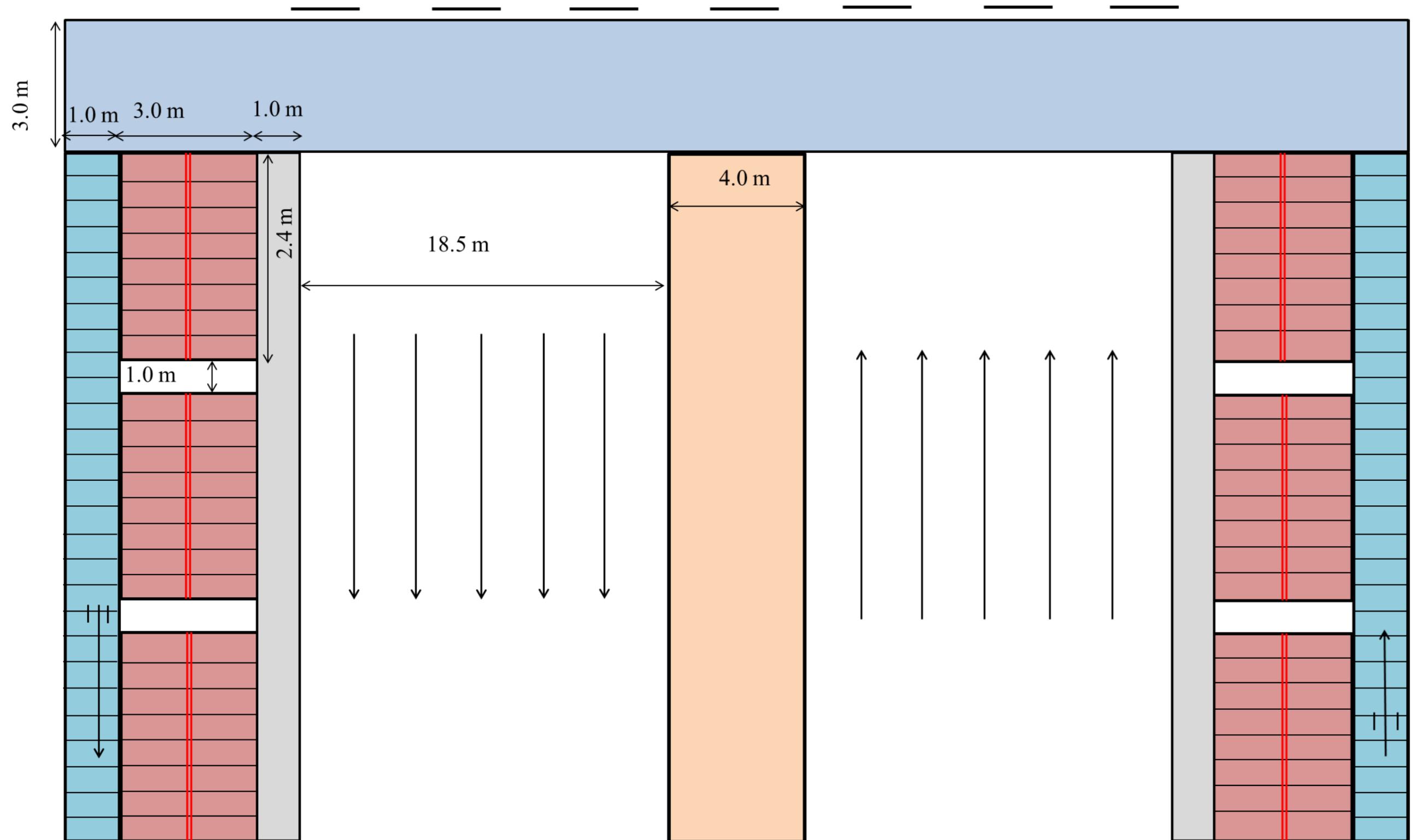


Figure 4.3: Top View for Suggested Improvement Alternative Hilla-Najaf Roadway within Study Area

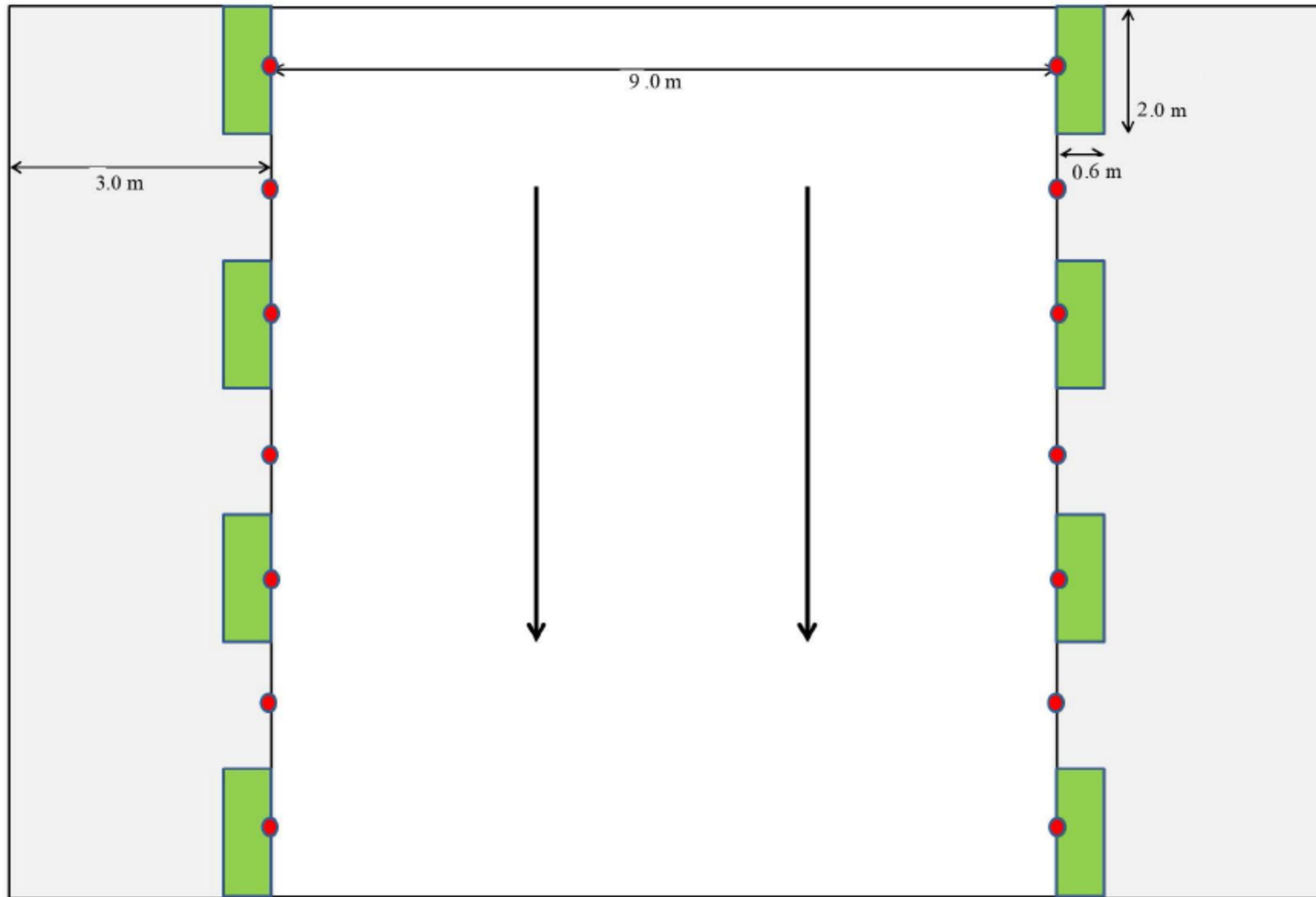


Figure 4.4: Top View for Suggested Improvement Alternative Muhrmatah Shat Al- Hilla within Study Area

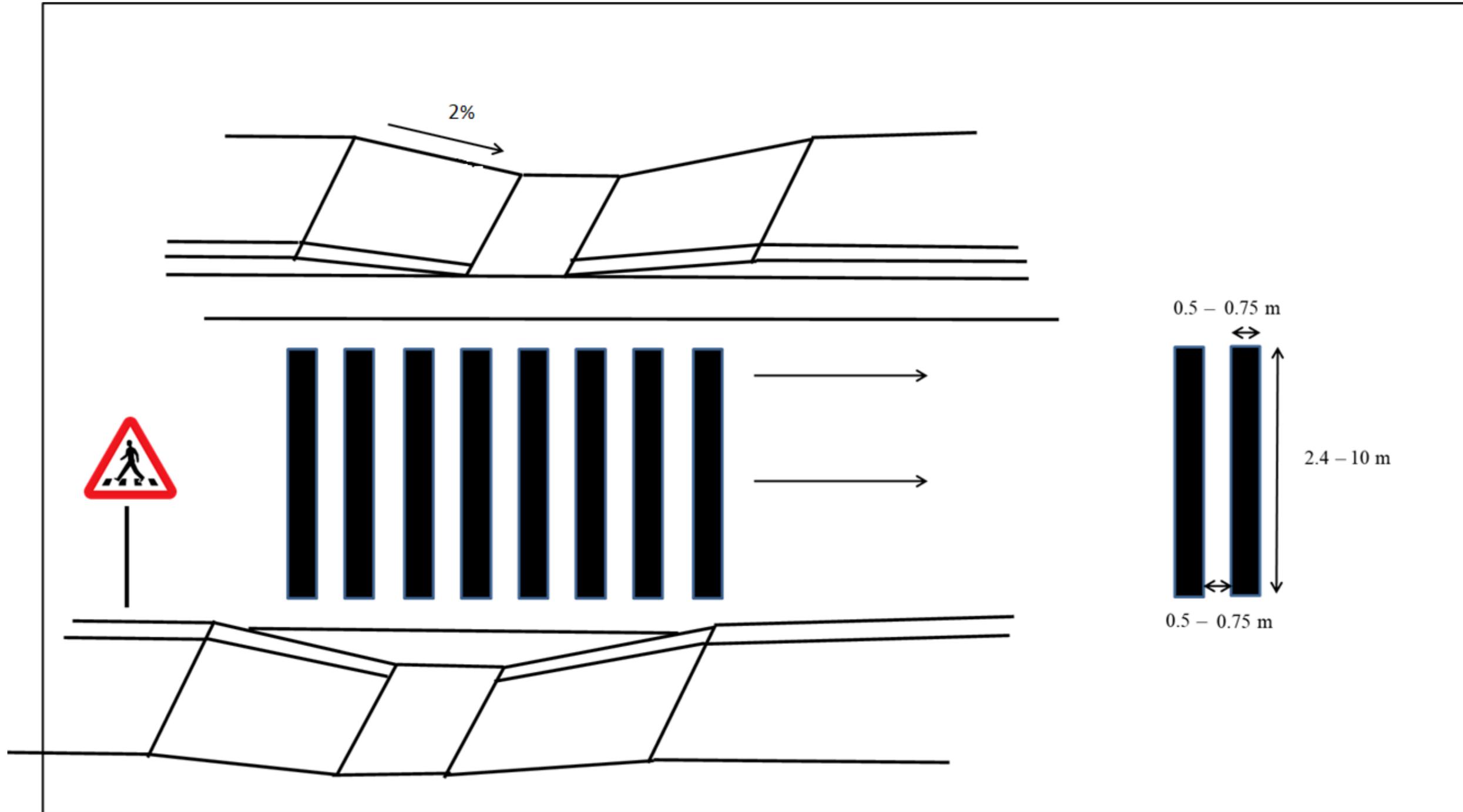


Figure 4.5: Zebra Crossing with Curb Grade Suggested Improvement Alternative Muhrmat Shat Al- Hilla within Study Area

4.4.3 AL-Mahdi AL-Muntazar Street (60) .

It is preferable to use a pedestrian crossing with Stairway, as well as electric elevators, because the study area is characterized by many activities for pedestrians with different ages, which require finding the necessary facilities for their crossing and movements.

The proposed stairway is symmetrical in terms of shape and dimensions for both directions, as shown in figure (4-6).

The shape and dimensions of the stairway comply with the technical specifications of (AASHTO, 2011).

When implementing this proposal, it is required to prevent at grade crossing in the 60th Street in front of the main garage of the city.

4.4.4 Abed Alkarim Kassem Street (Al Jamia) .

- Because of pedestrian generators on both sides of the roadway med-block crossing located and placed according to different activities for pedestrian movement within the study area.
- The crossing area is designed on the basis of controlling the traffic signal for pedestrians by pressing the stop button to minimize traffic volume of vehicles.
- This design allows pedestrians to ensure sufficient time to cross when necessary.
- The opening median, sidewalk and zebra crossing agree with (AASHTO, 2011) specification as show in Figure (4-7).

