Republic of Iraq
Ministry of Higher Education and Scientific Research
University of Babylon
College of Engineering
Civil Engineering Department

Study of Pedestrians Movement at Some Intersections in Hilla City

A Thesis

Submitted to the College of Engineering \ University of Babylon in Partial Fulfillment of the Requirements for the degree of Higher Diploma in Civil Engineering \Roads and Transportation

By

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Ramadan 1443 **April 2022**

بِسۡمِ ٱللَّهِ ٱلرَّحۡمَٰنِ ٱلرَّحِيمِ

﴿ يَرْفَعِ اللَّهُ الَّذِينَ آمَنُوا مِنْكُمْ وَالَّذِينَ أُوتُوا الْعِلْمَ دَرَجَاتٍ وَاللَّهُ بِمَا تَعْمَلُونَ خَبِيرٌ ﴾

صدق الله العظيم

[المجادلة: 11]

CERTIFICATE

I certify that this thesis which is entitled **''Study of Pedestrians Movement at Some Intersections in Hilla City.''** was prepared by **Thmar wael abul Kadeem** under my supervision at the College of Engineering, University of Babylon in partial fulfillment of the requirements for the degree of Higher Diploma in Civil Engineering / Roads and Transportation

Supervisor:

Signature:

Name: **Prof. Abdul Kareem N. Abbood**

Date: / / 2022

Acknowledgment

Praise is to Allah who gave me the ability and the desire to complete this work in spite of all the obstacles in the way of its completion.

I would like to express my deep appreciation to my supervisor **Prof. Abdul Kareem N. Abbood** for his great help, support, advice and encouragement through all the stages of preparing my study.

Finally, would like to express my sincerest thanks and dutiful gratitude to my husband, mother, father and all my family for their love and support which have been a source of strength and motivation.

ABSTRACT

The pedestrians mobility , transit , environment and the influence of their movement with the traffic operations of various important elements, which must be taken in to consideration the roads and intersections design, thus the study seek to assess the level of service (LOS) of pedestrians and give a solutions, treatments on according to scientific methodology based on a study of traffic analytical .

Tow signalized intersections in Hilla city have been studies with pedestrians facilities performance they are (Bab Al-hussin , and Al-jamiaa-40 street).

Data have been collected by using video camera with the aided Resident engineer department for camera project, according to feel survey included traffic engineering such as traffic volume for vehicles and pedestrians, pedestrians speed, number of phases, cycle length, yellow interval, lost time.

For each intersection within study area, engineering survey have been conducted too, included number of lanes, lane width, median width, average vehicle width. All this data collected within work day during (Monday, Tuesday, Wednesday) the as stated in AASHTO specification due to Peak Hour Volume (PHV) .

Data have been prepared by using Figures and Tables with the aided Excel software (2019). The data was analyzes by using Highway Capacity Manual HCM (2010) method to reach level of service for pedestrian within each signalized intersection, investigate with aided of Webster method level of service for each intersection.

The study have been concluded the following conclusions, the level of service was (LOS D) for pedestrian crossing within bab Al-Hussin signalized intersection; for Al jamiaa-40 street intersection with traffic sign the service level (LOS E) for pedestrian crossing which is indicate random movement many confident points between vehicles and pedestrians.

The study suggested the development of the signalized intersections in terms of equipping the intersections with marking and signing signals and redesign yellow interval within each signalized intersections in study area, this lead to increase safety and clearance time for pedestrian and vehicle. As the accident type (vehicle/pedestrians) increasing, the study recommended designing pedestrian bridges providing with moving stairway within the approaches and before the intersection area, providing the stairway with electrical energy technique.

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Chapter One

INTRODUCTION

1.1 General

Walking is one of the most important means of mode in transportation because every journey begins and finishes with a walk, in Transportation making plans taking walks is the most important mode of passage of people beings of their each day life. The walkability of any region and the facilities available for people determine its safety and environmental friendliness.

Safety pedestrians crossing at signalized intersections require a thorough understanding, particularly in mixed traffic situations, in order to provide necessary infrastructure as well as to reduce pedestrian delays by minimizing traffic signal delays, resulting in a reduction in factors influencing crossing speed according to signal faces for each approach within the study area.

In various situations, the Level of Service (LOS) is a quantitative method of evaluating the available or existing pedestrian facilities; Such as link un signalized intersection and signalized intersection. There are one of a kind parameters that can be used to determine the (LOS) of Pedestrian at signalized intersection facilities depend on signalized intersection performance also pedestrians control behavior and characteristics in the study area. The data needed to find each parameter is different.

(LOS) is found by:

- Flow Rate : The number of pedestrians crossing a specific point of the signalized intersection road in a given time period multiplied by the effective width of the footpaths yields the LOS.

- Speed: The distance traveled by a pedestrian is divided by the time it takes to cover the distance.
- Space: At any given time, the number of pedestrians within a one square meter area.

Walkways, crosswalks, traffic control elements, and curb cuts (depressed curbs and ramped sidewalks) and ramps for older walkers and those with mobility disabilities are all examples of pedestrian facilities. Bus stops or separate loading places, sidewalks on grade separations, and the stairs, escalators, or elevators associated with those facilities are all examples of pedestrian facilities.

1.2 Object of the Study

The main objectives of this study are:

- Evaluation of pedestrians movements, crossing and movement at signalized intersections as well as providing safe havens for pedestrians crossing in the study area to reach their destinations effectively and safety.
- Increase the efficiency of the level of service (LOS) for pedestrians crossing at signalize Intersections by increasing the efficiency of crossing due to prevent random crossing at intersections approaches.
- Suggest suitable options and alternatives that will be raise the level of service for pedestrians crossing during the total cycle time of the intersections to avoid interference with movements, as well as avoid conflict points that will lead to different type of traffic accidents especially vehicle pedestrians type.

1.3 Study Problem

Hilla city suffers from many traffic problems in their roadway network. Intersections in general and the signalized intersections are among the most important traffic nodes in which traffic problems are exacerbated and occupying crossings and pedestrians through which are among the most important traffic facilities that the intersection must provide to road users. Therefore, the problems of the study included the following subject:

- Traffic activities conflict with the pedestrians movements during moving and crossing intersection approaches, which characterized by irregularity movements, resulting in inefficiency yellow time interval which the intersection needs in evacuating pedestrians.
- A random activities of pedestrians, led to decrease in the operation speed of the intersection, as well as increase delay time, thus reducing the effective green time for all phases, resulting in reducing the level of service for intersections within study area.
- Signalized intersections suffer from alack and neglect in providing many traffic facilities, such as marking, signing, control, which contributed to the exacerbation of traffic problems for pedestrians.
- As a result of the increased number of critical points and ineffective pedestrian crossing. The possibility of a traffic accident has increased.

1.4 Important of the Study

The importance of this study lies in the fact that it is one of the few studies that penetrate into the pedestrian field and their crossing and movement in signalized intersection within study area, especially the signalized intersections in the city of Hilla, as most of the studies go to studying the designs of the road, intersections and do not give enough importance to the pedestrian in plans and studies, and although they are an essential part of the traffic elements on highways network and intersections.

• Determining the efficiency and capacity of pedestrian sidewalks approaches using the concept of Level of Service (LOS) by studying the current situation of pedestrian traffic volumes during traffic peak hours and working to improve the efficiency using that concept.

• When studying and evaluating pedestrian speed, consider the proportion of elderly pedestrians (65 and older) in the walking population. If 0 to 20% of pedestrians are elderly, a walking speed of 4.0 ft/s is recommended; if elderly pedestrians account for more than 20% of all pedestrians, a walking speed of 3.3 ft/s is recommended**.(HCM 2010)**

• Study of the total sidewalk width and the distance and type of obstacle in sidewalk (W_o) to determine the effective sidewalk width (W_E) for each study area on the intersections because it is important to determine the service provided by the sidewalk for the pedestrian.

1.5 Scope of the study

The research includes five chapters:

Chapter one : gives an introduction to the research work and gives idea about pedestrian level of service concept, objective, methodology and scope of study.

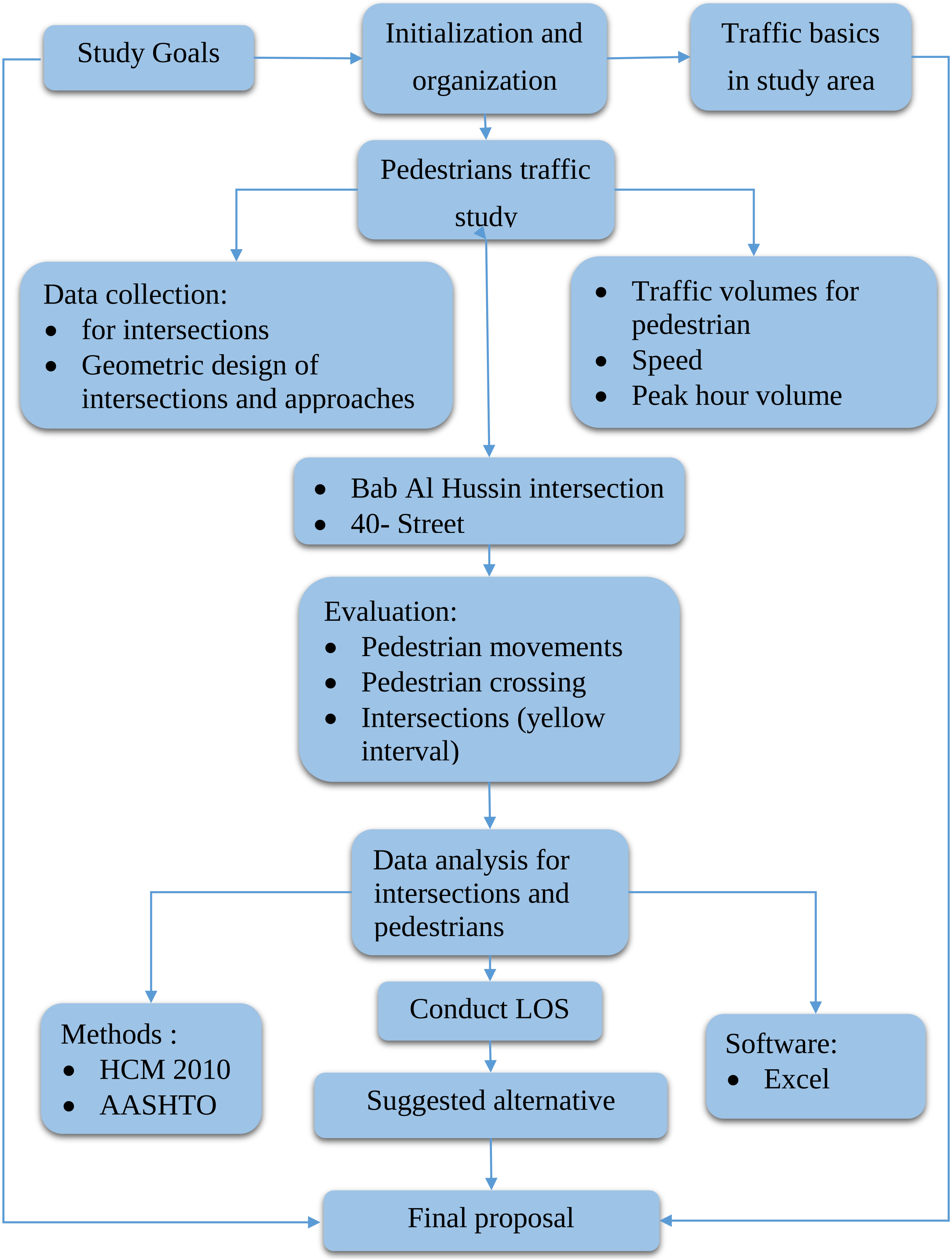
Chapter two : It is discussed in detail for various literatures review.

Chapter three: The study area, Tables, Figures, and specifics of the data collected for this study are all covered in this section..

chapter four : covers the methodology and procedures employed in this study, as well as providing an overview of the analysis strategy used.

Chapter five: shows the conclusions , recommendations , and suggestions for researches.

1.6 Methodology



Chapter Two

BASIC CONCEPT AND LITERATURE REVIEW

2.1 General

This chapter summarizes recent research on signalized intersections multimodal Level of Service (LOS). The research into traveler perceptions of Level of Service for pedestrians is grouped into the literature review. In recent years, researchers have focused their attention on pedestrian-related concerns, notably studies of pedestrian safety and pedestrian Level of Service (LOS) in developing nations. All types and details of signalized intersection with their improvement using engineering programs for previous studies are presented in this chapter.

2.2 Pedestrian Characteristic Studies

The following are the general characteristics of pedestrians that should be considered: [**Highway Design Manual 2005]**

- Pedestrian's action is less predictable than that of drivers because many Pedestrians believe they are outside the law in traffic matters.
- Pedestrians usually use the path that is the shortest distance between two points.
- Pedestrians have a natural reluctance to climbing steps or ramps when crossing roadways and they tend to avoid specific pedestrian underpasses or overpasses.
- Pedestrians are more susceptible to disobey traffic control devices than drivers.

- An important factor is age. Young pedestrians are more careless than the older pedestrians in traffic because of ignorance.

2.3 pedestrian studies

Pedestrians are the most weak users at signalized crossings, and their incorrect behaviors, such as signal violations and failure to cross at crosswalks, which are largely influenced by their safety perceptions, aggravate the issue. Understanding pedestrian perceptions can aid traffic engineers in improving facility planning, design, and operation so that pedestrians crossing at signalized intersections have a better experience. 1286 pedestrians were asked to score their safety perception on a scale of one to five in an intercept survey performed at 32 cross walks in Shanghai.

- Green walkers (GW), who enter in green, late walkers (LW), who enter in flashing green, and red walkers (RW), who enter in red, have been classified as three different types of pedestrian behavior. Refuge island settings and being involved in conflicts had significant effects on pedestrian perceptions, according to the results of a random effects ordered logic model developed and calculated. All type of pedestrians support the establishment of refuge Island however, LW feel safer if they can halt at refuge island, whilst RW believe they are less safe.