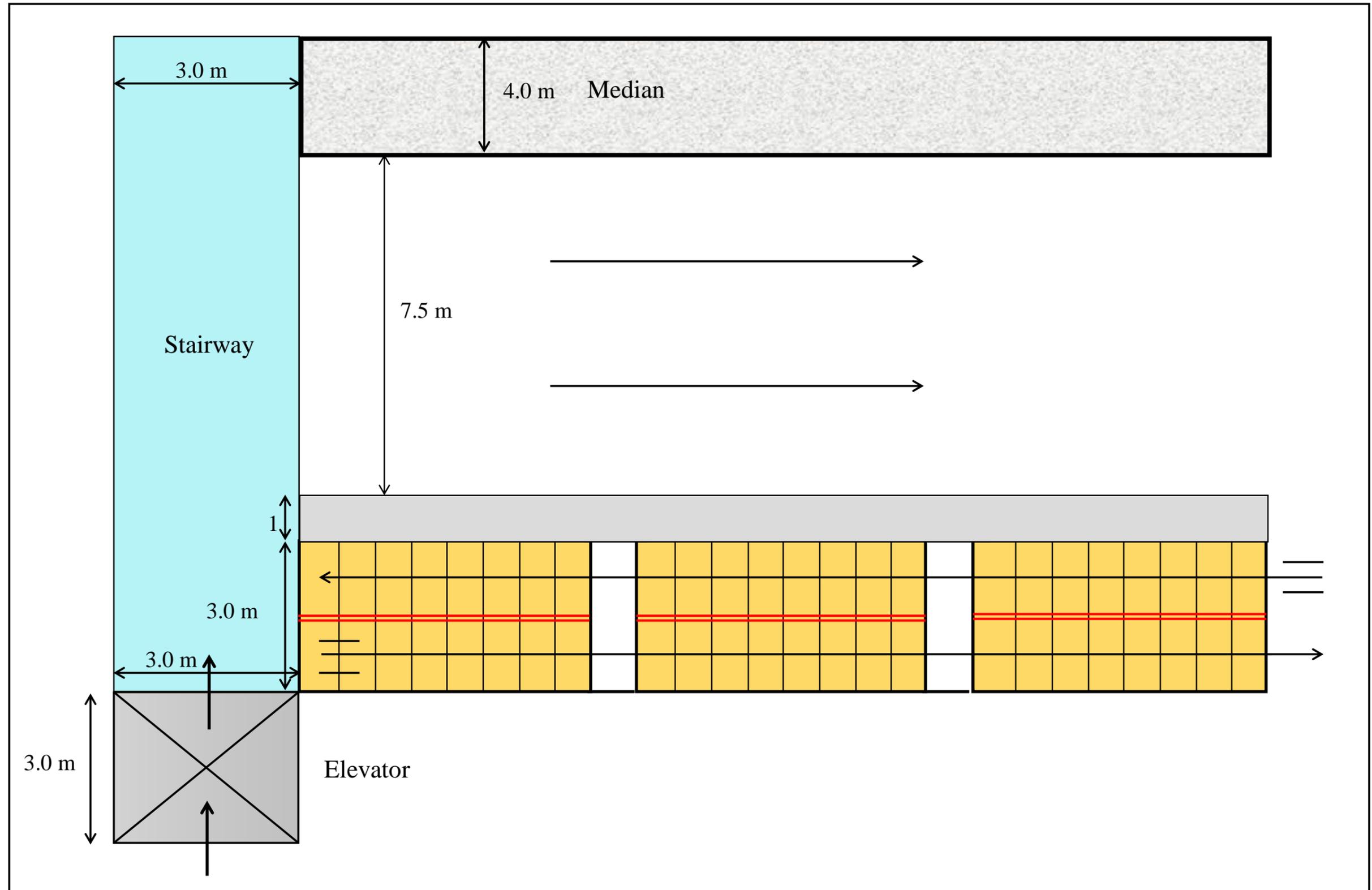


Figure 4.6: Top View for Stairway Crossing Suggested Improvement Alternative AL-Mahdi AL-Muntazar Street (60) within Study Area

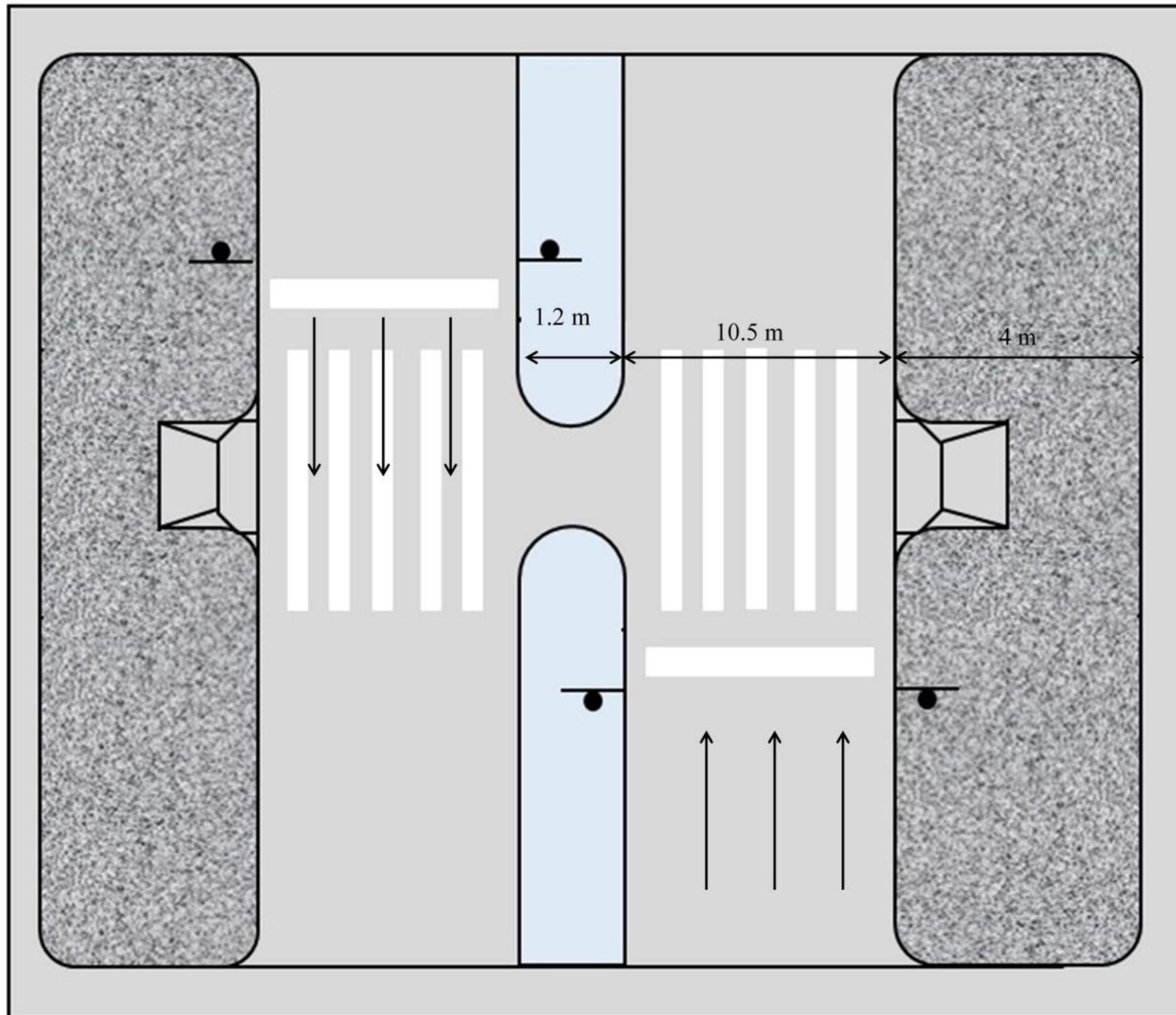


Figure 4.7: Mid-Block Crossing Curve Signal Suggested Improvement Alternative Abed Alkarim Kassem Street (Al Jamia) within Study Area

4.4.5 Al Jabal Street .

The proposed development of the study area is characterized by the following:

- Removing the violation to increase the effective width of the sideway (W_E) to increase the sidewalk' capacity for pedestrian movement.
- Designing pedestrian crossing areas according to the standard specifications, as shown in Figure (4-7) with replacement of the signal by using speed bumps of width (1) m to discourage the speed of vehicles and allow the appropriate times for pedestrian crossing.
- Furnishing the roadway and sidewalks with necessary signs to increase the safety factors for road users.

After carrying out the proposed development of the study area, the service's level (Level of Service) for the pedestrian's side and crossing areas was analyzed, as shown in Table (4-11).

Table 4.11: LOS for Ped. Sidewalk with Available Improvement

Location	Flow Rate V_P (p/min/ft.)	Pedestrians Sidewalk LOS
Hilla-Najaf Roadway (Babylon University Gates) Section Length.	17.15	B
Muhrmat Shat Al- Hilla.	42.1	C
AL-Mahdi AL-Muntazar Street (60).	1.6	B
Abed Alkarim Kassem Street (Al Jamia).	10.5	C
Al Jabal Street	13.6	B

4.5 Simulation Criteria by Using PTV VISSIM Software

PTV VISSIM is available to discuss vehicles and pedestrians confliction at the pedestrian's intersection, which has involved geometrical factors of pedestrian's intersection also vehicle flow and pedestrian intensity in order to identify the influence of vehicle and pedestrian conflict situation and traffic participant.

The study found the function of services, size and site attracting and generating great pedestrians traffic volume, which is related to the service level of roadway section.

From observation it can be found that great pedestrians' duration delays in crossing or walking have enough effect on their impatience, leading to enter in front of oncoming vehicles, resulting in decreases safety factors. PTV VISSIM software program used in this study to suggest available solutions that can improve pedestrians flow characteristics.

The Simulation steps as follow:

Step 1: Streets Specify on the Network

This is the connection between Street Maps that obtained from Google Map and VISSIM seems to be essential for improving the precision in identifying the geometric characteristics of the site alongside collected data from the field. Assess sites on the network through the user interface of the VISSIM software that linked with the Street Map significant contribution. Plate (4-1) presents a screenshot for the network of VISSIM software.

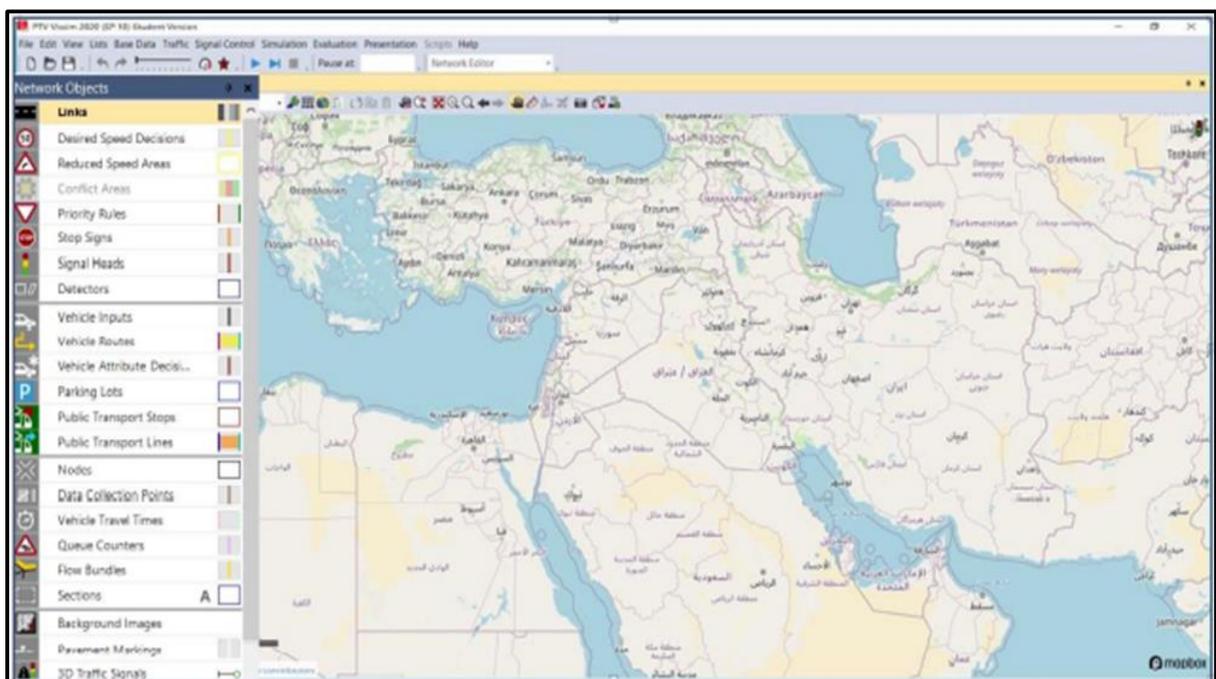


Plate 4.1: A Screenshot of the Street Map Network of VISSIM

Step 2: Setting up Links and Connectors:

Link is the main component of the road network in VISSIM software. Links generally refer to roads in networks, and connectors refer to the connection between those roads. Traffic flows are done through links only in one or more lanes. A drawing links (length of 500 m) for the chosen street, according to the engineering dimensions of the street. Plate (4-2) shows the links, the lanes' number, and the width of every lane. (Hilla Municipality Directorate / Projects Division).

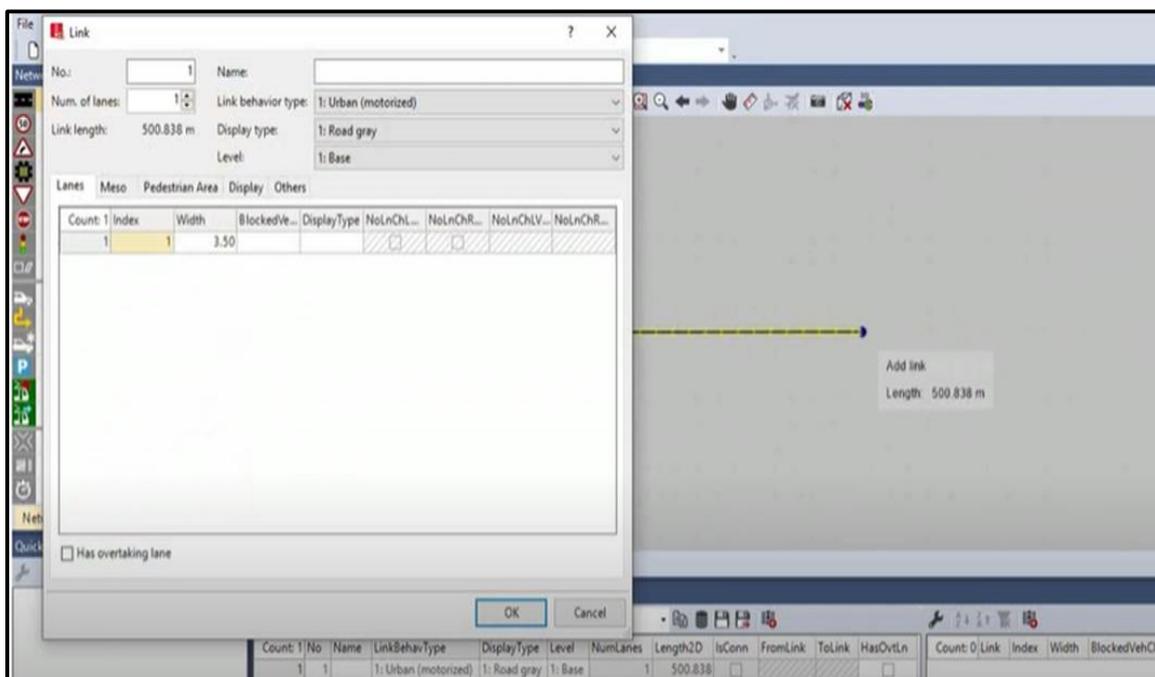


Plate 4.2: A Step of Establishing Links

Step 3: Setting up a pedestrian crossing area

The study analysis AL-Mahdi AL-Muntazar Street (60) with pedestrian crossing facilities in order to ensure the simulation criteria, as shown in Plates (4-3a), (4-3b) and (4-3c).

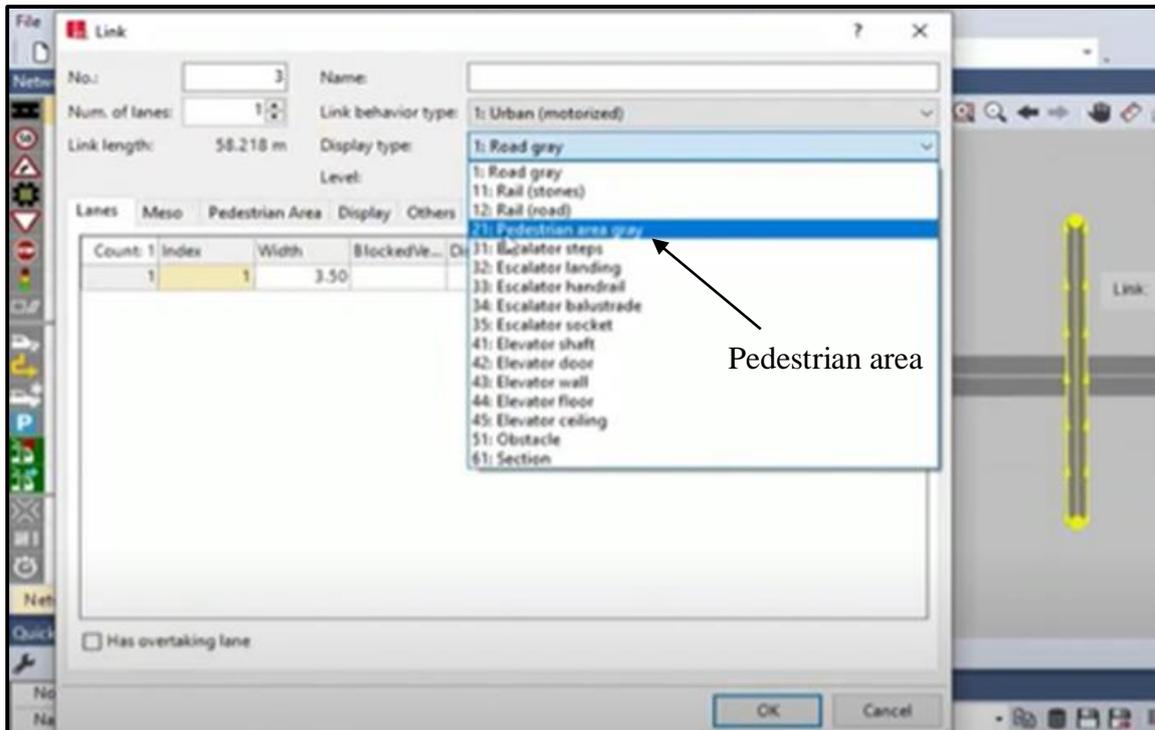


Plate 4.3: A Step of Establishing pedestrian area

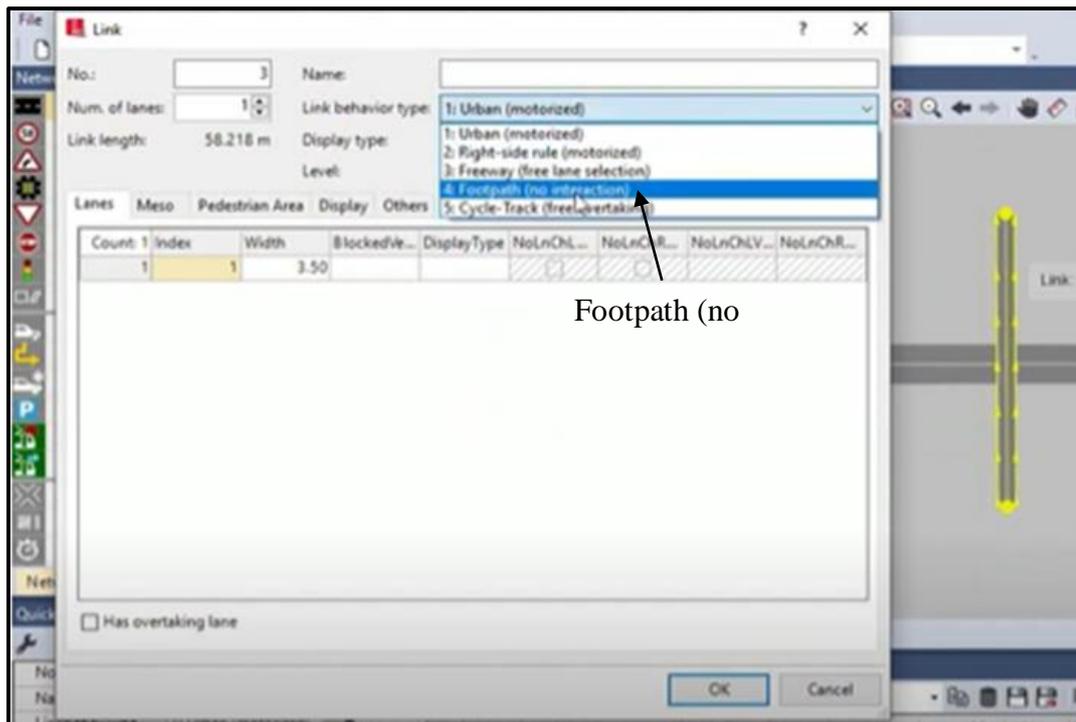


Plate 4.4: a) A Step of Establishing pedestrian area

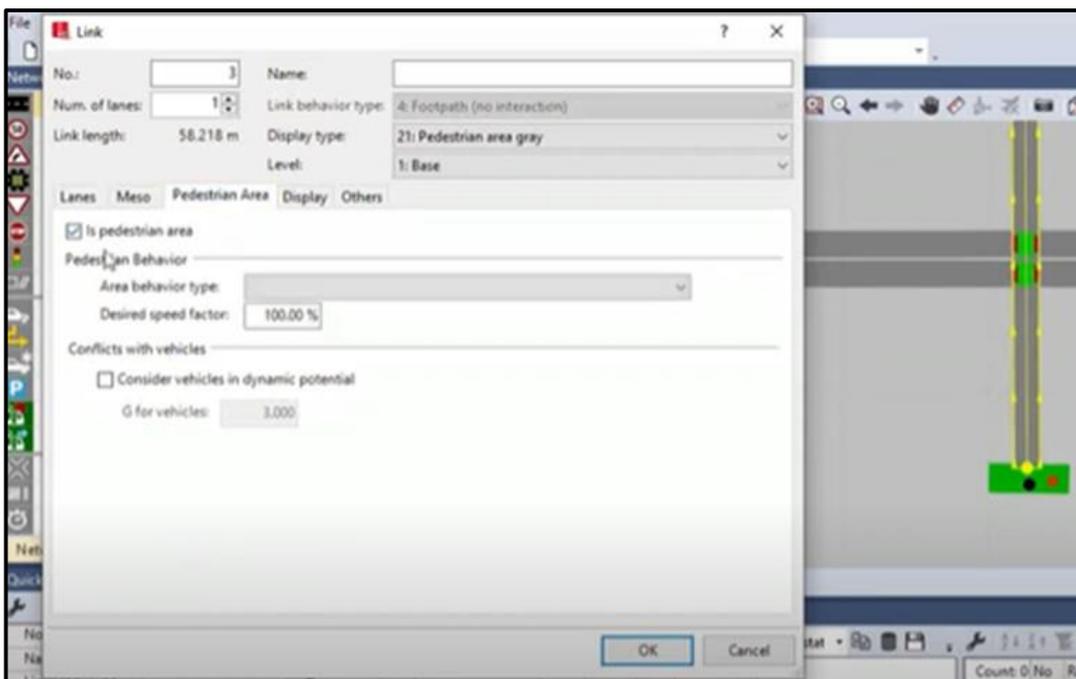


Plate 4.5: b) A Step of Establishing Pedestrian Area

Step 4: Setting up conflict areas

Determine the conflict areas between pedestrians and vehicles, giving priority to pedestrians.