Based on the findings, some recommendations for crosswalk design and operation are proposed**. (Ying Ni, Yninging Cao, Keping Li, 2017).**

- In Poland, many pedestrians are killed or injured while crossing the street. The study provides an overview of innovative options for enhancing pedestrian crossing safety, including automatic pedestrian recognition, dynamic traffic signs, and improved illumination. Video technology with image analysis appears to be the most promising future option among pedestrian detection systems its challenges, current improvements, and advantages are discussed. Dynamic traffic signs, which contain pulsating lights mounted on "pedestrian crossing" signs and activated when persons waiting to cross are spotted, already use pedestrian detectors. (**Witold Czajewski, Paweł Dąbkowski and Piotr S Olszewski. 2013**).

- Pedestrians may not always follow the crossing regulations of

when and where to cross the road at signalized intersections. The efficiency of safety countermeasures at such localities is substantially harmed by this unsafe activity. As a result, it is very important to understanding illegal behavior is critical for developing more effective and targeted measures. In order to solve the issue. Video based observation was used to acquire one set of data at three signalized intersections. Another set of data came from an online questionnaire survey, which yielded 275 valid responses. Finally, the presentational properties of illegal crossings at signalized intersections were examined, and two Bayesian network based behavior models were created to evaluate the characteristics and their effects. (**Yingyng Ma, Siyuan Lu and Yuanyan Zhng. 2020)**

- When constricting traffic signals at signalized intersections,

pedestrian walking speed is a significant and necessary parameter. In a twice crossing, however, there is a lack of awareness of pedestrian speed characteristics. Pedestrians were divided into groups based on their age, gender, and group size, and the speed characteristics of each group were studied. Furthermore, each age group was separated into five categories based on gender and group size, with the effect sizes of gender and group size on speed-changing at the two stages being investigated. The findings reveal considerable disparities in walking speed between genders and ages, as well as between group sizes.

Different factors influence speed change in both directions in the young group, whereas the same parameters affecting speed shift in both directions affect middle and old groups, demonstrating that the suggested model is successful in mimicking pedestrian speed characteristics of double crossing. This study establishes a theoretical basis for determining pedestrian movement intentions, signal timing optimization, and pedestrian infrastructure improvements at signalize intersections. **(yongqing guo, xiaoyuan wang, xinqiang meng, Jie wang, yaqi Liu. 2019).**

2.4-Intersections

The overall area where two or more highways intersect or unite, including the roadway and roadside facilities for traffic moving within the area, is referred to as an intersection. An intersection leg is a highway that radiates from an intersection and is a part of it. The most typical four-legged intersection is where two motorways cross each other. An intersection with more than four legs is not recommended. Intersections are an important element of a highway facility since their design influences the facilities efficiency, safety, speed, cost of operation, and capacity. On one or more of the highways, each intersection involves through or cross traffic, as well as possible turning movements between them. Such movements may be used to enable various geometric designs and traffic control, depending on the type of intersection. **(AASHTO;2010)**

2.4.1 Un signalized Intersections

The Un signalized Intersection Improvement Guide focuses on the un signalized intersection, which is defined as any at-grade intersection of two or more public roadways where cars, bicyclists, and pedestrians do not have the right-of-way regulated by a highway traffic signal. Un -signalized intersections are classified according to the form of traffic control, the area type (urban, suburban, or rural), and the number of approach legs. Because the scope of the Un signalized Intersection Improvement Guide is defined by the form of intersection traffic control, it also serves as the base for the classification of un signalized intersections in the Guide. **(FHWA;2013)**

2.4.2 Signalized-Intersections

In their most basic form, signalized intersections provide users with indications as they approach the intersection. In addition to signaling intersections, pedestrian signals may be required at sites along a corridor where there are large concentrations of pedestrians. This type of traffic management can be applied at signalized intersections with pedestrian pushbuttons and signal heads, or at non-signalized places with large pedestrian traffic volumes. (FHWA;2013)

Signalized-intersections provide a distinct walk phase for pedestrians crossing the roadway, and they should be scheduled to enable enough time for pedestrians to safely cross the street. The guideline for pedestrian walking speeds at signalized-intersections has recently been lowered from four to 3.5 feet per second to better represent average pedestrian walking speeds and the aging population. This reduction is required by the 2009 Federal manual on uniform traffic control devices (MUTCD), although it has not yet been approved by the California version of the (MUTCD). In regions with a high number of kids, older persons, or impaired pedestrians crossing, a slower walking tempo of 2.8 f/s is recommended. Pedestrians benefit from shorter cycle lengths and longer walk intervals because they improve service and encourage signal compliance. At signalized-intersections, pedestrians can choose from several degrees of signal time. **(San Francisco planning Department, 2019)**

2.5 level of service (LOS) Studies

The HCM (2010) also designs six LOS for pedestrian facilities, ranging from "A" to "F," with "A" indicating the best operational conditions and "F" indicating the worst. As boundaries for the various LOS, it uses specific average pedestrian space values. According to HCM (2010), pedestrian speed decreases as volume and density rise. The degree of mobility offered to individual pedestrians, as well as the average speed of the pedestrian stream, reduces as density rises and pedestrian space decreases.

According to HCM 2000, there are two types of pedestrian facilities: uninterrupted and interrupted. Pedestrian facilities are characterized as uninterrupted pedestrian facilities or off-street pedestrian facilities when they are not affected by motorized forms of transportation, and vice versa. Several research on the analysis of LOS of pedestrian facilities have been conducted.

In this regard, the researcher discussed the development of adjustment factors for effective pedestrian facility design based on pedestrian walking speeds under influences such as age and gender, land uses, temporal variations, cell phone usage, carrying luggage while walking, and moving in groups; on three types of facilities, sidewalks, wide sidewalks, and precincts **[Rastogi et al. (2011)]**

Another study was conducted at the University of Technology in Malaysia (UTM), with the purpose of evaluating and improving the pedestrian level of service on campus. The study was based on pedestrian design indicators that were discussed according to given guidelines, and the study composed a formula that based on all indicators to determine the pedestrian level of service. **[Asadi- Shekari et al., 2014]**

The evaluation of pedestrian level of service has focusing on qualitative measure more than quantitative measure, a measure of effectiveness was used for the determined of pedestrian facilities, and the measure of effectiveness changes depending on the type of facility, for crossing the measure of effectiveness depends on pedestrian delay, available vehicle gaps, safety, a study about analyzing problems related to pedestrian level of service of crosswalk, it was noticed that the evaluation of pedestrian level of service has focusing on qualitative measure more than quantitative measure, a measure of effectiveness was used for the evaluation of pedestrian**.[Kadali and Vedagiri, 2015]**

Others developed a pedestrian (LOS) model based on a percent of pedestrian crossings that are impacted by turning vehicles at signalized-intersections. [**Hubbard, Awwad, and Bullock, 2007]**

The HCM 2000 equation for pedestrian delay at signalized intersections, which assumes pedestrians reach at an intersection at random, was refined by the researchers. They evaluated at pedestrian delays at coordinated signal intersections and discovered that they were much longer than expected if arrivals were ran dom. according to the authors determined the HCM pedestrian delay equation should be updated to include the impacts of signal coordination. **[Chilukuri and Virkler,2005]**

Another study devised a pedestrian (LOS) method based on three distinct pedestrian crossing outcomes: non-contradictory, compromised, and failed. Their case study findings revealed that the most common cause of failed and compromised pedestrian crossings was a somewhat high number of vehicular right turns provided by an exclusive right turn lane with a big turning radius and an obtuse angle.[**Clark et al.2001]**

A stated-preference survey was also used to look into crossing LOS. Area occupancy, pedestrian flow, and walking speed were determined to be the most important predictors of LOS at signalized intersections.. **[Lee et al.2007]**

Similarly, **[Muraletharan Et Al.,2005]** investigated the elements that influence pedestrian LOS at crosswalks and discovered that the presence of turning vehicles is the most relevant factor.

While confirming these findings, the researcher added to our understanding of the critical factors that evaluate pedestrian perceptions of (LOS) at signalized intersection crossings. They discovered that the number of right turns on red for the street being crossed, motor vehicle volumes on the street being crossed, midblock 85 % speed of the vehicles on the street being crossed, permissive left turns from the street parallel to the crosswalk the number of lanes being crossed, the pedestrian's delay, and the presence or absence of right turn channelization islands were all major factors in pedestrians LOS at intersection. [**Petritsch et al;2008]**

The other study gives a classification and analysis of the data obtained using several methods for the evaluation of urban street Level of Service (LOS). The basic concept of urban streets and LOS is examined. LOS is statistically and qualitatively assessed. The success of applying quantitative methods to define LOS criteria for an urban street is measured by Average Travel Speed (ATS) on street segments. The method of collecting travel speed data has evolved over time, moving away from the standard followed moving observer method and toward a distance measurement system.

(Bhuyan &Minakshi Sheshadri Nayak;2013)

A new pedestrian LOS measure that is sensitive to several pedestrian phasing options is proposed, as well as a technique for field implementation. A compromised crossing is defined by this methodology, known as the % compromised method, as one in which the pedestrian is delayed or changes travel direction or speed in reaction to turning vehicles. This method can be used to detect the cycles in which there are compromises due to turning vehicles, or it can be used to identify individual pedestrians or pedestrian platoons. Due to right turns on red, this study presented quantitative evidence that the leading pedestrian interval did not work as well as standard concurrent pedestrian phasing. **(Sarah Marie Lillo Hubbard;2021)**

Another study looked into the significance of pedestrian LOS in developing countries, specifically at unprotected midblock crosswalks. A review of the literature on pedestrian LOS at various facilities such as the sidewalk, intersection, and midblock crosswalk was conducted to achieve this aim. The study highlighted the need for more pedestrian LOS studies in mixed traffic settings at various facilities. **[Raghuram Bhadradri Kadali, P.Vedagiri; (2016)]**

The effects of pedestrian characteristics, traffic design, and operating factors on pedestrian Level of service (LOS) were investigated. The perception of pedestrians and traffic operations both have a substantial impact on pedestrian LOS. Age, trip purpose, single step crossing, nearside crossing, and confrontations with left turning vehicles were all significant factors when other variables were held constant. When the actual waiting time exceeded 60 seconds, the perceived waiting time increased higher than the actual waiting time, according to the study. Perceived after 120 seconds. **(ZiWen Ling ChrisTopher R. CheRry ying Ni;2015)**

Another study examines the characteristics of pedestrian movement on sidewalks. In Samawah, the fundamental relationships of flow, speed, and density were examined and analyzed. At four survey sites, the video capturing method was used to observe pedestrian characteristics such as flow and speed. The findings of this study were compared to the findings of previous studies. Finally, pedestrian movement on sidewalks was defined at the level of service borders. **[Noorance Al-Mukaram & Sarah SaFa aldeen Musa;2020]**

2.6 Type of Pedestrians Crossings

Zebra, Pelican, Puffin, Toucan, and Pegasus crossings are the five different forms of formal pedestrian crossings presently in use in the United King dom.

2.6.1 Zebra-Crossings

marked Black and white painted stripes across the road, as well as blinking amber beacons. Accordant to the Highway-Code Link to External Website Motorists must give way when someone has moved onto a crossing. Pedestrians should, however, stay on the curbside until approaching vehicles have come to a complete stop. Although Zebra Crossings are less expensive to construct than traffic signal controlled crossings, they should not be used on roads with speeds above 35 mph. The width of the line was (0.5m) and width of the crossing area was not less than a (3m)**[Iraqi Highway Design Manual, 2005]**.

2.6.2 Pelican-Crossings

Drivers should see red, amber, and green signals, with red man-green man signal heads on the other side of the road from pedestrians waiting to cross. These are controlled by a pedestrian push button unit. Pedestrians should not cross when the red man is lit (although it is not against the law to do so). Drivers must stop while the constant red traffic sign is lit, according to the Highway Code. The green man will then signal for pedestrians to cross the road, after ensuring that it is safe to do so. Pedestrians should not begin crossing when the green man begins to flash, even if there is still enough time for those on the crossing to complete their trip safely. When the steady green man is lit at most Pelican-Crossings, a bleeping sound is played to alert the visual impaired. Without these beepers, a tactile rotating knob under the push button unit may be installed, that turns when the green man is illuminated.

Figure (2.1) Illustrate the pelican crossing type.

2.6.3 Puffin -Crossings

They are not like Pelican crossings in that there is no flashing green man/flashing amber indicator. On-crossing pedestrian detectors determine the overall crossing time each time. The demand For the crossing is still activated by the push button unit, but curbside pedestrian detectors have been installed to cancel non-essential demands (when a person crosses before the green man lights). The red man/green man signals are now located above the push button unit on the pedestrian side of the road at the most recent Puffin crossings. Pedestrians waiting at the crossing are encouraged to look both at the approaching traffic and at the red man/green man signal with this layout. In most cases, the push button unit will have either beepers or tactile turning knobs.

2.6.4 Toucan-Crossings

In most cases, the push button unit will have either beepers or tactile turning knobs. are generally used next to a cycling path and are meant for both pedestrians and bicycles (Cyclists are not permitted to use the Zebra, Pelican, or Puffin Crossings to cross the road). They use the same signals as Pelicans, however in addition to the green man, they have a green cycle symbol. Toucan crossings, like Puffin crossings, can be far-sided or near-sided, and, like Puffin crossings, the crossing time is determined each time using on crossing detectors. A Toucan's price is equal to that of a Puffin.

Figure (2.2) Illustrate the toucan crossing type.

2.6.5 Pegasus-Crossings

Similar to Toucan crossings, but with a red/green horse sign and higher positioned push buttons for horse riders to cross. This kind of crossing is only utilized in situations when there are a lot of crossing movements over a busy main road. Equestrian crossings can be designed just for horses and riders, or they can be coupled with cycling and/or pedestrian amenities. A holding coral separates horses from pedestrians in both cases.