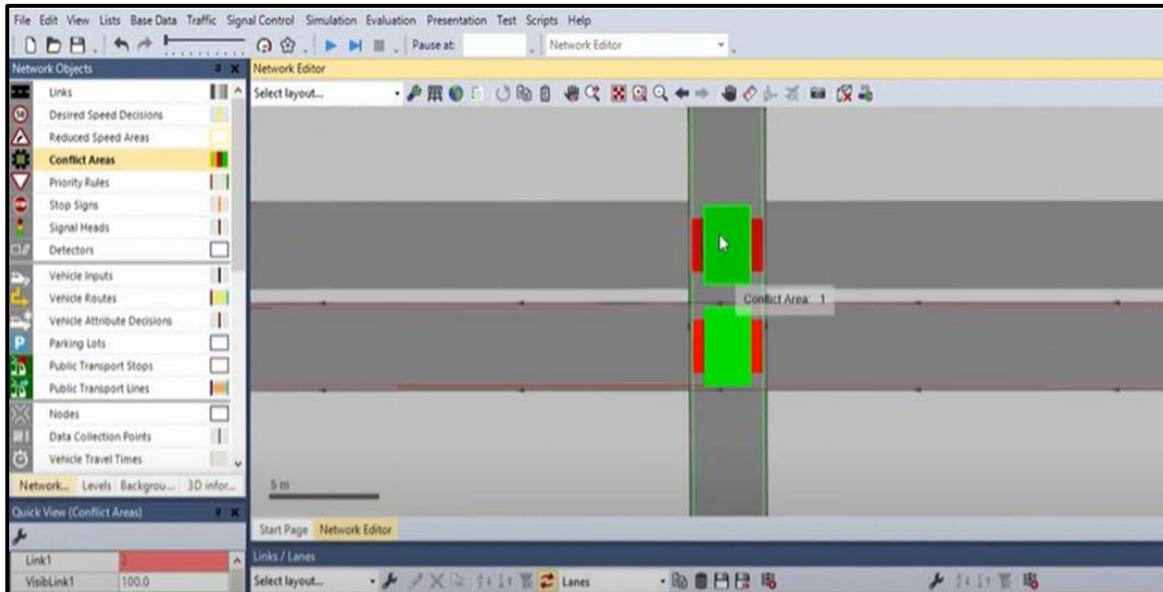


Plate 4.6: A Step of Establishing Conflict Areas

Step 5: Setting up

The pedestrian traffic volumes being entered into the pedestrians crossing area through (pedestrian Inputs), as shown in Plates (4-5 a), (4-5 b) and (4-5 c).

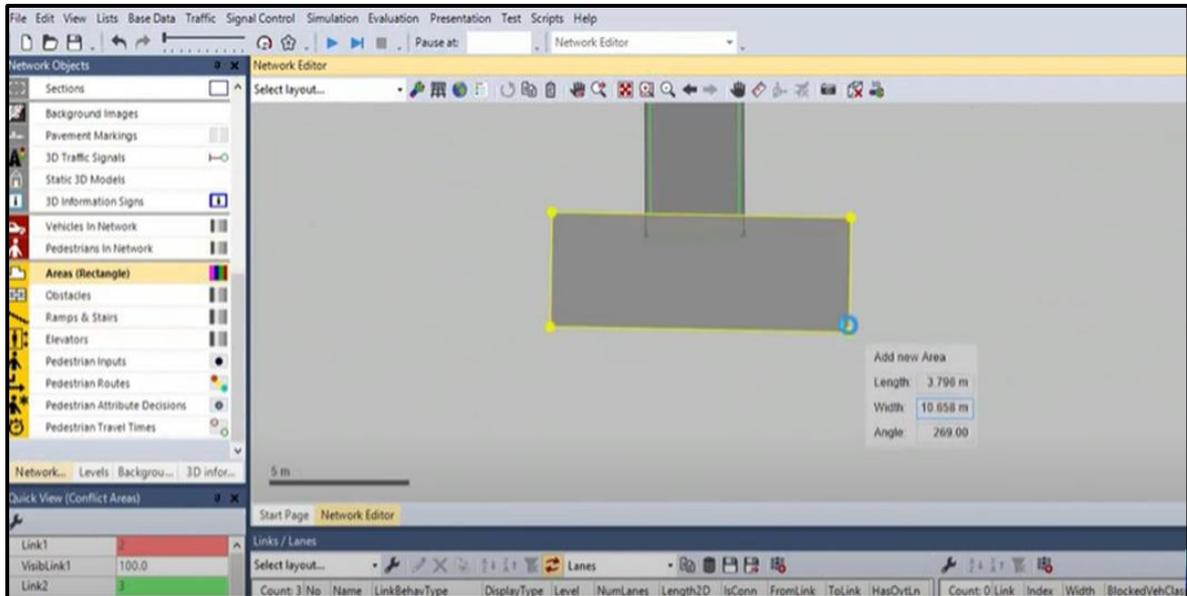


Plate 4.7: a): A Step of Establishing Areas

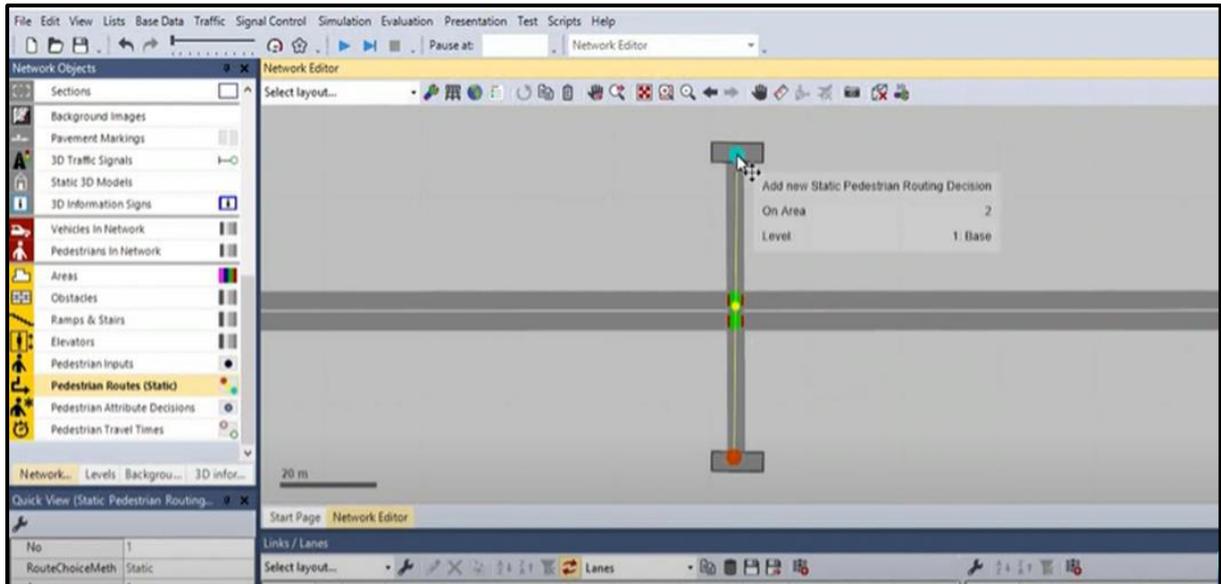


Plate 4.8: b): A Step of Establishing Pedestrian Routes

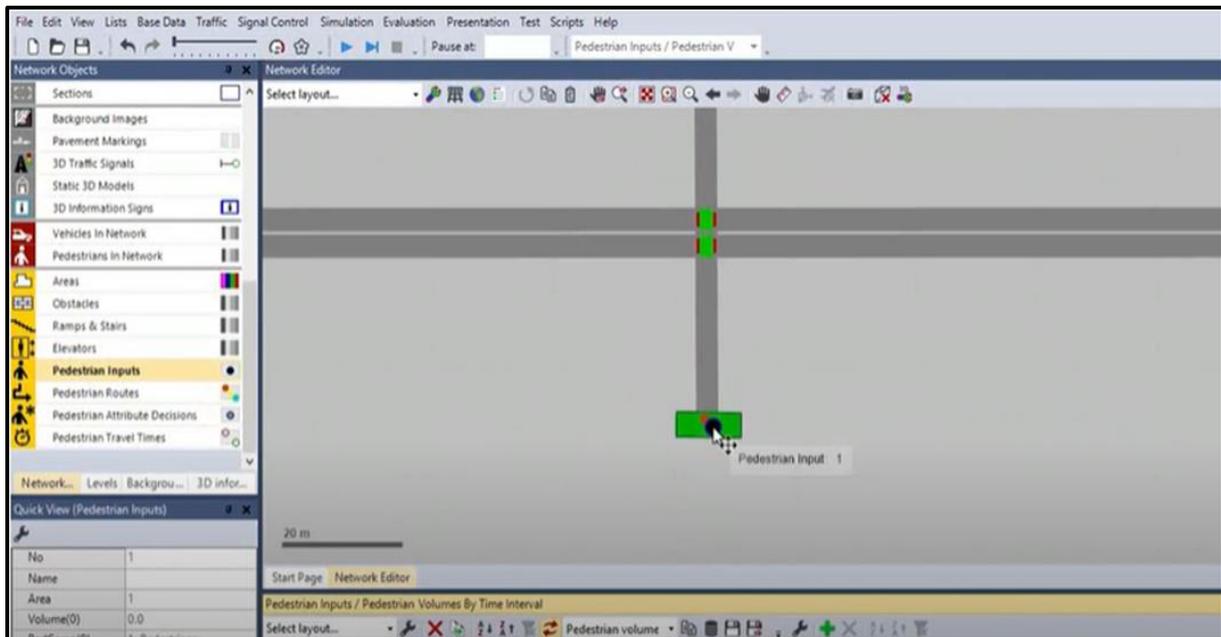


Plate 4.9: c) A Step of Establishing Pedestrian Inputs

Step 6: Setting up

Entering the traffic volumes of vehicles into the street through (Vehicle Inputs), as shown in Plates (4-6 a) and (4-6 b).

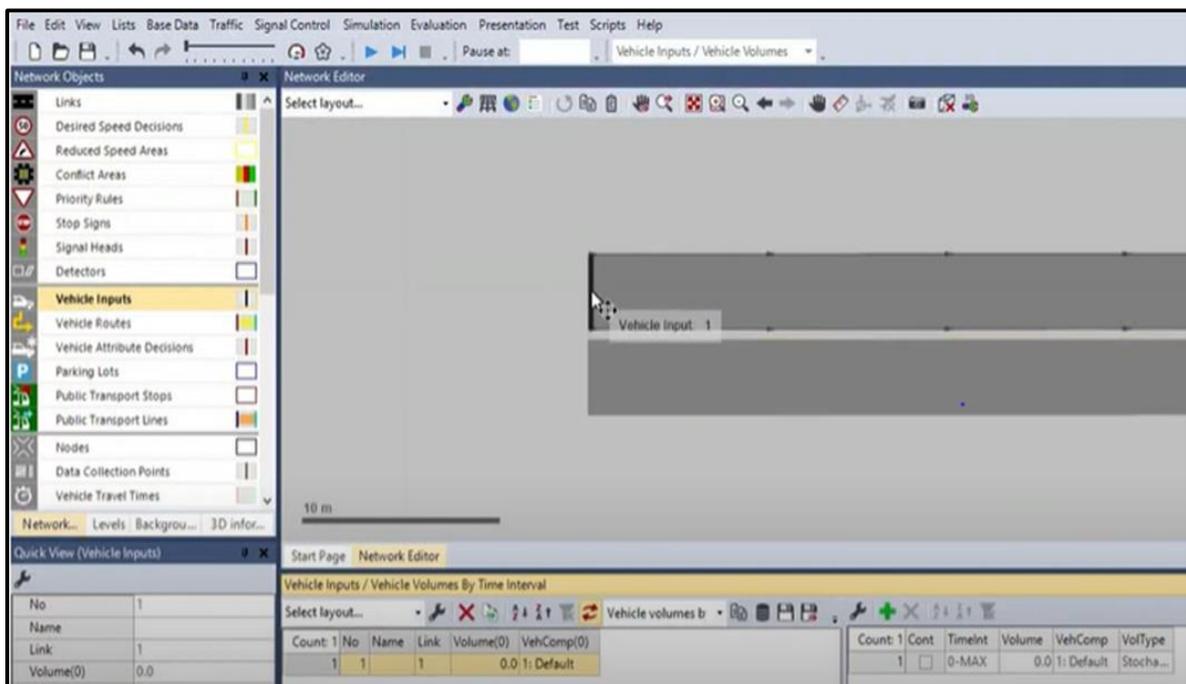
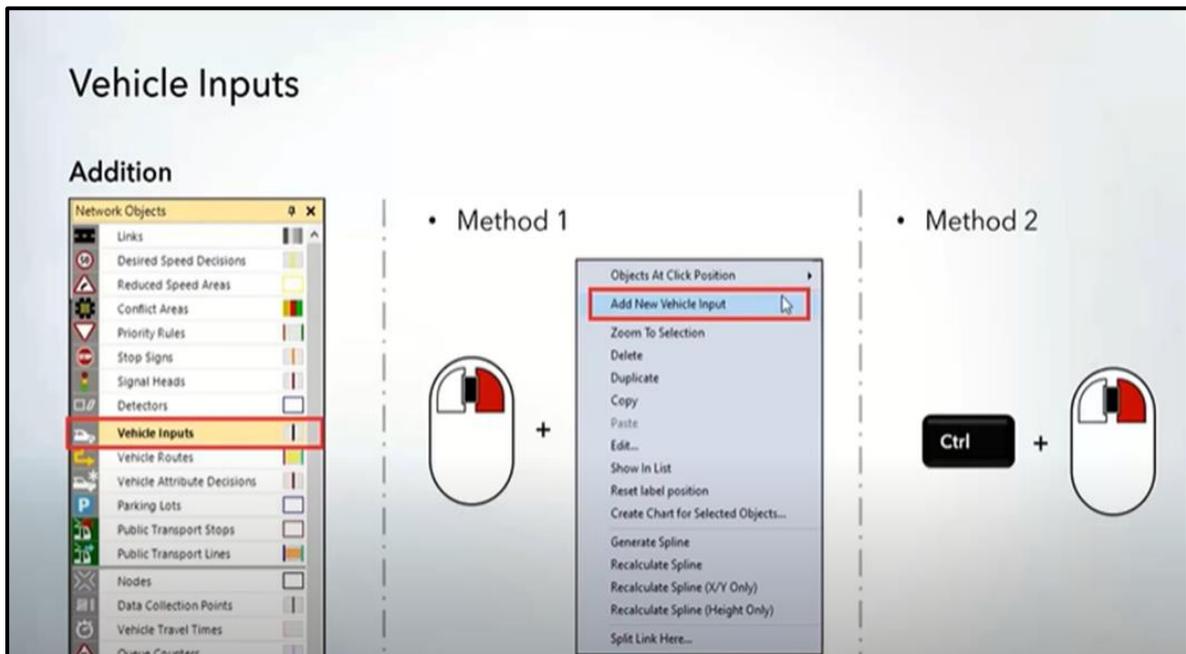


Plate 4.10: A Step of Establishing Vehicle Inputs Plate.