Figure (2.3) Illustrate the Pegasus Crossing Type.

2.7 pedestrian level of service methods

There are many methods can evaluate the pedestrian's level of service, and the method used **(HCM;2010)** which are: **(Sisiopiku et al;2007)**

2.7.1 Highway Capacity Manual (HCM)

The most widely accepted method of quantifying pedestrian LOS is the Highway Capacity Manual 2010 (HCM 2010). "A qualitative measurement describing operational parameters within a traffic stream, based on service measures like as speed and travel time, freedom to maneuver, traffic disruptions, comfort and convenience," according to the HCM 2010. The approach used is based on basic correlations between pedestrian traffic variables such as density, speed, and flow, which are similar to the factors considered in estimating vehicular LOS. For pedestrian LOS, the HCM 2010 methodology includes criteria for evaluating uninterrupted facilities, staircases, crossing pedestrian streams, signalized pedestrian facilities, and crossing traffic stream queue zones. The methodology calculates (LOS) for sidewalks using the space service measure as well as the additional criterion of unit flow rate, speed, and volume/capacity (v/c) Ratio.

2.7.2 Australian Method

The pedestrian LOS method used in Australia is primarily based on three factors: physical characteristics, location factors, and user factors. Based on an assessment of the elements impacting LOS, pedestrian conditions are graded from LOS (A) (ideal pedestrian condition) to LOS (E) (un suitable pedestrian condition).

Path width, surface quality, impediments, crossing possibilities, and support facilities are all factors to consider. path environment, Connectivity, path environment, and the possibility of vehicle conflict are all addressed by location factors. The degree to which the path provides a helpful, direct, and logical link between attractors and producers of pedestrian trips is referred to as connectedness. The degree of pleasantness of the surrounding environment is measured by path environment, which is generally related to distance from the street. The number of pedestrians on the path, the mix of path users, and personal security are all factors to consider. The researchers developed this model in an iterative process that included testing and improvement, and they determined that it is a strong basis for continued pedestrian LOS measurement. It also efficiently detects which elements play a role in determining whether the LOS is high or low.

2.7.3 Trip Quality Method

This method generates nine evaluation criteria for examining pedestrian walkways for their pleasantness, safety, and functionality by combining urban design architectural principles with practical safety and capacity factors. Enclosure definition, complexity of path network, building articulation, complexity of spaces, buffer, transparency, shade trees, overhangs awnings various roof lines, and physical components condition are among the nine factors evaluated.

Each measure is graded on a scale of one to five, with one being the worst and five being the best. This method offers poor results to facilities that are not pedestrian-friendly. Taking these factors and the suggested grading system into consideration, the trip quality technique can be utilized to compute an average score for the facility under review. The literature was deficient in providing information on how to give values to each factor, an issue that is highly dependent on the opinion of the observers.

This method has the advantage of allowing each measurement to be listed separately rather than establishing an aggregate LOS score for the entire road. This can then be used to suggest specific actions to improve the pedestrian attractiveness of a corridor.

2.7.4 Landis Method

This method makes a great attempt to objectively quantify a pedestrian's perceptions of safety and comfort in a road side setting. The measurement provides an indication of how effectively roadways accommodate pedestrian movement. The Florida Department of Transportation has endorsed this model, which was constructed using a stepwise multivariable regression analysis of 1250 observations from an event that put 75 individuals on a street walking course in Pensacola, Florida.

The Landis method measures the quality of sidewalk operation by taking into account a pedestrian's perception of safety and Comfort.

2.7.5 Conjoint Analysis

By combining several attributes affecting pedestrian movement, the conjoint analysis evaluates pedestrian LOS for sidewalks and crosswalks. The attributes are weighted according to how important they are to the user. Sidewalk width and separation, obstructions, flow velocity, and cycling events are all factors to consider while designing a sidewalk. The attributes for crosswalks are corner space, turning vehicles, crossing facilities, and delay. Both are rated on a scale of one to three, with one being the best. Two traffic-related features and two non-traffic-related attributes are considered in both sidewalk and crosswalk evaluations.

This method's set of parameters was developed based on a large user survey done in and around Hokkaido University in Sapporo, Japan. Based on user responses, the user survey offered utility values for each level.

The Data Analysis and Results section includes a summary of how these are utilized to determine LOS. It's worth noting that include too many attributes can make respondents feel burdened and lower the number of responses received. Only frequent users' responses were considered in the Sapporo study project. These responses were linked to utility values and used as the basis for determining LOS.

2.8 Level of Service Descriptions

The following paragraphs explain the level-of-service standards for walkways: **(HCM 2010)**

- Level of Service “A”: Pedestrians move in desired paths without altering their movements in response to other pedestrians. Pedestrians can choose their own walking speeds, and conflicts between them are unusual.
- Level of Service “B”: Pedestrians have enough space to move at their own speed, bypass other pedestrians, and avoid crossing conflicts. Pedestrians at this stage begin to notice other pedestrians and respond to their presence while choosing a walking path.
- Level of Service “C”: sufficient space for regular walking speed and to avoid other pedestrians in mainly unidirectional streams. Minor conflicts might arise from reverse-direction or crossing movements, and speeds and flow rates are reduced.
- Level of Service “D”: the ability to choose one's own walking speed and to avoid other Pedestrians is limited. Crossing or reverse FLow movements are more likely to cause conflict because they require frequent changes in speed and location. Although the LOS

allows for relatively smooth flow, there is likely to be friction and interaction between pedestrians.

- Level of Service “E”: Almost all pedestrians slow down their typical walking speed and modify their gait frequently. Only shuffling allows you to move forward in the lowest range. There isn't enough space to move slower pedestrians. Cross-flow and reverse-flow movements are only achievable with extreme difficulty. With stoppages and pauses in flow, design volumes approach the limit of walkway capacity.
- Level of Service “F”: All walking speeds are severely limited, and forward movement is only possible by shuffling. Other pedestrians will come into contact with you on a regular basis, which is unavoidable. Cross-flow and reverse-flow movements are nearly impossible to accomplish. The flow is unpredictable and irregular. Queued pedestrians tend to have more space than flowing pedestrian streams.

2.9 Summary

Previous studies show that signaled Intersections, the concept of pedestrIan level of Service“LOS” was carried out to be clear and many different researchers related to the parameters affecting pedestrian LOS were found out and discussed in this chapter, along with different method for determining the pedestrian LOS followed by different researchers. In this research, the highway capacity method (HCM;2010) was applied to analyze the study area. Also this chapter discussed the Pedestrian crossings as they represent the most important places for pedestrian when they cross the roadway. According to the literature review much more research can be done on the current pedestrian LOS methodology and the collection of data by videography is found to be an efficient and accurate technique.

Chapter Three

METHODOLOGY AND DATA COLLECTION

3.1 General

This chapter deal with data collection and methodology techniques used in evaluating traffic volumes for vehicles and pedestrians. In order to eliminate or reduce variance in the data collected , data was collected on weekdays only, since the traffic flow characteristics on most signalized intersections go through major volume changes during holiday and weekends, in comparison with the usual weekday traffic conditions.

3.2 Definition of Al- Hilla City

Hilla is an Iraqi city and the center of Babel Governorate, has a population of 970 thousand people. It is about 100 km from in the south Baghdad, and about 60 km from Najaf. It is also located near the ancient city of Babylon, which is one of the most important ancient historical regions in the world., This zone consists of several activities' centers, including schools, cafes, restaurants, shopping malls and other departments of government as well as residential neighborhoods. The number of vehicles in Hillah is increasing rapidly without significantly increasing the network of the road capacity, leading to increased delay time and a lesser level of service (LOS). Moreover, the specified area contains several erratic junctions in terms of traffic or designing engineering as well as incorrect drivers behavior. The situations of traffic should be putting in the considerations when studying and evaluating them using modern software. To find appropriate traffic and engineering solutions for efficient traffic flow.

3.3 Data Collection

The selected two signalized intersections represent the study area that is located within the urban area of the Hilla city; it appears surrounded by a large number of private, commercial shops, as well as governmental educational institutions. According to the field survey, investigations have been done in various times of a day for the signalized intersections within study area to reach the most significant time for collection data in order to identify peak hour period. The peak hour for the pedestrians and vehicles were found to be at the morning with the aided of field survey and asking of police staffs that are in the study area, so the peak flow period occurs between (7:45-8:45) A.M.

So each traffic data for each approaches was recorded by using video camera method with aided of resident engineer department for the cameras project, during three weekdays (Monday, Tuesday and Wednesday) in order to collect pedestrians flow and average speed rather for vehicles.

Information from these investigations listed in Figures and Tables, which were assembled into (15 Minutes) intervals.

Data collection was done during the winter 2021, specifically in November. Manual count method has been used also in order to investigate pedestrian’s average speed, using stopwatch and counters. The percentage of elderly (persons whom more than 65 years old) are conducted too, for each intersections approaches in order to meet average speed of pedestrians according to AASHTO standard specification.

3.4 Study Area

The study chose two signalized intersections, which they have a significant impact pedestrians movement, crossing and activities. As pedestrians at these intersections face many challenges that threaten safety, convenience and efficiency factors. Which leads to a reduced level of service for pedestrians and vehicles alike, within the approaches of the intersection studied. The two signalized intersection that have been studied are :

- Bab Al-Hussein
- Al-Jamiaa-40 street

The form of traffic control, code and name listed in Table (3.1)

Table (3.1) the Selected Signalized Intersections of the Study Areas

Intersection code	Intersection name	Control type
1	Bab Al-Hussein	Signalized intersection
2	Al-Jamiaa-40 Street	Signalized intersection

3.3.1 Bab Al-Hussein Intersection

It is signalized intersection with three phases, the southern approach (SB) of the intersection leads to 40-street, and the approach of it (WB), led western to Al-Tayarah area, while the eastern approach (EB) leads to the city center, the intersection is characterized by the fact that it transfer traffic volume for pedestrians and vehicles, while traffic congestion represents a major challenge, especially during peak hour volume. One of its disadvantages its insufficient time for pedestrians to cross through intersection approaches.

The geometric features of Bab Al-Hussian signalized intersection listed in Table (3.2)

Table (3.2) Geometric Features for Bab Al-Hussian Intersection

Nodes	Approaches	Approaches width (m)	Number of lanes
Bab Al-hussin	SB	12.4	4
	WB	15	4
	EB	13	4

3.3.2 Al-Jamiaa-40 Street Intersection

It is signalized intersection with four phases, the northern approach (NB) of the intersection leads to 40-street, and the western approach (WB)leads to Al-Jamiaa area, while the eastern approach (EB) leads to Al-Thmaziaa, and the approach of it (SB), led southern to Al-Zeraa area, this intersection transfers traffic volume for pedestrians and vehicles, as traffic congestion increases during peak hours.

The geometric features of Al-Jamiaa-40 Street signalized intersection listed in Table (3.3)

Table (3.3) Geometric Features for Al-Jamiaa-40 Street Intersection

Nodes	Approaches	Approaches width (m)	Number of lanes
AL-jamiaa- 40 street	NB	11	3
	SB	11	3
	WB	10	3
	EB	12.3	3

Figures (3.2), (3.3) shows the layout of the Bab Al-Hussian intersection, and Al-Jamiaa-40 Street Intersection

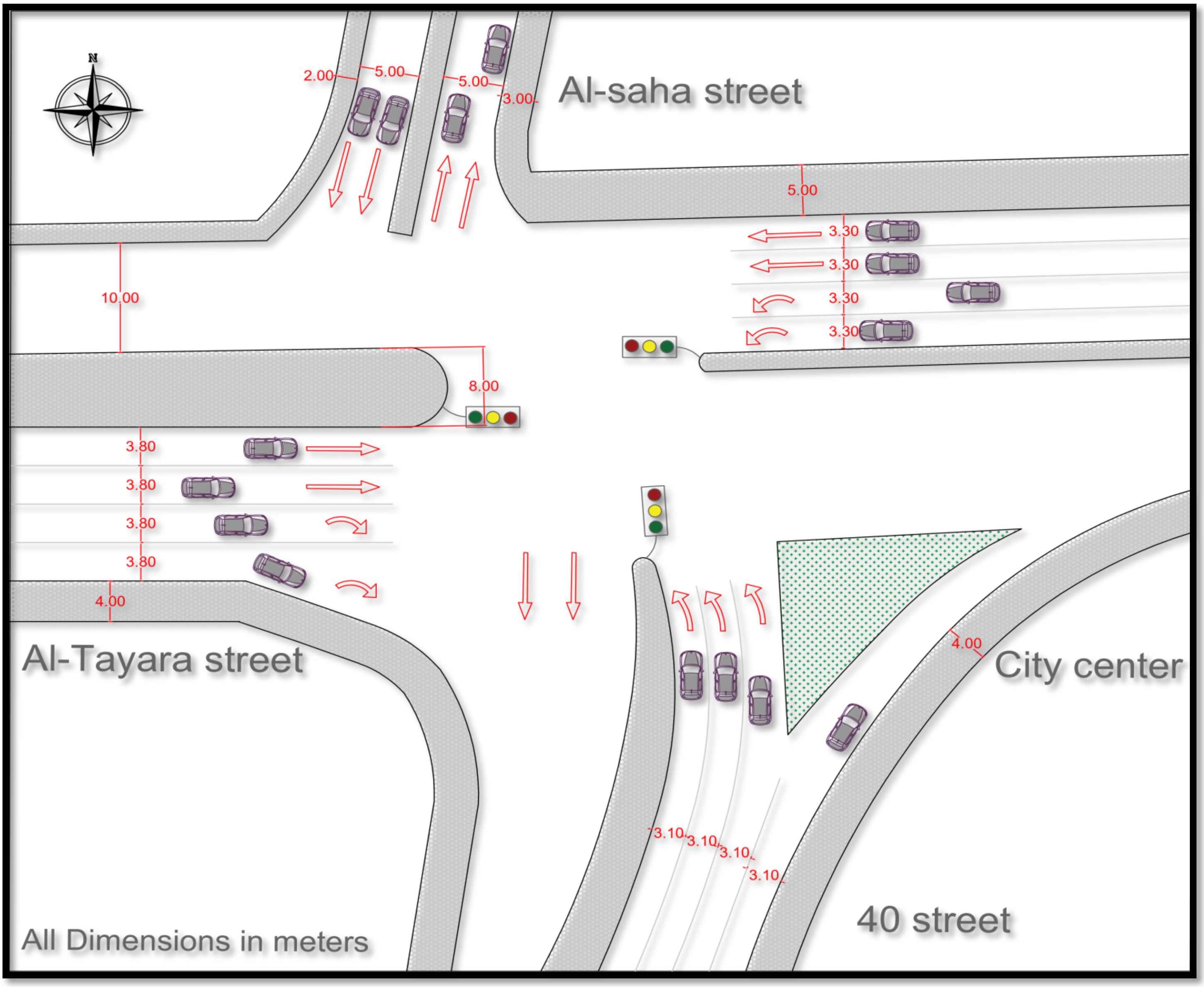


Figure (3. 6) bab Al-Hussuin intersection layout

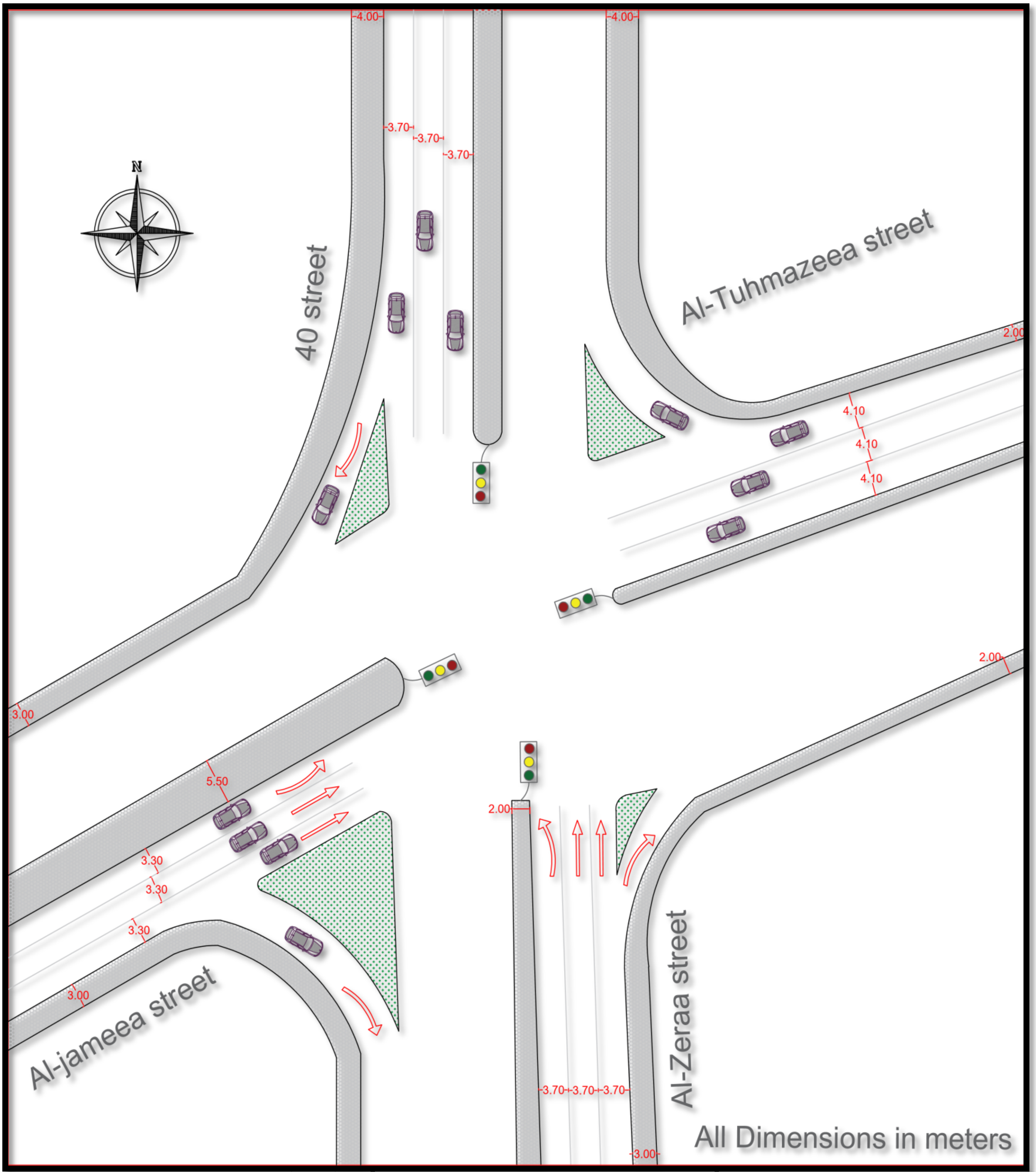


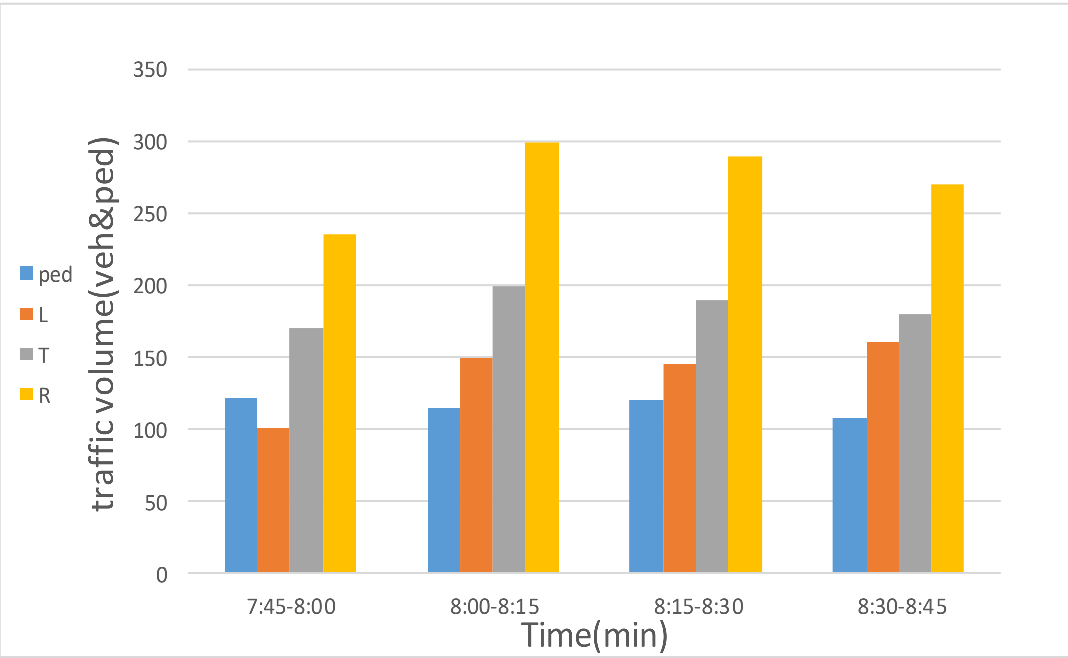
Figure (3. 7) Al-jamiaa-40 street intersection layout

The following table describe the pedestrian traffic volume in Bab AL-Hussien intersection /SB.

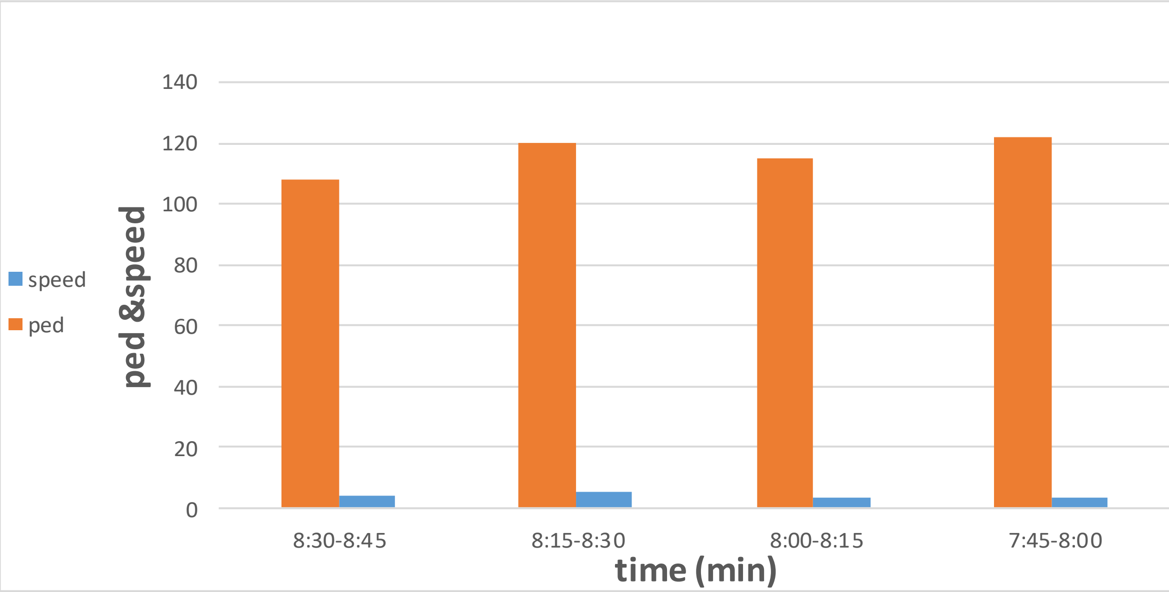
Table (3.4):Variation of Traffic Flow for Pedestrian and Vehicle

Time	No. of Vehicle (pc/15min)			Pedestrian movement		
	L	T	R	ped	Elderly %	Speed (ft/sec)
7:45-8:00	101	170	263	112	20	3.28
8:00-8:15	150	200	300	115	19	3.44
8:15-8:30	145	190	290	120	15	5.1
8:30-8:45	160	180	270	108	16	4.2

*ped = pedestrian



Figure(3.4) Traffic Volumes at Bab-Al Hussian

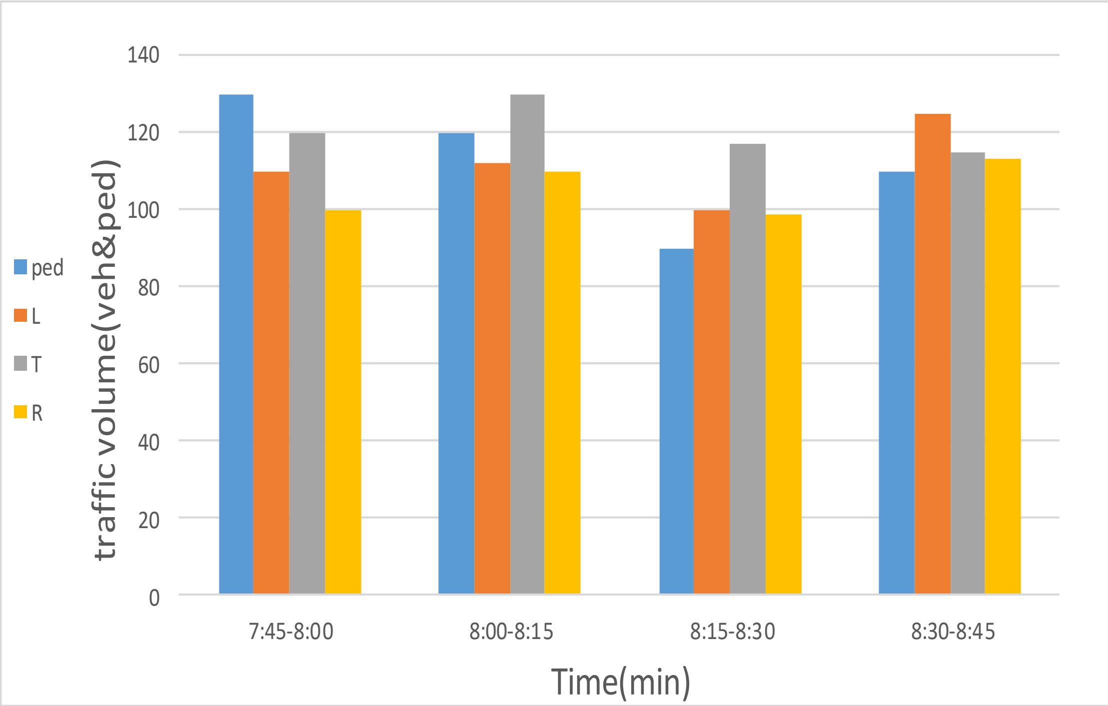


Figure(3.5) ped&speed at Bab Al-Hussian

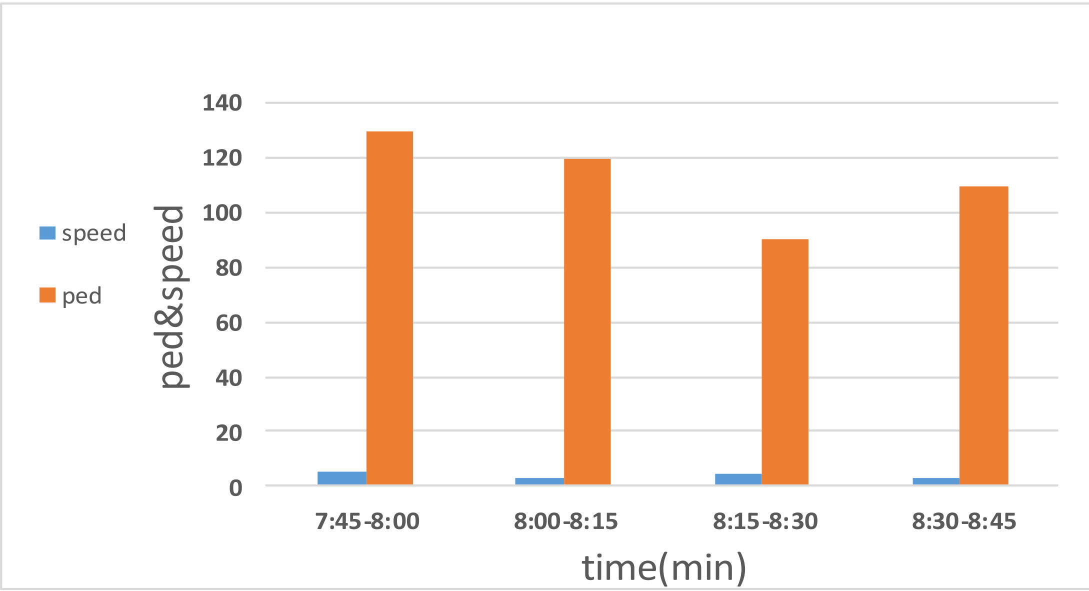
The following table describe the pedestrian traffic volume in Bab AL-Hussian intersection /EB.