Step 7: Setting up

The items Determined in this step are (speed, delay and travel time for pedestrians) to be counted, as shown in Plates (4-7 a) and (4-7 b).

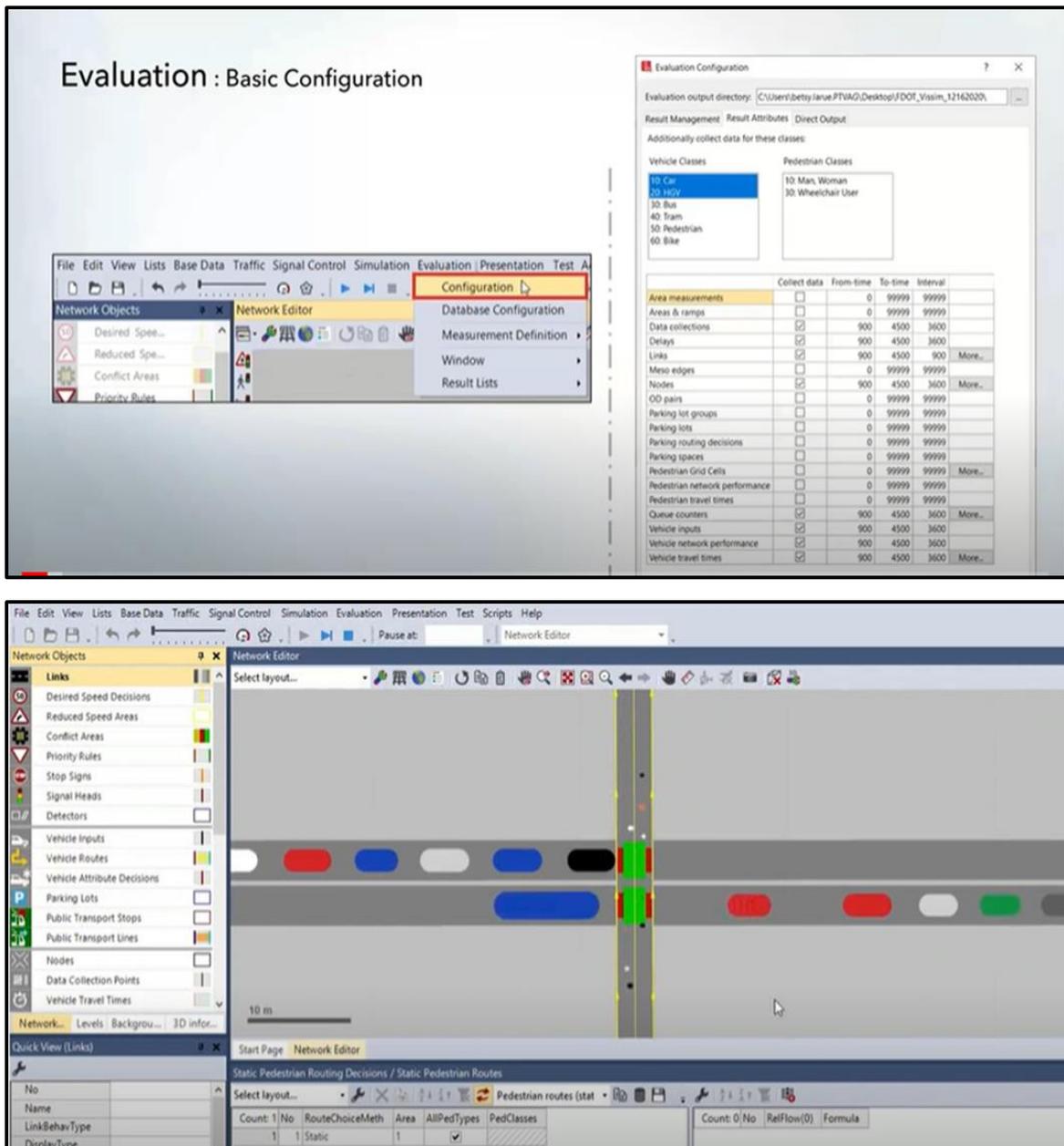


Plate 4.11: a): A Step of Establishing configuration, b): A Step of Establishing simulation

Step 8: Setting up

Speed is adopted to determine Level of Service for the chosen street from the study area, and compared with LOS from the arithmetic method according to the equation (4-1) and then choose the worst.

4.6 Statistical Analysis of Pedestrian Parameters within the Study Area

The study determines the correlation between flow, density and speed of pedestrian which they are main parameters significant effect on traffic facilities such as walking, movement, walkway, stairway and sidewalk, as shown in equations (2-1) and (2-2).

In order to ensure (HCM, 2010) method, with the aid of (SPSS) software programme the student examines the type of equation (Linear & 2nd Order) to estimate pedestrian flow, speed and density relationship as shown in Table (4-11).

4.6.1- F-Test:

It is one of the important and commonly used parametric statistical tests called (ANOVA) (Analysis of Variance), Regression analysis used to determine the relationship between a dependent variable (Y) and one or more independent variables (X). The test based on the null hypothesis theory, as follows:

- There is no significant relationship between the dependent variable and the independent variable
- $H_0 = 0.00$ (Null Hypothesis).
- There is a significant relationship between the independent and the dependent variables
- $H_1 \neq 0.00$ Alternative Hypothesis.

The basic rule in testing the relationships between variables is:

If the (F value) calculated from the statistical software program greater than the (F value) calculated from the Table (4-12), this means rejecting the null hypothesis and accepting the alternative hypothesis.

Therefore, (F- Test) is an important statistical indicator that confirms the relationship between variables, as well as the rest of the statistical outputs analysis, such as the correlation coefficient (R), the coefficient of determination (R^2), in addition to the amount of standard error of estimation (SE).

4-6-2- Statistical Analysis of Data for Hilla-Najaf Roadway:

Statistical analysis of the data performed by calculating (F) value from Table (4-12), based on the value of df_1 and df_2 , which are the outputs of software program appendix (A-1)

$$d_{f1} = 1, d_{f2} = 6$$

$$F_{from\ Table} = 5.99$$

($F_{calculated}$) value extracted through the data processing procedure in the statistical program report (Appendix A-1).

$$F_{calculated} = 20.045$$

It was found that $F_{calculated} > F_{(from\ Table)}$

$$20.045 > 5.99$$

Therefore, according to the statistical analysis, we reject the null hypothesis and accept the alternative hypothesis

$$H_1 \neq 0.00$$

Therefore, there is a significant relationship between the dependent variable (speed) and the independent variable (density) for pedestrians within study area according to the linear equation, as well as the strength of the relationship between variables, due to the value of the correlation coefficient ($R=0.895$), coefficient of determination ($R^2=0.757$) as well as the amount of Standard Error of Estimation =15.083.

Table (4-13) shows the statistical outputs of all steps of statistical analysis for the study areas.

Table 4.12: calculated (F value) (Statistical Methods,2009)

1. PROBABILITY LEVEL $p = .95$

n_2	$n_1 = 1$	2	3	4	5	6	7	8	10	20	∞
1	161.4	199.5	215.7	224.6	230.2	234.0	236.8	238.9	241.9	248.0	254.00
2	18.51	19.00	19.16	19.25	19.30	19.33	19.35	19.37	19.40	19.45	19.50
3	10.13	9.55	9.28	9.12	9.01	8.94	8.89	8.85	8.79	8.66	8.53
4	7.71	6.94	6.59	6.39	6.26	6.16	6.09	6.04	5.96	5.80	5.63
5	6.61	5.79	5.41	5.19	5.05	4.95	4.88	4.82	4.74	4.56	4.36
6	5.99	5.14	4.76	4.53	4.39	4.28	4.21	4.15	4.06	3.87	3.67
7	5.59	4.74	4.35	4.12	3.97	3.87	3.79	3.73	3.64	3.44	3.23
8	5.32	4.46	4.07	3.84	3.69	3.58	3.50	3.44	3.35	3.15	2.93
9	5.12	4.26	3.86	3.63	3.48	3.37	3.29	3.23	3.14	2.94	2.71
10	4.96	4.10	3.71	3.48	3.33	3.22	3.14	3.07	2.98	2.77	2.54
11	4.84	3.98	3.59	3.36	3.20	3.09	3.01	2.95	2.85	2.65	2.40
12	4.76	3.89	3.49	3.26	3.11	3.00	2.91	2.85	2.75	2.54	2.30
13	4.67	3.81	3.41	3.18	3.03	2.92	2.83	2.77	2.67	2.46	2.21
14	4.60	3.74	3.34	3.11	2.96	2.85	2.76	2.70	2.60	2.39	2.13
15	4.54	3.68	3.29	3.06	2.90	2.79	2.71	2.64	2.54	2.33	2.07
16	4.49	3.63	3.24	3.01	2.85	2.74	2.66	2.59	2.49	2.28	2.01
17	4.45	3.59	3.20	2.96	2.81	2.70	2.61	2.55	2.45	2.23	1.96
18	4.41	3.55	3.15	2.93	2.77	2.66	2.58	2.51	2.41	2.19	1.92
19	4.38	3.52	3.13	2.90	2.74	2.63	2.54	2.48	2.38	2.16	1.88
20	4.35	3.49	3.10	2.87	2.71	2.60	2.51	2.45	2.35	2.12	1.84
21	4.32	3.47	3.07	2.84	2.68	2.57	2.49	2.42	2.32	2.10	1.81
22	4.30	3.44	3.05	2.82	2.66	2.55	2.46	2.40	2.30	2.07	1.78
23	4.28	3.42	3.03	2.80	2.64	2.53	2.44	2.37	2.27	2.05	1.76
24	4.26	3.40	3.01	2.78	2.62	2.51	2.42	2.36	2.25	2.03	1.73
25	4.24	3.39	2.99	2.76	2.60	2.49	2.40	2.34	2.24	2.01	1.71
26	4.23	3.37	2.98	2.74	2.59	2.47	2.39	2.32	2.22	1.99	1.69
27	4.21	3.35	2.96	2.73	2.57	2.46	2.37	2.31	2.20	1.97	1.67
28	4.20	3.34	2.95	2.71	2.56	2.45	2.36	2.29	2.19	1.96	1.65
29	4.18	3.33	2.93	2.70	2.55	2.43	2.35	2.28	2.18	1.94	1.64
30	4.17	3.32	2.92	2.69	2.53	2.42	2.33	2.27	2.16	1.93	1.62
40	4.08	3.23	2.84	2.61	2.45	2.34	2.25	2.18	2.08	1.84	1.51
60	4.00	3.15	2.76	2.53	2.37	2.25	2.17	2.10	1.99	1.75	1.39
120	3.92	3.07	2.68	2.45	2.29	2.17	2.09	2.02	1.91	1.66	1.25
∞	3.84	3.00	2.60	2.37	2.21	2.10	2.01	1.94	1.83	1.57	1.00

Table 4.13: Statistical Regression Analysis Discribe Bedestrian Flow, Speed & Density Relationship within Study Area

Study Area	Equation	Relationship	Coefficient of Correlation R	Adjusted R ²	Standard Error of Estimate	F Value calculated	F Value from Table	ANOVA analysis
Hilla-Najaf Roadway (Babylon University Gates) Section Length.	Linear	Speed / Density	0.895	0.767	15.083	24.045	5.99	Alternatives Hypothesis
	2 nd Order	Flow / Speed	0.830	0.564	2.677	5.527	5.79	Null Hypothesis
Muhrmata Shat Al- Hilla.	Linear	Speed / Density	0.989	0.975	3.619	274.012	5.99	Alternatives Hypothesis
	2 nd Order	Flow / Speed	0.990	0.972	1.268	120.902	5.79	Alternatives Hypothesis
AL-Mahdi AL-Muntazar Street (60).	Linear	Speed / Density	0.876	0.769	45.01	20.021	5.99	Alternatives Hypothesis
	2 nd Order	Flow / Speed	0.850	0.724	0.181	6.563	5.79	Alternatives Hypothesis
Abed Alkarim Kassem Street (Al Jamia).	Linear	Speed / Density	0.608	0.265	35.695	3.528	5.99	Null Hypothesis
	2 nd Order	Flow / Speed	0.883	0.691	1.485	8.833	5.79	Alternatives Hypothesis
Al Jabal Street	Linear	Speed / Density	0.658	0.338	20.321	4.579	5.99	Null Hypothesis
	2 nd Order	Flow / Speed	0.988	0.966	0.334	100.775	5.79	Alternatives Hypothesis

Form Table (4-13) the statistical analysis indicate a significant relationship between pedestrian flow, speed and density according to statistical parameters such as coefficient of correlation (R, Adjusted coefficient of determination (R^2), standard error of estimate and F test value). The summary of statistical analysis shows in Appendix.

Chapter Five

Conclusions and Recommendations

CHAPTER FIVE

5. Conclusions Recommendations for Future Investigations

5.1. Conclusions

- The investigation found, based on the evaluation of the current situation, that the level of service (LOS) for the roadway sections that were studied ranges (B-F), while the level of service for pedestrians sidewalk and walkway ranges between (B-F), that indicates the aggravation of the pedestrians problems within the study area.
- The problem of violations of the rights of way for pedestrians and the random parking of vehicles, as well as the lack of safe facilities for their crossing and movement, made pedestrian movements random, increased the conflict points, and reduced the safety factors, and convenience in study area.
- The alternatives adopted by the study, which were built on the basis of a traffic study, as well as the simulation made with the aid of (PTV VISSIM) software and scientific analysis using (HCM, 2010) method with design of the crossing areas and sidewalks according to (AASHTO, 2011) specifications resulted in an increase in the level of service for the sidewalks and crossing areas (from F to B&C).

- Based on the statistical analysis of traffic data for pedestrian characteristics using the (SPSS) software program, as well as studying the relationships between traffic flow, speed and density of pedestrians. The study concluded that the linear equation reflected the relationship between speed and density. While the second order equation reflected the relationship between traffic flow and pedestrian speed based on the outputs values of the correlation, F- Test values, has also shown a significant effect between the independent and the dependent variables which led to accept the alternative hypothesis and reject null hypothesis.

5.2. Recommendations for Future Investigations

- Most of the roadways design in Hilla city neglected the design of sidewalks and crossing for pedestrians facilities according to the approved standard specifications. Providing studies and suitable convenient design to ensure safety elements for the main component that is considered in traffic facilities.
- Conduct a comprehensive transportation study for pedestrian flow characteristics in Hilla city.
- Activate strict laws and regulations to limit encroachments on sidewalks for pedestrians and crossing facilities to not allow random parking on both sides of the roadways.

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Appendix A

Appendix A: Experimental Data

A. Appendix A

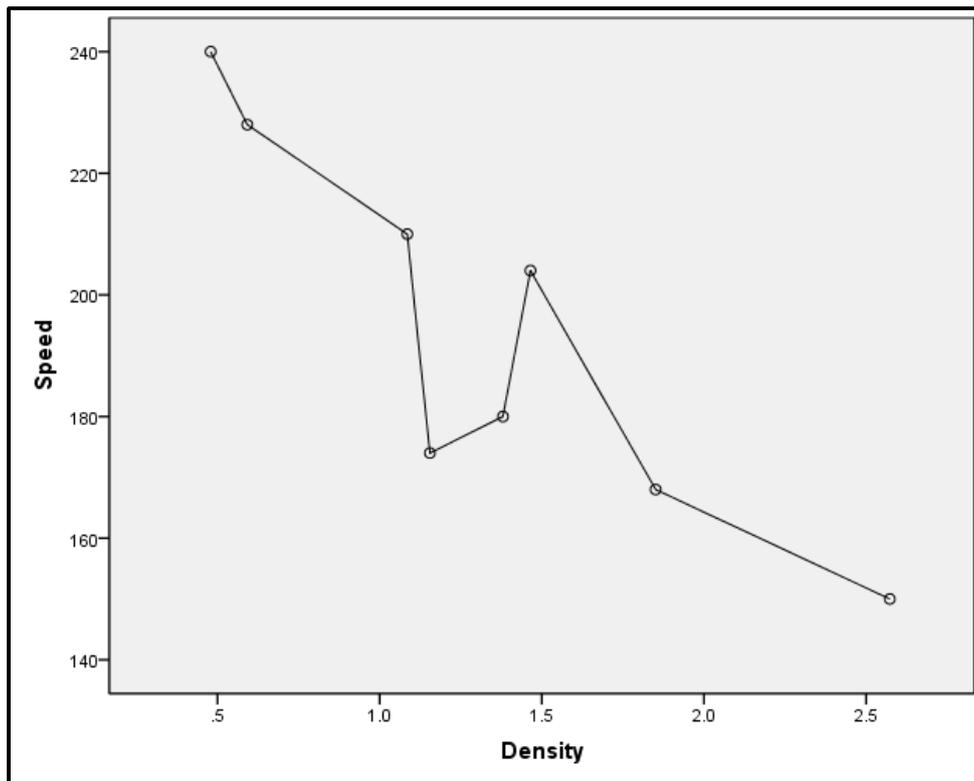


Figure A.1: Pedestrian Speed-Density Relationship Study Area No. (1)

Table A.1: Pedestrian Speed-Density Relationship Linear Regression Analysis

Model Summary

R	R Square	Adjusted R Square	Std. Error of the Estimate
.895	.800	.767	15.083

The independent variable is Density.

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Regression	5470.468	1	5470.468	24.045	.003
Residual	1365.032	6	227.505		
Total	6835.500	7			

The independent variable is Density.

Coefficients

Appendix A

Model Summary

R	R Square	Adjusted R Square	Std. Error of the Estimate
.895	.800	.767	15.083

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
Density	-41.371	8.437	-.895	-4.904	.003
(Constant)	248.963	12.366		20.132	.000

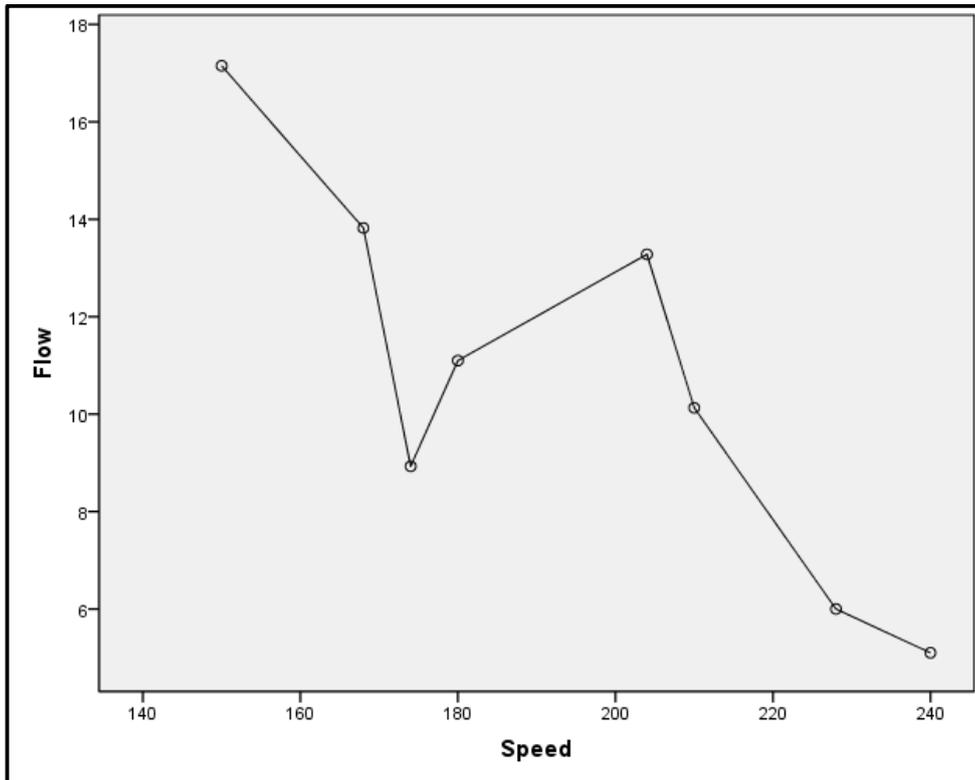


Figure A.2: Pedestrian Flow-Speed Relationship Study Area No. (1)

Table A.2: Pedestrian Flow- Speed Relationship 2nd Order Regression Analysis

Model Summary

R	R Square	Adjusted R Square	Std. Error of the Estimate
.830	.689	.564	2.677

The independent variable is Speed.

ANOVA

Appendix A

Model Summary

R	R Square	Adjusted R Square	Std. Error of the Estimate
.830	.689	.564	2.677

	Sum of Squares	df	Mean Square	F	Sig.
Regression	79.225	2	39.613	5.527	.054
Residual	35.835	5	7.167		
Total	115.060	7			

The independent variable is Speed.

Coefficients

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
Speed	-.083	.504	-.641	-.165	.875
Speed ** 2	-6.255E-5	.001	-.189	-.049	.963
(Constant)	29.251	48.606		.602	.574

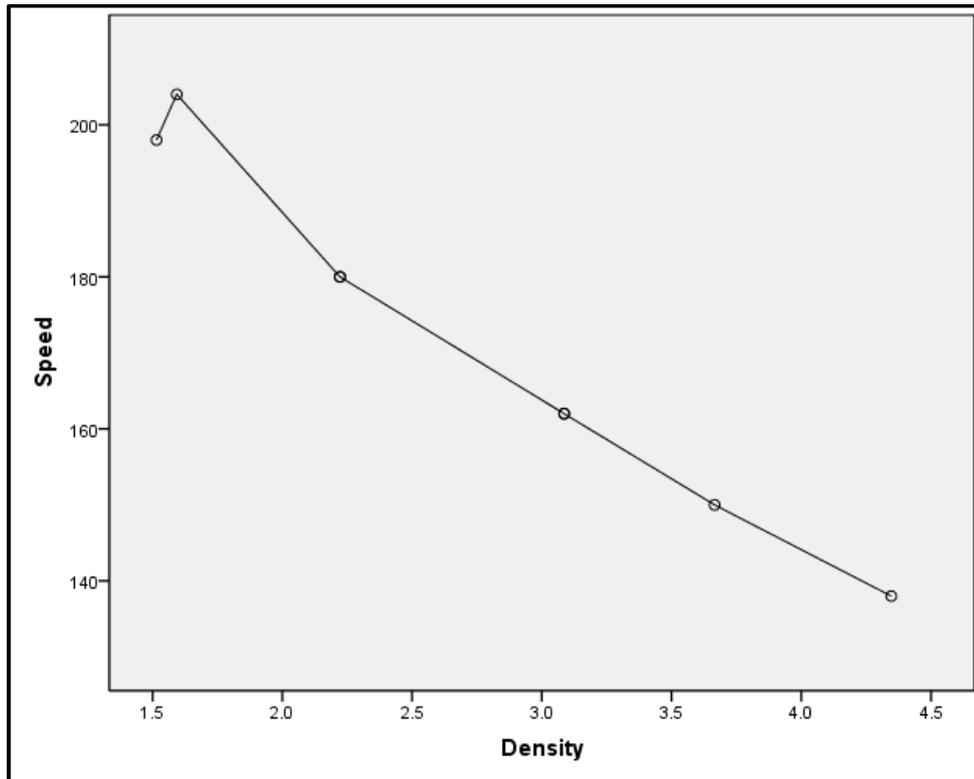


Figure A.3: Pedestrian Speed-Density Relationship Study Area No. (2)

Table A.3: Pedestrian Speed-Density Relationship Linear Regression Analysis

Appendix A

Model Summary

R	R Square	Adjusted R Square	Std. Error of the Estimate
.989	.979	.975	3.619

The independent variable is Density.