Table (3.5)Variation of Traffic Flow for Pedestrians and Vehicles

Time	No. of Vehicle (pc/15min)			Pedestrian movement		
	L	T	R	ped	Elderly %	Speed (ft/sec)
7:45-8:00	110	120	100	130	25	5.3
8:00-8:15	112	130	110	120	18	3.1
8:15-8:30	100	117	99	90	22	4.7
8:30-8:45	125	115	113	110	12	2.9



Figure(3.6) Traffic Volumes at Bab-Al Hussian

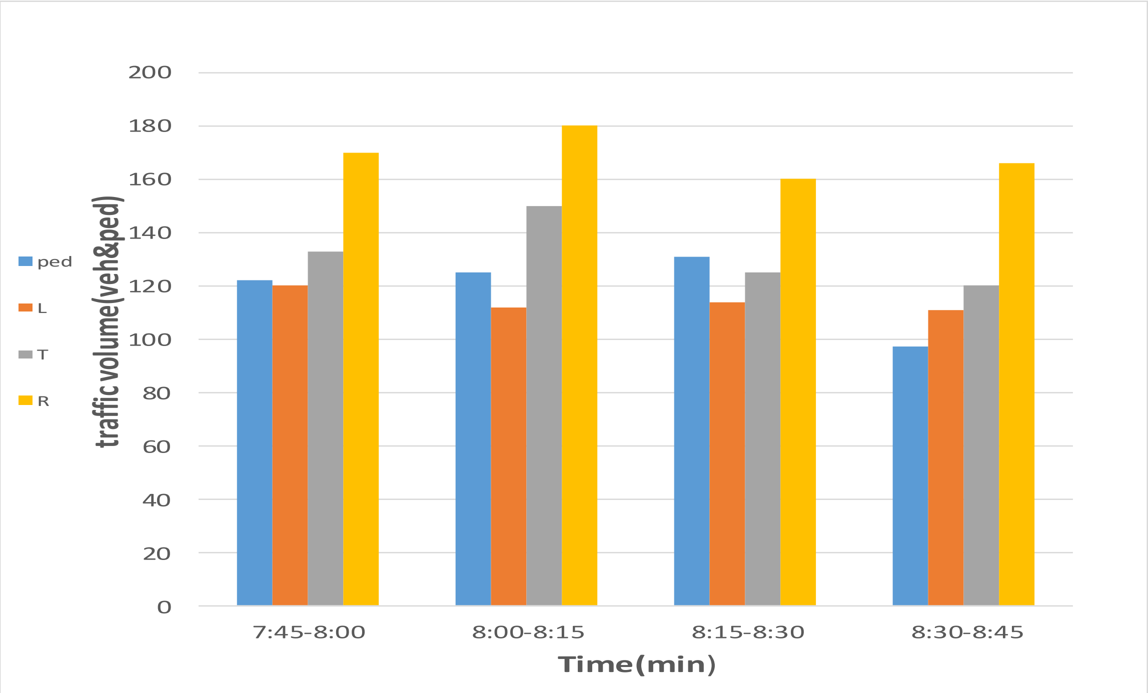


Figure(3.7) ped&speed at Bab Al-Hussian

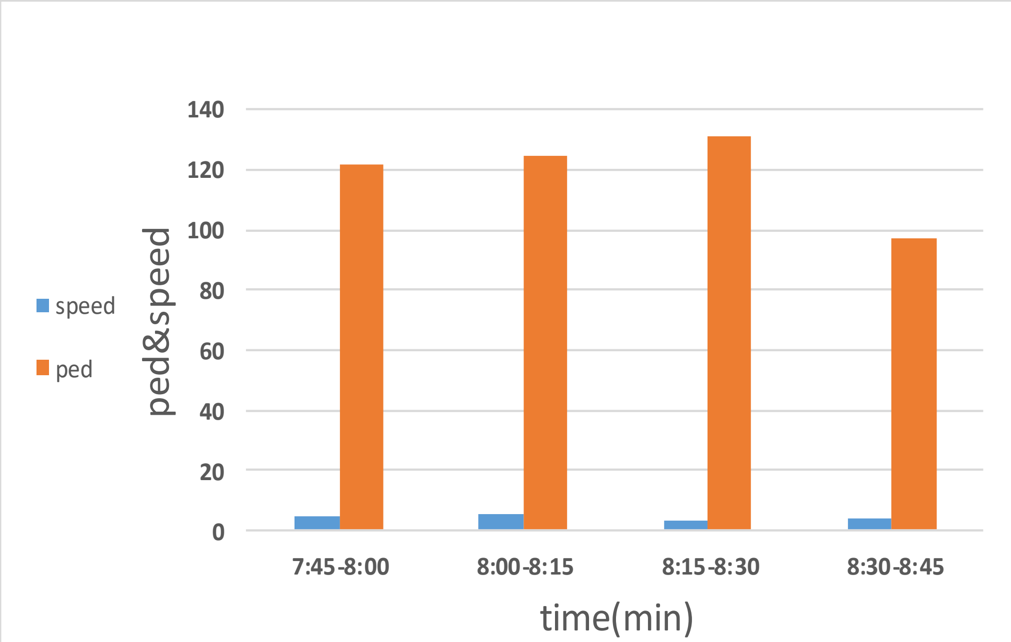
The following table describe the pedestrian traffic volume in bab AL-Hussien intersection /WB

Table (3.6):Variation of Traffic Flow for Pedestrians and Vehicles

Time	No. of Vehicle (pc/15min)			Pedestrian movement		
	L	T	R	ped	Elderly %	Speed (ft/sec)
7:45-8:00	120	133	170	122	18	4.5
8:00-8:15	112	150	180	125	15	5.3
8:15-8:30	114	125	160	131	20	3.3
8:30-8:45	111	120	166	97	23	4.2



figure(3.8) traffic volumes at bab-al hussin



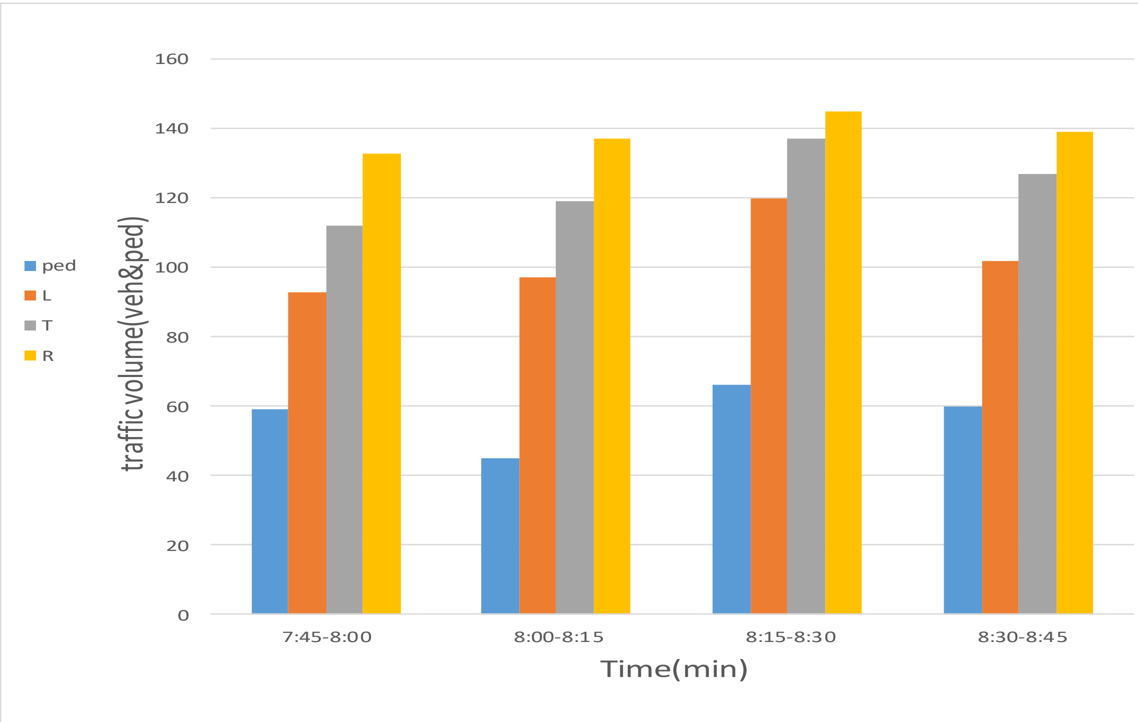
Figure(3.9) ped&speed at Bab Al-Hussian

From Bab Al-Hussian signalized intersection according to the Tables shown (3.4), (3.5), (3.6) it was found that the 15min peak between [8:00-8:15 and 8:15-8:30] while the traffic flow for pedestrian disturbed, Figures (3.4), (3.6), (3.8) describe the relationship between traffic volumes of vehicles and pedestrians flow within study area with time, all Figures show conflicts point between vehicles and pedestrians according to peak hour volume especially at (8:00-8:15) peak 15 min.

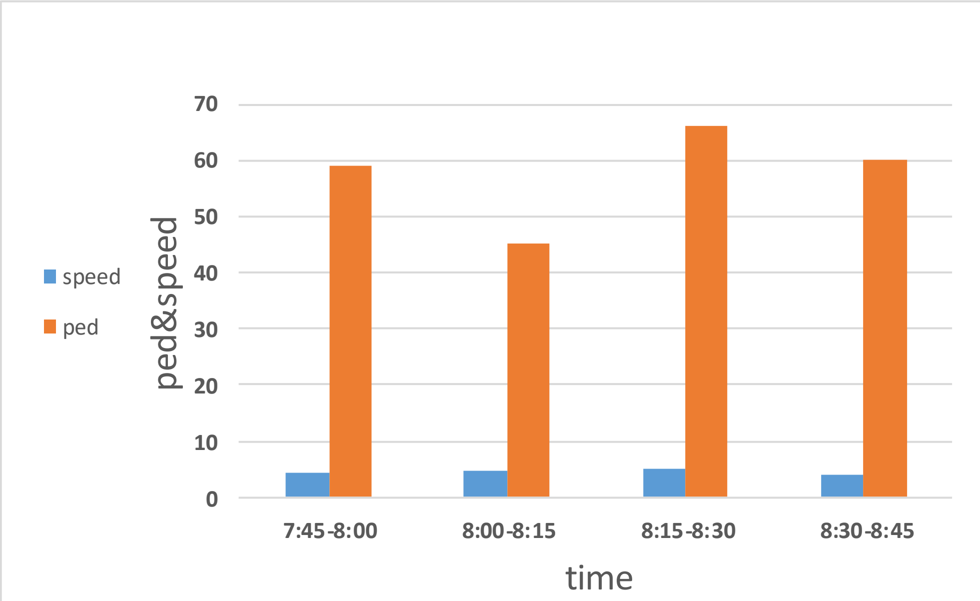
The following table describe the pedestrian traffic volume in Al-Jamiaa-40 Street intersection /NB

Table (3.7):Variation of Traffic Flow for Pedestrians and Vehicles

Time	No. of Vehicle (pc/15min)			Pedestrian movement		
	L	T	R	ped	Elderly %	Speed (ft/sec)
7:45-8:00	93	112	133	59	22	4.3
8:00-8:15	97	119	137	45	17	4.7
8:15-8:30	120	137	145	66	19	5.1
8:30-8:45	102	127	139	60	21	3.9