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Regression	3588.914	1	3588.914	274.012	.000
Residual	78.586	6	13.098		
Total	3667.500	7			

The independent variable is Density.

Coefficients

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
Density	-22.598	1.365	-.989	-16.553	.000
(Constant)	233.151	3.924		59.420	.000

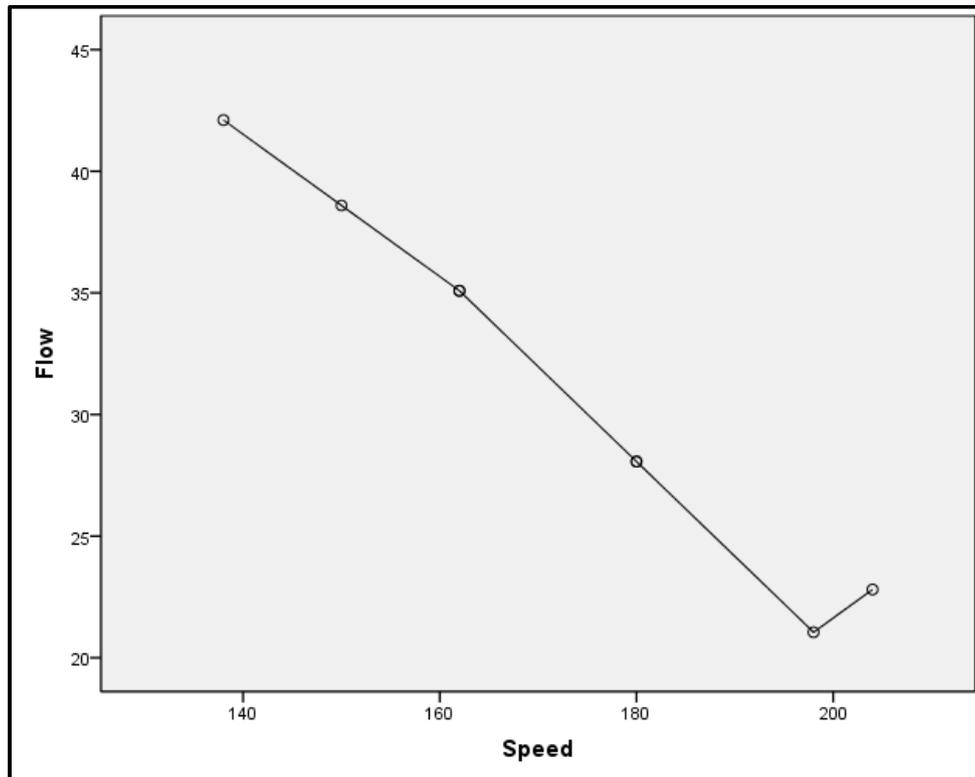


Figure A.4: Pedestrian Flow-Speed Relationship Study Area No. (2)

Appendix A

Table A.4: Pedestrian Flow- Speed Relationship 2nd Order Regression Analysis

Model Summary

R	R Square	Adjusted R Square	Std. Error of the Estimate
.990	.980	.972	1.268

The independent variable is Speed.

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Regression	388.617	2	194.308	120.902	.000
Residual	8.036	5	1.607		
Total	396.653	7			

The independent variable is Speed.

Coefficients

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
Speed	-.478	.366	-1.455	-1.306	.248
Speed ** 2	.000	.001	.466	.418	.693
(Constant)	100.201	31.186		3.213	.024

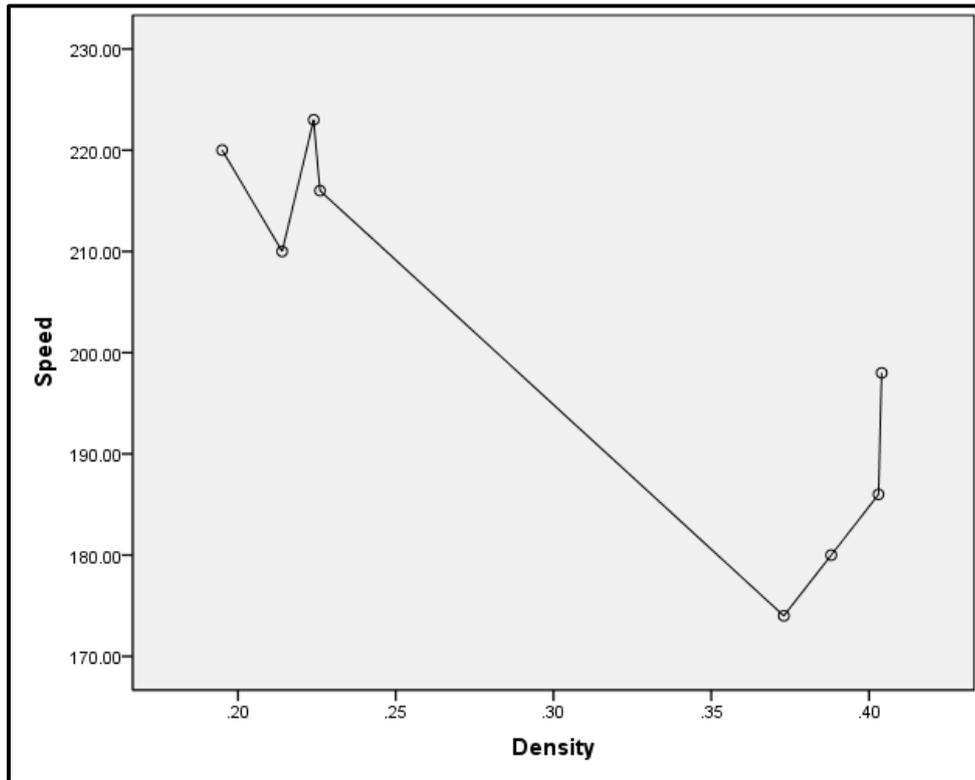


Figure A.5: Pedestrian Speed-Density Relationship Study Area No. (3)

Table A.5: Pedestrian Speed-Density Relationship Linear Regression Analysis

Model Summary and Parameter Estimates

Dependent Variable: Speed

Equation	Model Summary					Parameter Estimates	
	R Square	F	df1	df2	Sig.	Constant	b1
Linear	.769	20.024	1	6	.004	254.011	-175.151

The independent variable is Density.

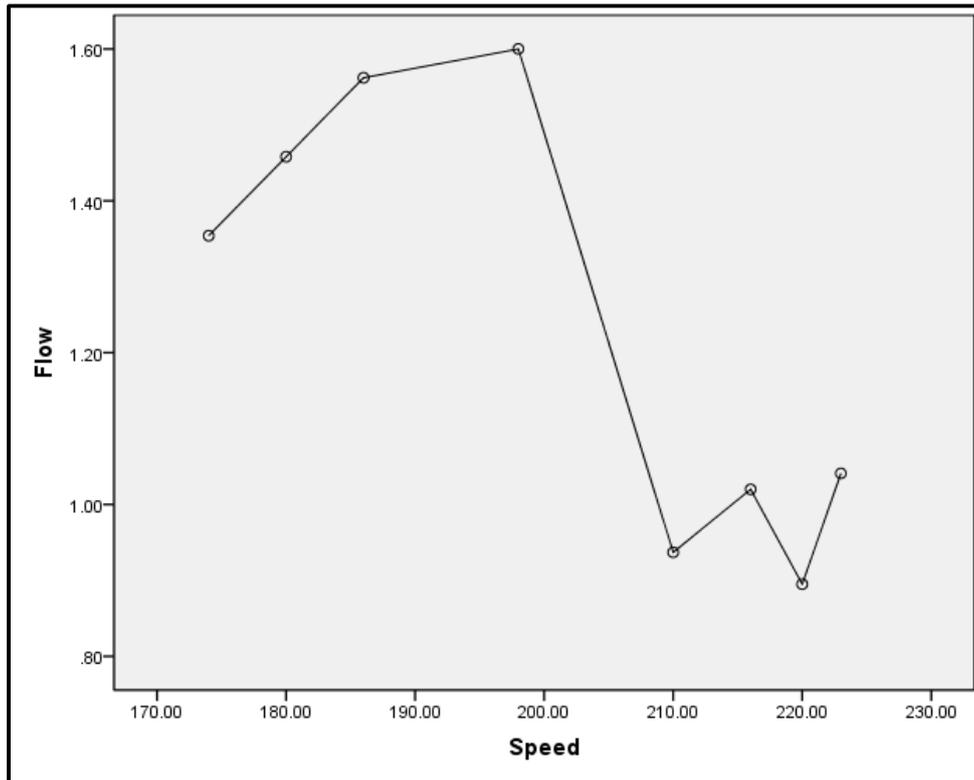


Figure A.6: Pedestrian Flow-Speed Relationship Study Area No. (3)

Table A.6: Pedestrian Flow- Speed Relationship 2nd Order Regression Analysis

Model Summary and Parameter Estimates

Dependent Variable:Flow

Equation	Model Summary				
	R Square	F	df1	df2	Sig.
Quadratic	.724	6.563	2	5	.040

Model Summary and Parameter Estimates

Dependent Variable:Flow

Equation	Parameter Estimates		
	Constant	b1	b2
Quadratic	-13.405	.161	.000

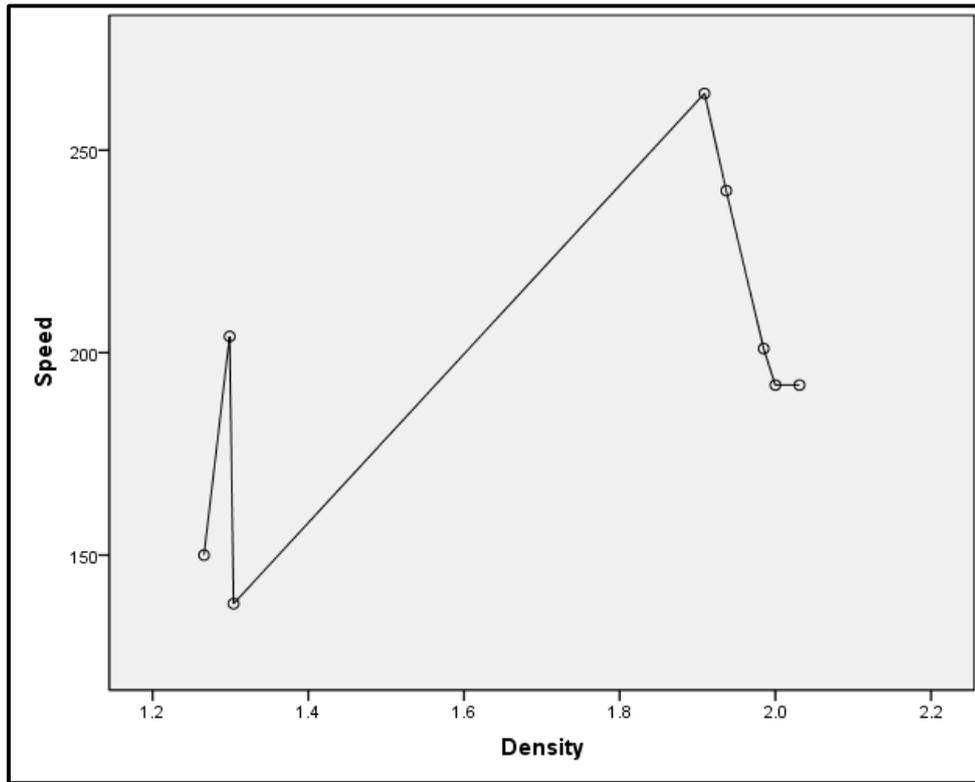


Figure A.7: Pedestrian Speed-Density Relationship Study Area No. (4)

Table A.7: Pedestrian Speed-Density Relationship Linear Regression Analysis

Model Summary

R	R Square	Adjusted R Square	Std. Error of the Estimate
.608	.370	.265	35.695

The independent variable is Density.

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Regression	4494.893	1	4494.893	3.528	.109
Residual	7644.982	6	1274.164		
Total	12139.875	7			

The independent variable is Density.

Coefficients

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
Density	71.289	37.955	.608	1.878	.109
(Constant)	75.267	66.357		1.134	.300

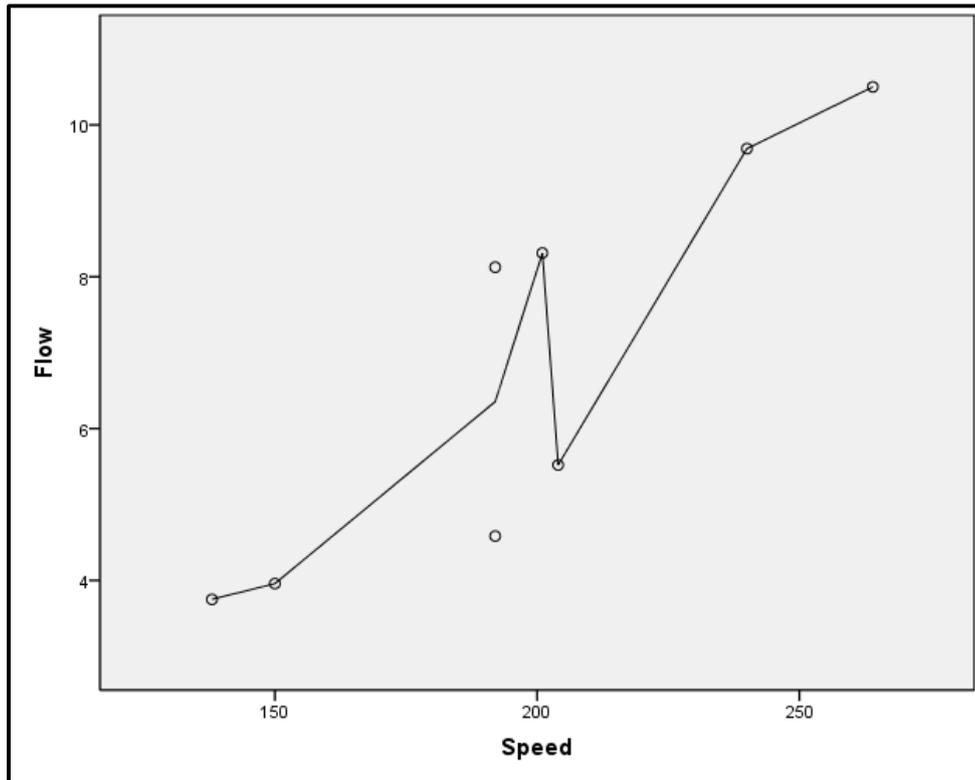


Figure A.8: Pedestrian Flow-Speed Relationship Study Area No. (4)

Table A.8: Pedestrian Flow- Speed Relationship 2nd Order Regression Analysis

Model Summary

R	R Square	Adjusted R Square	Std. Error of the Estimate
.883	.779	.691	1.485

The independent variable is Speed.

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Regression	38.970	2	19.485	8.833	.023
Residual	11.029	5	2.206		
Total	49.999	7			

The independent variable is Speed.

Coefficients

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
Speed	.032	.128	.501	.252	.811

Appendix A

Model Summary

R	R Square	Adjusted R Square	Std. Error of the Estimate
.883	.779	.691	1.485
Speed ** 2	6.130E-5	.000	.384
(Constant)	-2.031	12.489	-.163
			.855
			.877

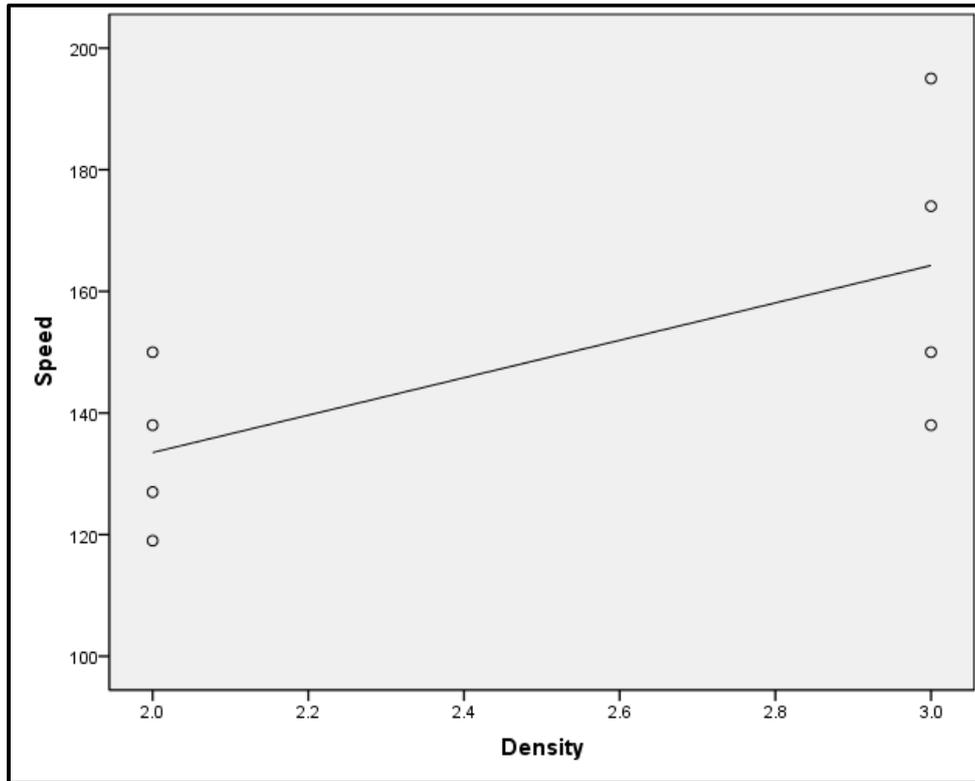


Figure A.9: Pedestrian Speed-Density Relationship Study Area No. (5).

Table A.9: Pedestrian Speed-Density Relationship Linear Regression Analysis

Model Summary

R	R Square	Adjusted R Square	Std. Error of the Estimate
.658	.433	.338	20.321

The independent variable is Density.

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Regression	1891.125	1	1891.125	4.579	.076
Residual	2477.750	6	412.958		

Appendix A

Model Summary

R	R Square	Adjusted R Square	Std. Error of the Estimate
.658	.433	.338	20.321
Total	4368.875	7	

The independent variable is Density.

Coefficients

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
Density	30.750	14.369	.658	2.140	.076
(Constant)	72.000	36.635		1.965	.097

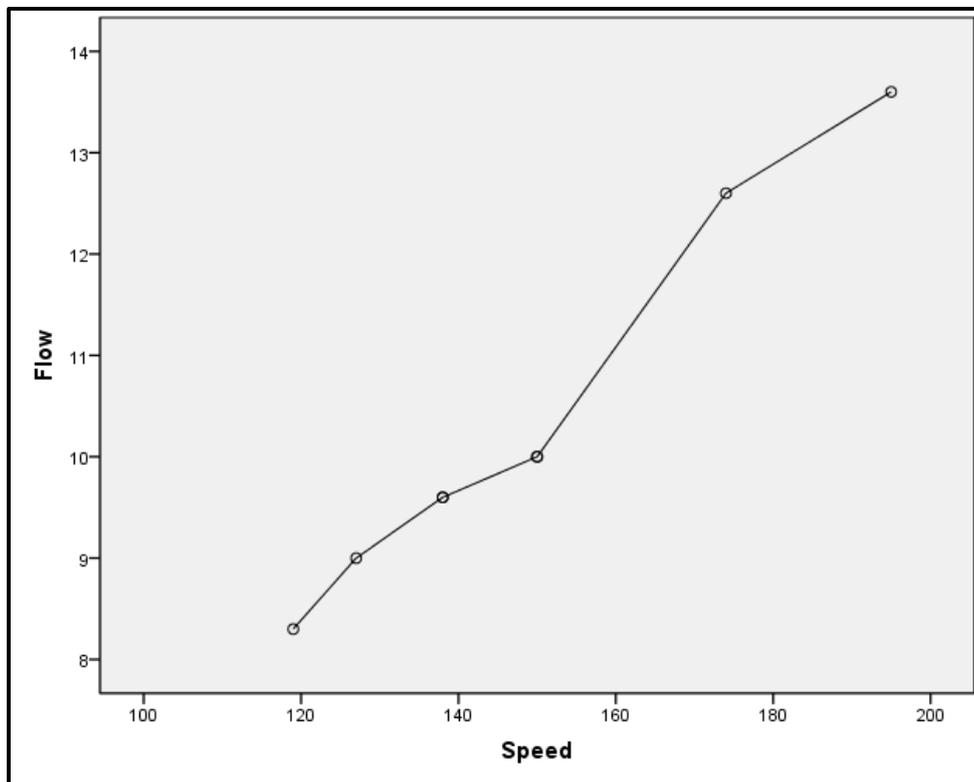


Figure A.10: Pedestrian Flow-Speed Relationship Study Area No. (5)

Appendix A

Table A.10: Pedestrian Flow- Speed Relationship 2nd Order Regression Analysis

Model Summary

R	R Square	Adjusted R Square	Std. Error of the Estimate
.988	.976	.966	.334

The independent variable is Speed.

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Regression	22.462	2	11.231	100.775	.000
Residual	.557	5	.111		
Total	23.019	7			

The independent variable is Speed.

Coefficients

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
Speed	.015	.069	.209	.220	.835
Speed ** 2	.000	.000	.779	.819	.450
(Constant)	4.009	5.337		.751	.486

الخلاصة

في حياتنا الحديثة، أصبح المشي والعبور وسيلة مهمة للمشاة للوصول إلى أهدافهم المختلفة. ومع ذلك، فإن عمليتي المشي والعبور تتطلب مسارات جانبية وممرات وسلالم وغيرها من المرافق المرورية داخل منطقة الازدحام التي تجب ان تكون على قدر معين من الكفاءة والأمان، وذلك لتقليل تداخل الحركات بين المشاة والمركبات، الذي يؤدي إلى العديد من الحوادث المرورية. وهذا يستدعي إجراء الدراسات اللازمة والبحث عن الحلول المناسبة لضمان عوامل سلامة المشاة لتوفير مسارات لهم تتناسب مع نشاطهم في المناطق الحضرية.

تروم الدراسة إلى تحقيق عدة أهداف مثل تقييم تأثير خصائص المشاة وتدفق حركة المرور بالإضافة إلى سرعة المشي على كفاءة المشاة (LOS) وذلك بالاستعانة بالنماذج الإحصائية والمرورية لبيان تأثير المتغيرات وتأثيرها على كفاءة المشاة. وكفاءة تدفق حركة المشاة. ولهذا الغرض تم اختيار خمسة مواقع ضمن النطاق الحضري لمدينة الحلة.

تم جمع البيانات الخاصة بسير وعبور المشاة من المسح الميداني حيث تم حساب التدفق ومتوسط السرعة والكثافة والتباعد. كما تم تضمين عرض المسار وعدد الممرات وتصنيف المركبات لكل قسم محدد أيضاً.

توصلت الدراسة إلى أن (LOS) لمقاطع الطريق كان يتراوح ما بين (B-F) في حين أن (LOS) للمشاة كان يتراوح ما بين (B-F) مما يشير إلى تفاقم مشكلة المشاة في منطقة الدراسة. وكذلك حسب مخرجات برنامج المحاكاة (PTV VISSIM) فإن التحليل باستخدام طريقة (HCM, 2010) و تصميم مناطق العبور والأرصفة طبقاً لمواصفات (AASHTO, 2011) أدى إلى زيادة في مستوى خدمة (LOS) للأرصفة ومناطق العبور من (F إلى B & C)

كما وتم التحليل الاحصائي باستخدام برنامج (SPSS) حيث تم دراسة العلاقات بين تدفق حركة المرور وسرعة وكثافة المشاة. وعكست المعادلة الخطية العلاقة بين السرعة والكثافة، أما في الترتيب الثاني؛ عكست المعادلة العلاقة بين التدفق المروري وسرعة المشاة في معظم أقسام منطقة الدراسة.

قيم اختبار -F بينت وجود تأثير مهم بين المتغيرات المستقلة والتابعة مما أدى إلى قبول الفرضية البديلة ورفض الفرضية الصفرية بالإضافة إلى وجود تأثير مهم لمعامل الارتباط (R) ومعامل التحديد (R²) والخطأ المعياري للتقدير (SE)

واقترحت الدراسة أليات تنقل شاملة لتدفق المشاة في مدينة الحلة تشمل وسائل لعبور المشاة ضمن الطرق والتقاطعات على شكل شبكات ذات تصميم حديث ومناسب للبيئة ومرافق العبور الآمنة للحد من الحوادث المرورية التي تؤدي إلى الوفاة أو الإصابة أو الإعاقة.



جمهورية العراق
وزارة التعليم العالي والبحث العلمي
جامعة بابل كلية الهندسة
قسم الهندسة المدنية

دراسة خصائص تدفق المشاة في بعض مناطق الازدحام داخل مدينة الحلة

رسالة

مقدمة الى قسم الهندسة المدنية في كلية الهندسة / جامعة بابل
وهي جزء من متطلبات نيل درجة الماجستير في الهندسة/ الهندسة المدنية/ المواصلات
من قبل

لمياء شاكر فاضل

(بكالوريوس في الهندسة المدنية - 1998)

بإشراف

أ. عبد الكريم ناجي عبود