Figure(3.10) Traffic Volumes at Al-Jamiaa-40 Street

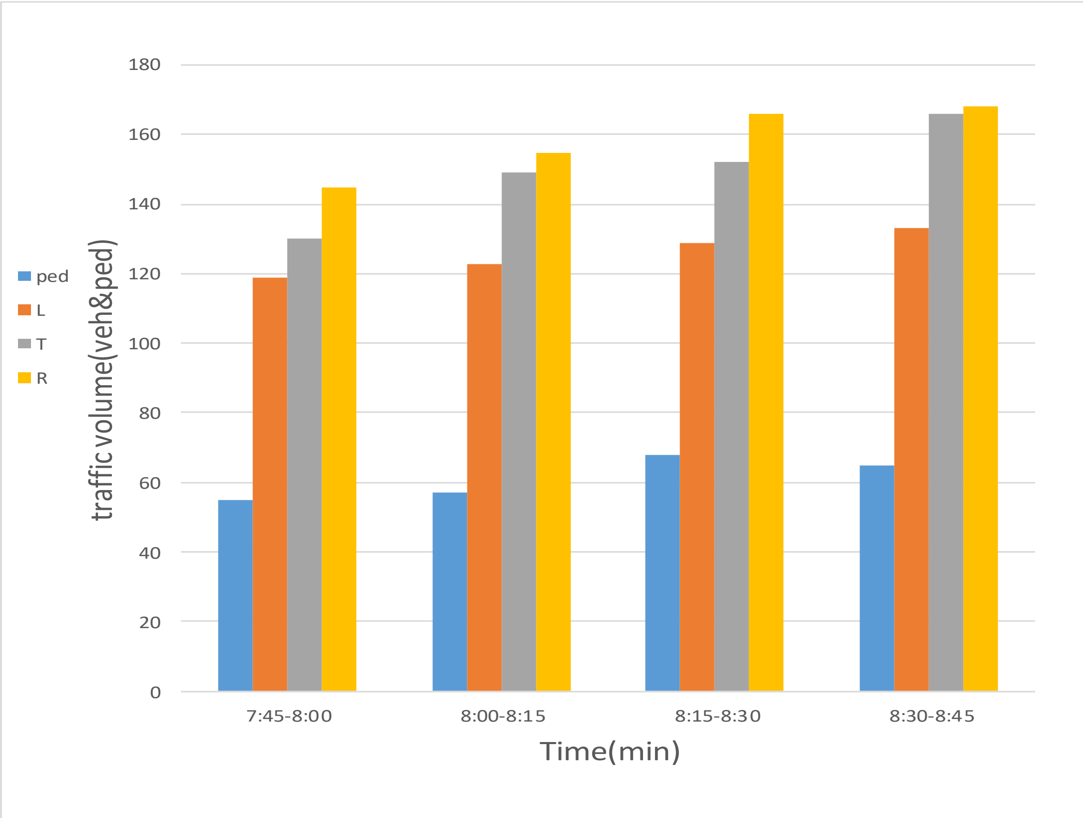


Figure(3.11) ped&speed at Al-Jamiaa-40 Street

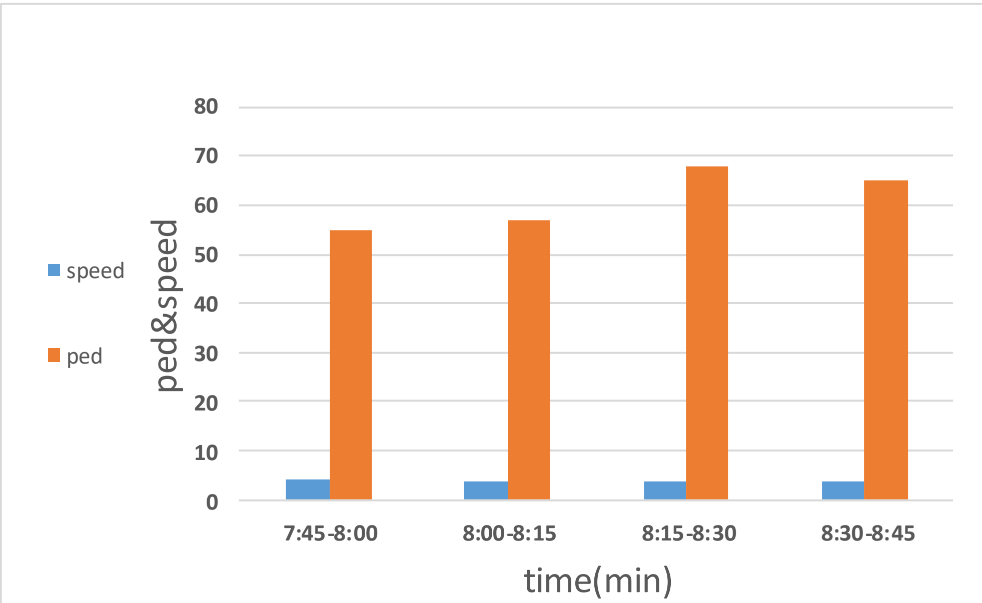
The following Table describe the pedestrian traffic volume in Al-Jamiaa-40Street intersection /SB

Table (3.8):Variation of Traffic Flow for Pedestrians and Vehicles

Time	No.of vehicle (p15min)			Pedestrian movement		
	L	T	R	ped	Elderly %	Speed (ft/sec)
7:45-8:00	119	130	145	55	15	4.1
8:00-8:15	123	149	155	57	19	3.8
8:15-8:30	129	152	166	68	24	3.6
8:30-8:45	133	166	168	65	16	3.9



Figure(3.12) Traffic Volumes at Al-Jamiaa-40 Street

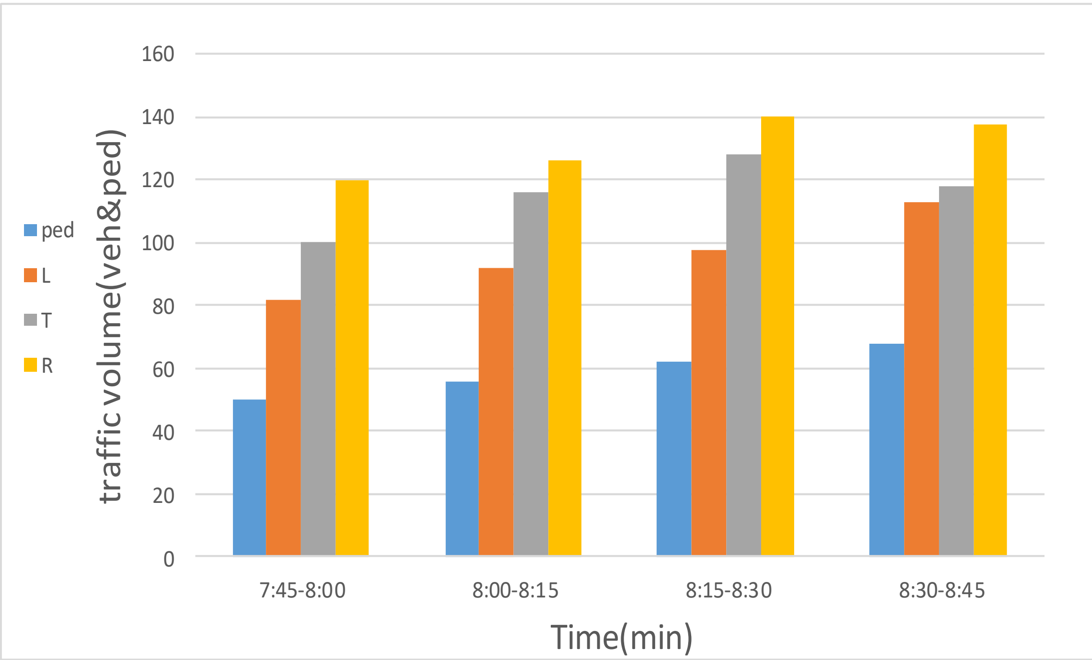


Figure(3.13) ped&speed at Al-Jamiaa-40 Street

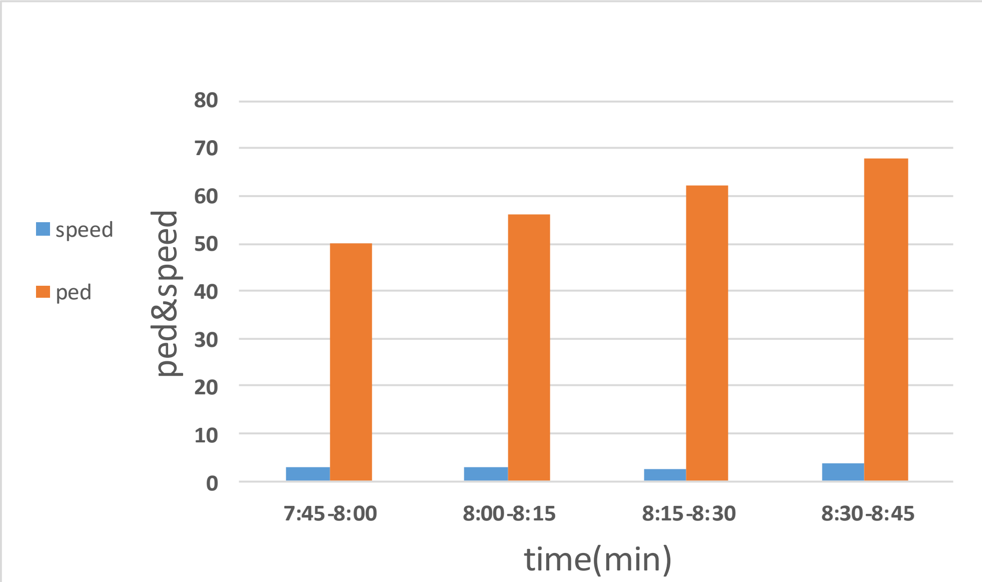
The following Table describe the pedestrian traffic volume in Al-Jamiaa-40 Street intersection /EB

Table (3.9):Variation of Traffic Flow for Pedestrians and Vehicles

Time	No. of vehicle (pc/15min)			Pedestrian movement		
	L	T	R	ped	Elderly %	Speed (ft/sec)
7:45-8:00	82	100	120	50	22	3.1
8:00-8:15	92	116	126	56	16	2.9
8:15-8:30	98	128	140	62	17	2.7
8:30-8:45	113	118	138	68	20	3.8



Figure(3.14) Traffic Volumes at Al-Jamiaa-40 Street

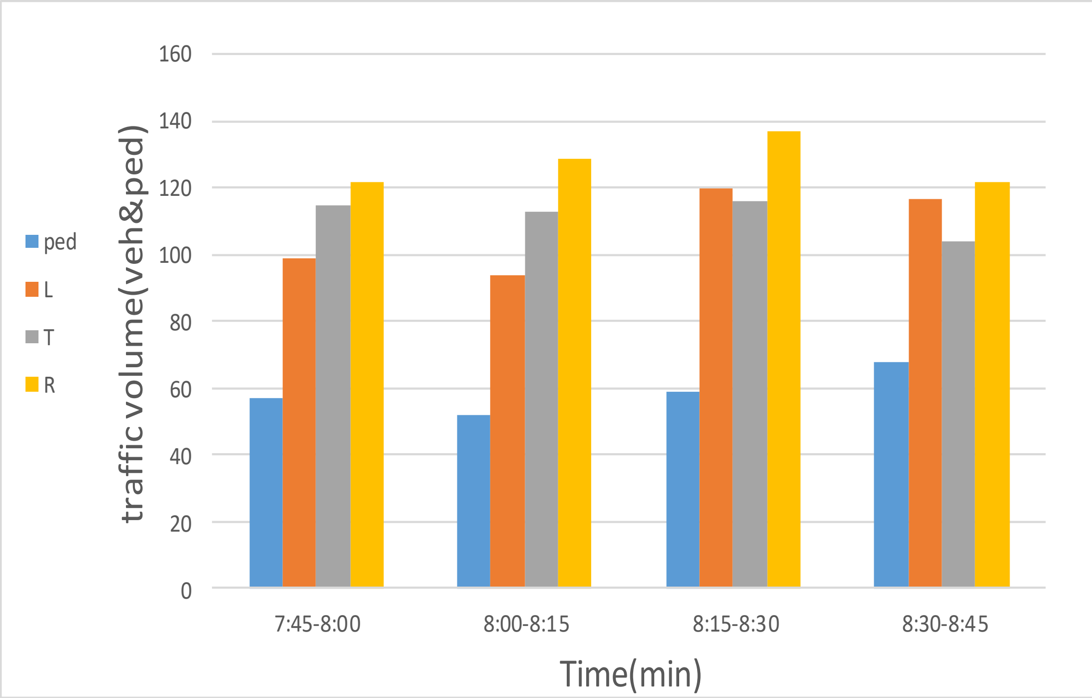


Figure(3.15) ped&speed at Al-Jamiaa-40 Street

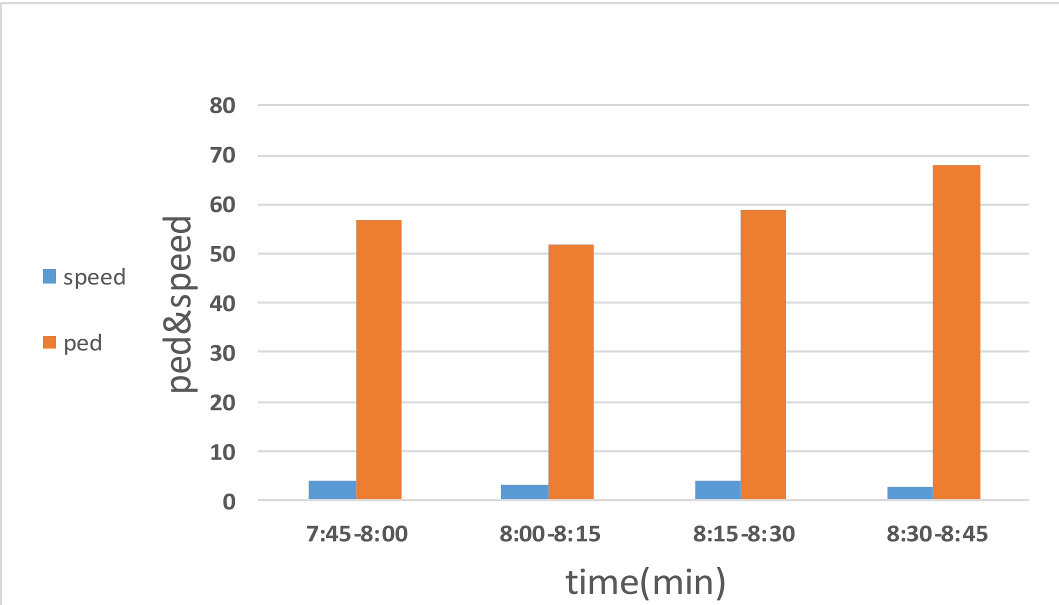
The following Table describe the pedestrian traffic volume in Al-Jamiaa-40 Street intersection /WB

Table (3.10):Variation of Traffic Flow for Pedestrians and Vehicles

Time	No. of vehicle (pc/15min)			Pedestrian movement		
	L	T	R	ped	Elderly %	Speed (ft/sec)
7:45-8:00	99	115	122	57	13	3.7
8:00-8:15	94	113	129	52	19	3.2
8:15-8:30	120	116	137	59	25	3.9
8:30-8:45	117	104	122	68	18	2.5



Figure(3.16) Traffic Volumes at Al-Jamiaa-40 Street



Figure(3.17) ped&speed at Al-Jamiaa-40 Street

From Al-Jamiaa-40 Street signalized intersection according to the Tables shown (3.7), (3.8), (3.9) and (3.10) it was found that the 15min peak between [8:15-8:30 and 8:30-8:45] while the traffic flow for pedestrian disturbed, Figures (3.10), (3.12), (3.14), and (3.16) describe the relationship between traffic volumes of vehicles and pedestrians flow within study area with time, all Figures show conflicts point between vehicles and pedestrians according to peak hour volume especially at (8:15-8:30) peak 15 min.

The elderly is shown through the Tables (3.4), (3.5), (3.6), (3.7), (3.8), (3.9), and these percentages were obtained through a questionnaire form that includes details about the pedestrian, their age and gender, in addition to asking them about design matters related to the pedestrian. According to the questionnaire form shown in appendix A

3.5 Sample Size

The sample size that must be interviewed is determined by the entire population of the study region. And the criteria set out by the United States Public Roads were provided in Table (3.11). The Hilla Statistics Directorate was used to ensure the correctness according to the Table (3.12). From Bab Al-Hussian intersection a sample size of 700 household was established, while Al-Jamiaa-40 Street a sample size of 650.

The equations and details indicate the size of the sample surveyed, and this is useful in future studies when conducting Al-Hilla Transportation Comprehensive Study. However, the study extracted the sample from the data collection site in the two intersections, where more than 100 samples were determined for each intersection within the study area according to field survey with the aided of resident engineer department for camera project.

Table (3.11) : Standards for Determining Specimen Size

Population of study area	**Specimen size (dwelling units)**	
	Recommended	**Min**
Less than 50×10^3	1/5(20 percent)	1/10(10 percent)
50×10^3 - 150×10^3	1/8(12 percent)	1/20(5 percent)
150×10^3 - 300×10^3	1/10(10 percent)	1/35(2.86 percent)
300×10^3 - 500×10^3	1/15(6.67 percent)	1/50(2 percent)
500×10^3 - 1000×10^3	1/20(5 percent)	1/70(1.43 percent)
Higher than 1000×10^3	1/25(4 percent)	1/100(1 percent)

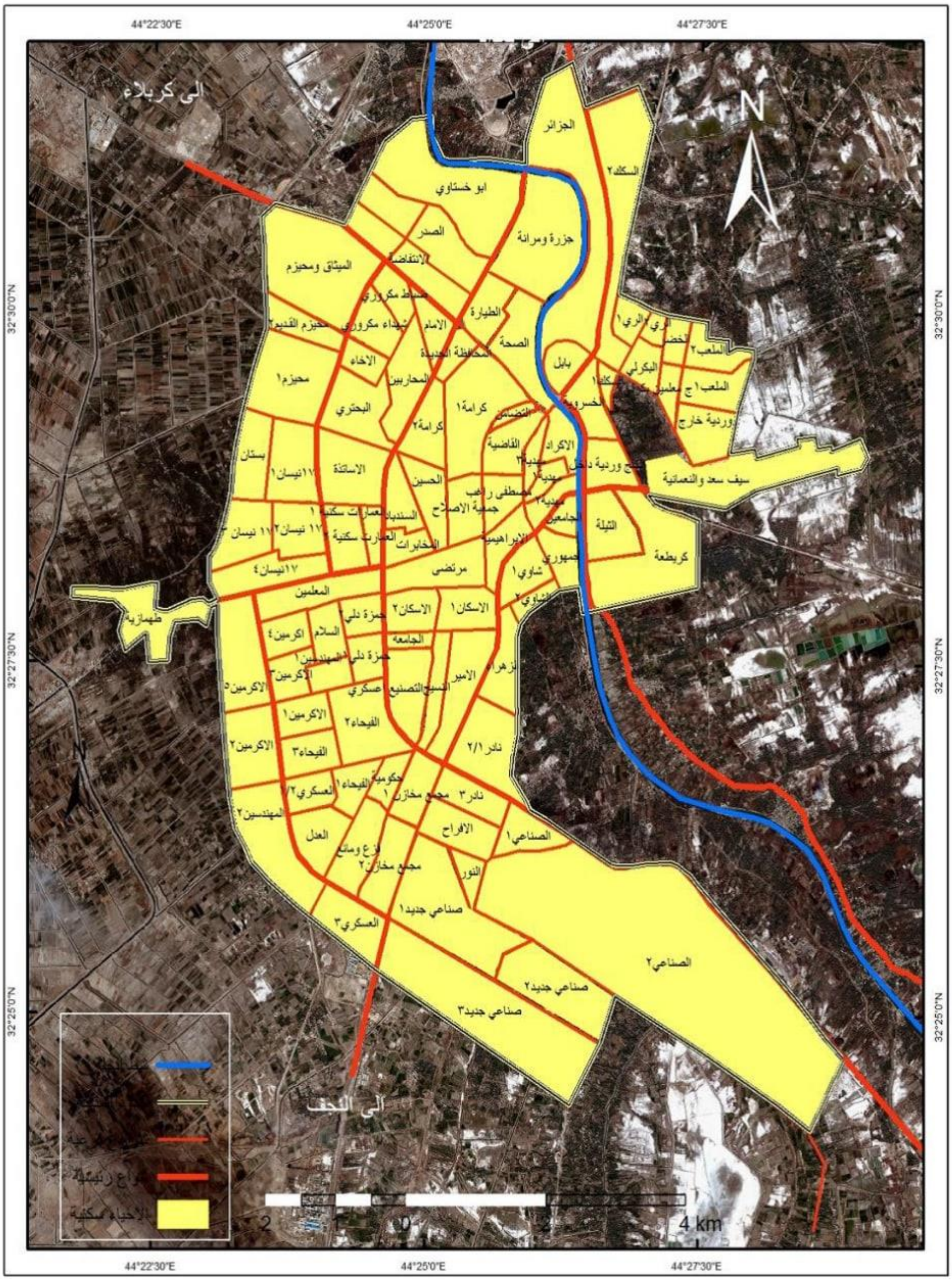


Figure (3.18) Zones of Hilla City (by the researcher with the cooperation of the Municipality Director of Hilla City)

Table (3.12):Population from the Babil statistics directorate, and land uses (District)

Study Area	Zone	Zone name	District No	Population 2018
Bab Al-Hussian	1	Al-akraad	208	4972
	2	babel	101	1952
	3	Al- saha	410	5322
	4	Al-tyara	412	1822
Al-Jamiaa-40 Street	5	Al -qadiaa	216	3300
	6	Mustafa ragaib	214	1400
	7	Al-hussin	403	3748
	8	Al-ebrahemya	212	2516
	9	Al-murtda	614	1500

Chapter Four

COLLECTION AND ANALYSIS OF DATA

4.1 General

This chapter analyze the data which were collected from field survey, that used to evaluate intersection efficiency by determine the service's level (LOS) of pedestrians in intersections with traffic signs, depending on highway capacity manual (HCM 2010) method. Delay and time-space are computed for pedestrians according to field survey in the selected area. To increase safety and clearance time for pedestrian and vehicle redesign yellow interval within each signalized intersections within study area. HCM provide LOS criteria for pedestrian and mean LOS flow standards for sidewalks to crossing signalized intersections as shown :

Table(4-1) LOS standards For Pedestrians at Intersections with traffic signs **(HCM;2010)**

LOS	Delaying of Pedestrian (s/p)	Noncompliance Probability
A	Less than 10	Low
B	Greater than or equal 10-20	
C	Greater than 20-30	Moderate
D	Greater than 30-40	
E	Greater than 40-50	Great
F	Greater than 60	Very great

Table (4.2) Mean LOS Flow Standards For Walkway and Sidewalk **(HCM2010)**

LOS	Spacing (ft/p)	Rating of Flow (p/min/ft)	Speeding (ft/s)	v/c Proportion
A	Greater than 60	Less than or equal 5	Greater than 4.25	Less than or equal 0.21
B	Greater than 40-60	Greater than 5-7	Greater than 4.17-4.25	Greater than 0.21-0.31
C	Greater than 24-40	Greater than 7-10	Greater than 4-4.17	Greater than 0.31-0.44
D	Greater than 15-24	Greater than 10-15	Greater than 3.75-4	Greater than 0.44-0.55
E	Greater than 8-15	Greater than 15-23	Greater than 2.5-3.75	Greater than 0.55-1
F	Less than or equal 8	Variable	Less than or equal 2.5	Variable

4.2 Major Parameter for Evaluating Signalized Intersection Operations

The following are the parameters to evaluating the operation of intersections:

4.2.1 Cycle length

The length of cycle seems to be the period that expires from the beginning of the green indicator to the conclusion of the red indicator in seconds for one full color cycle of signal indicator **(Miller, Bigelow,Garber;2019)**

$$C_o = \frac{1.5L + 5}{1 - \sum Y_i} \dots\dots\dots\dots\dots Eq(4-1)$$

C_o = optimal period of cycle (sec)

L= totally lost time/cycle (sec)

Y_i = optimal magnitude of the proportions of flows of approach/flows of saturation for entirely lane sets

Table (4- 3) Peak Hour and Flow Characteristics for Bab Al-Hussian Signalized Intersection.

	Hourly volume	Flow rate	PHF
SB	2419	4×650=2600	2419÷2600=0.93
EB	1331	4×353=1412	2419÷1412=0.94
WB	1661	4×442=1768	2419÷1768=0.94

For SB/

Left / DHV= $\frac{556}{PHV} = \frac{556}{0.93}$ = 597 veh /h /ln

Through / DHV= $\frac{440}{PHV} = \frac{440}{0.93}$ = 473 veh /h /ln

Right / DHV= $\frac{523}{PHV} = \frac{523}{0.93}$ = 562 veh /h /ln

For EB/

Left / DHV= $\frac{447}{PHV} = \frac{447}{0.94}$ =475 veh /h /ln

Through / DHV = $\frac{482}{0.94}$ = 512 veh /h /ln

Right / DHV = $\frac{422}{0.94}$ = 448 veh /h /ln

For WB/

Left / DHV= $\frac{457}{PHV} = \frac{457}{0.94}$ = 486 veh /h /ln

Through / DHV = $\frac{528}{0.94}$ = 561 veh /h /ln

Right / DHV = $\frac{576}{0.94}$ = 612 veh /h /ln

Table (4-4) Variation of Traffic and Saturation Flow for Bab Al-Hussian Signalized Intersection

	(SB)			**EB**			**WB**		
Lanes	L	T	R	L	T	R	L	T	R
V_i	**597**	**437**	**562**	**475**	**512**	**448**	**486**	**561**	**612**
S_i	**1900**	**1900**	**1900**	**1900**	**1900**	**1900**	**1900**	**1900**	**1900**
V_i/S_i	**0.3**	**0.23**	**0.29**	**0.25**	**0.27**	**0.23**	**0.25**	**0.29**	**0.32**
Y_i	**0.3**			**0.27**			**0.32**		

$Y_i = \sum 0.3 + 0.27 + 0.32 = 0.89$

$C_o = \frac{1.5*3*4+5}{1-0.89}$ = 209 sec

Table (4- 5) Peak Hour and Flow Characteristics for Al-Jamiaa-40Street Signalized Intersection.

	Hourly volume	Flow rate	PHF
NB	1735	4×460=1840	1735÷1840=0.94
SB	1441	4×380=1520	1441÷1520=0.95
EB	1371	4×369=1476	1371÷1476=0.93
WB	1388	4×360=1440	1388÷1440=0.96

Table (4- 6) Variation of Traffic and Saturation Flow for Al-Jamiaa-40Street Signalized Intersection

	(NB)			SB			EB			WB		
Lanes	L	T	R	L	T	R	L	T	R	L	T	R
V_i	**429**	**458**	**461**	**447**	**415**	**321**	**387**	**386**	**346**	**447**	**466**	**322**
S_i	**1900**	**1900**	**1900**	**1900**	**1900**	**1900**	**1900**	**1900**	**1900**	**1900**	**1900**	**1900**
V_i/S_i	**0.2**	**0.24**	**0.21**	**0.23**	**0.21**	**0.16**	**0.2**	**0.2**	**0.18**	**0.23**	**0.24**	**0.16**
Y_i	**0.24**			**0.23**			**0.2**			**0.24**		

* V_i = Traffic flow , S_i = Saturation flow

$Y_i = \sum 0.24 + 0.23 + 0.2 + 0.24 = 0.91$

$C_o = \frac{1.5*3+5}{1-0.91}$ = 255 sec

From calculations and analysis it was found that the cycle length for Bab Al-Hussian equal to (209) sec and Al-Jamiaa-40Street (255) sec, while the optimum cycle time not more than 120 sec as recommended. This condition indicate increases in level of service due to high traffic volume pass through intersections approaches. So the intersection needed to minimize and process to improve traffic facilities as well as it gives bad effects on pedestrians movement and crossing.

4.2.2 delay approach

$dj = (CA + \frac{B}{Vj})\frac{100-P}{100}$................. Eq (4-2)

d_j = mean delaying/vehicle j_{th} approaches throughout i_{th} phase.

$A = \frac{(1-ג\ )2}{2(1-\ ג*x\ )}$

$B = \frac{xj}{2(1-xj)}$

C = period of Cycle (sec.).

V_j(vehicles.lanes^{-1}.sec^{-1}) = actually Volume in j_{th} approaches.

ג = ratio of period of Cycle which was green effectively

(G_{ei} /C_0) , whereas, G_{ei} operational green period for part j .

x_j = saturating degree for the j_{th} approaches= V_j/ s .

s_j (vehicles.lanes^{-1}.sec^{-1})= saturated flowing for the j_{th} approaches

P = correction percent ranges from (5-15%) for normal condition.

-Determine; גi, xi for bab Al-Hussin / SB

$g_A = \frac{Yi}{Y} * ge = \frac{0.3}{0.89} \times 92 = 31\ sec$

ג $= \frac{g}{c} = \frac{31}{209} = 0.15$

$x = \frac{v}{\lambda * S} = \frac{0.17}{0.15*0.53} = 2.1$

$A = \frac{(1-0.15)^2}{2(1-0.15*2.1)} = 0.527$

$B = \frac{2.1}{2(1-2.1)} = -4$

d_j= 86.8 sec /veh

Table (4-7) Evaluation of Delay Time for Each Approach within Bab Al-Hussian and Al-Jamiaa-40 Street Signalized Intersections

Study Area		Delay Approach (sec/veh)
Bab Al-Hussin	SB	86.8
	EB	89.9
	WB	84.2
AL-Jamiaa-40 Street	NB	115
	SB	115.2
	EB	115
	WB	115.3

4.3 Parameter to Determined pedestrians operations

The following parameter must be determined in order to estimate level of service for pedestrians movement and crossing for each intersection with traffic signs. Which they are studies **[HCM;2010] :**

- Delay
- Net – Time Space
- Cross Time
- Space

4.3.1 Delay

Delaying is defined as the difference between the travelling duration experienced and the duration of travelling reference that have been resulted in perfect situations.

The average delay d_p = average pedestrian delay (s)

per pedestrian is described by formula :

$$d_p = \frac{0.5(c-g)^2}{c} \text{ .... Eq (4-3)}$$

Where:

g (s)= operational green period (for pedestrian) c (s)= duration of cycle

LOS standards for pedestrians at intersections with traffic signs, depending on pedestrian delaying.

Calculation of pedestrian delay for Bab Al-Hussian and Al-Jamiaa-40 Street intersections with traffic signs:

Average pedestrian delay $d_p = \frac{0.5(209-92)^2}{209}$ =32.7 sec

Average pedestrian delay $d_p = \frac{0.5(255-95)^2}{255}$ =50 sec

The calculation of LOS for pedestrians shown in the Table (4.8) according to Table (4.1)

Table (4.8) LOS for Pedestrian at Signalized Intersections

Study area	Delay (sec)	LOS
Bab Al-Hussian	32.7	D
Al-Jamiaa-40 Street	50	E

4.3.2 Net Time -Space

Computed according to equation:

$Ts = LW_E\,[G-\frac{L}{2S}]$………… Eq (4-4)

Where:

Ts =duration-space (ft^2_s)

L = length of crosswalk (ft)

W_E =effective width of crosswalk (ft)

S = mean pedestrians speeding (ft/s)

G =green duration for phase

4.3.3 Cross Time

Total cross duration needed to clear an crossing intersection has been simulated depending on formula:

$t = 3.2 + \frac{L}{S} + \left[2.7\ \frac{N}{W}\right] \dots\dots\dots\dots. Eq\ (4-5)$ For W> 10ft

$t = 3.2 + \frac{L}{S} + [0.27\ \times N] \dots\dots\dots\dots. Eq\ (4-6)$ For W≤ 10ft

Where:

t= totally cross duration (s)

L= length of crosswalk (ft) =65.6 ft

S= average speed of pedestrians (ft/s)

W = width of crosswalk (ft)

N= pedestrians number crossing throughout an interval

$$N = \frac{V(C-G)}{C} \dots\dots\dots\dots\dots\dots\dots. Eq(4-7)$$

V= pedestrian volume (p/15min)

4.3.4 Space

It has been identified by divided the duration-space obtainable for crossing by the totally occupancy duration, as in formula:

$$M = \frac{TS}{T} \dots\dots\dots\dots\dots\dots Eq(4-8)$$

M= circulation space (ft^2/p)

T= totally crosswalk use duration p-s

$T = (V_i\text{-}V_o)t$ ……………. $Eq(4-9)$

V_i(p/cycle)= pedestrian's inbound volume

V_o(p/cycle)= pedestrian's outbound volume

For Bab Al-Hussian intersection

TS=65.6×9.7(92-$\frac{65.6}{2\times5.1}$) =54449 ft^2_s

$N = \frac{120(209-92)}{209}$ =67 P\cycle

For W=9.7<10 ft

$t = 3.2 + \frac{65.6}{4.1} + [0.27 \times 67]$=34 s

T = (150+120) 34=9180 p-s

M= 54449/ 9180 =6 ft^2/p

The following Table(4.9) show calculation the LOS according to the Table (4.2)

Table (4.9) LOS for Pedestrian Sidewalk to Crossing Signalized Intersections

Study area	M (ft^2/p)	LOS
Bab AL-Hussian	6	F
Al-Jamiaa-40 Street	13	E

4.4 Improvement of intersections

Redesign for signalized intersection approach by marking and singing intersection crossing area according to specific classification standard as will as provide the intersection with suitable lighting within study area as show in Figures (4-1), (4-2)

It was suggested also redesign the yellow interval for each intersection in order to increase safety for pedestrians crossing increase intersection efficiency by providing clearance time for pedestrians and vehicles .

Yellow time alarm for coming red, redesign amber time useful in signalized intersections to avoid dilemma zone for driver to pass the intersection safely without hesitate.

Redesign yellow time show in equation :

$$\tau_{min} = \delta + \frac{W+L}{u_o} + \frac{u_o}{2(a+Gg)} \text{............ Eq (4-10)}$$

Whereas:

δ = reactions duration of Perception (sec)

W = intersection's width (ft)

L = vehicle's length (ft)

u_o = speeds limitation on line (ft/sec)

a = constant's braking deceleration rate (ft / sec^2)

G = approaches grade

g= accelerations resulting from gravity (32.2 ft/sec^2)

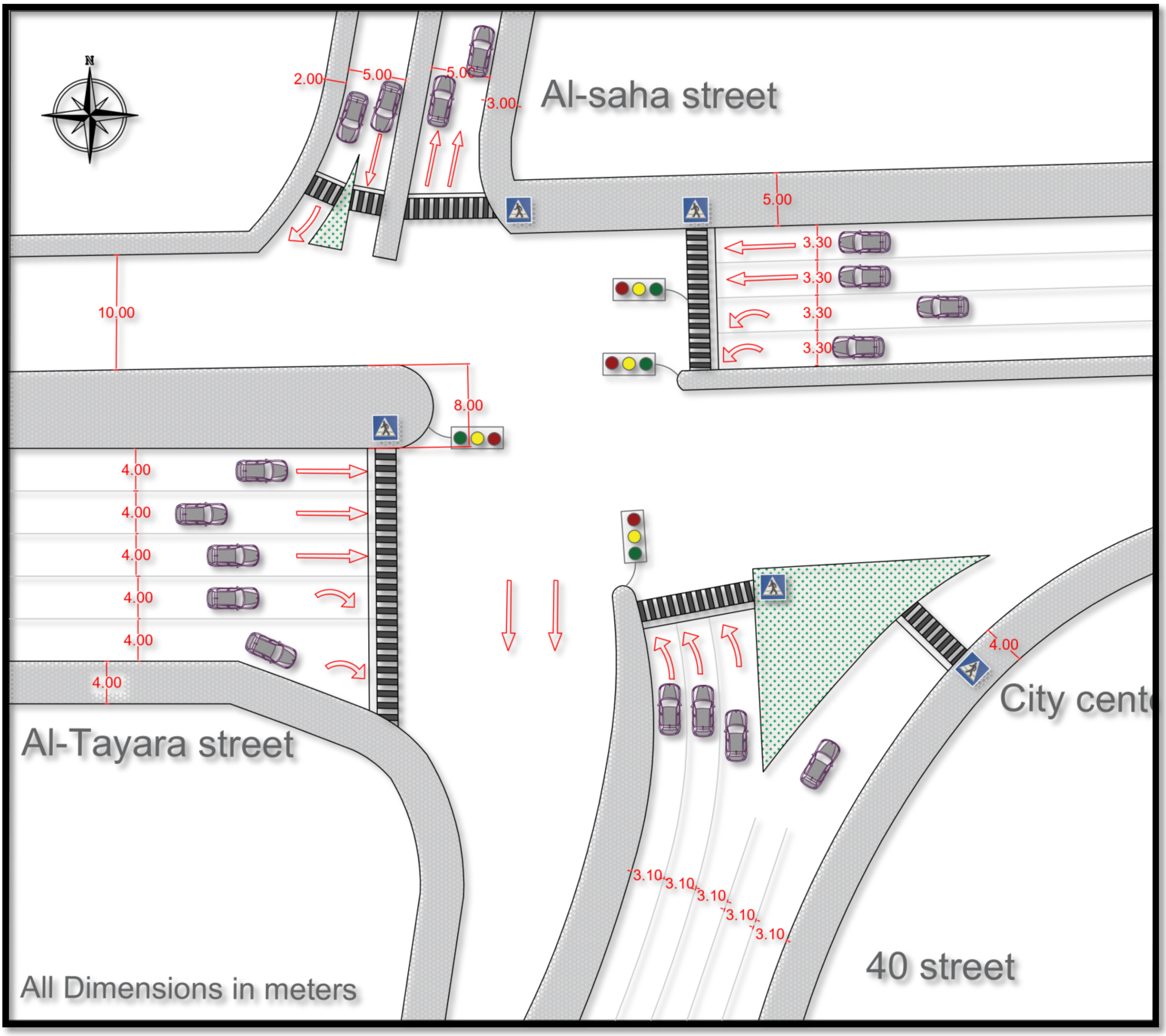


Figure (4.1) improvement proposal for Bab Al-Hussin intersection

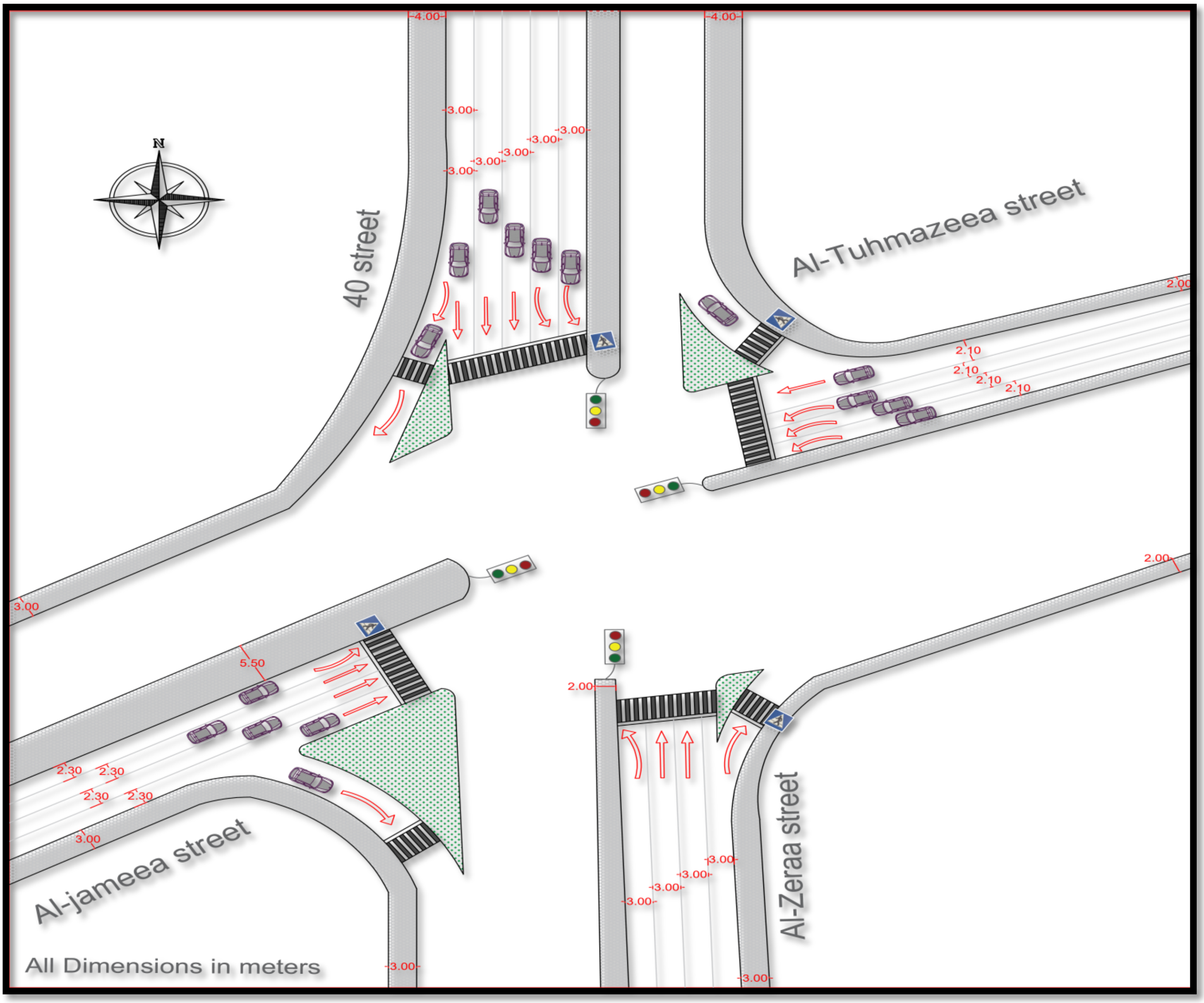


Figure (4.2) Improvement Proposal for Al-Jamiaa-40 street Intersection

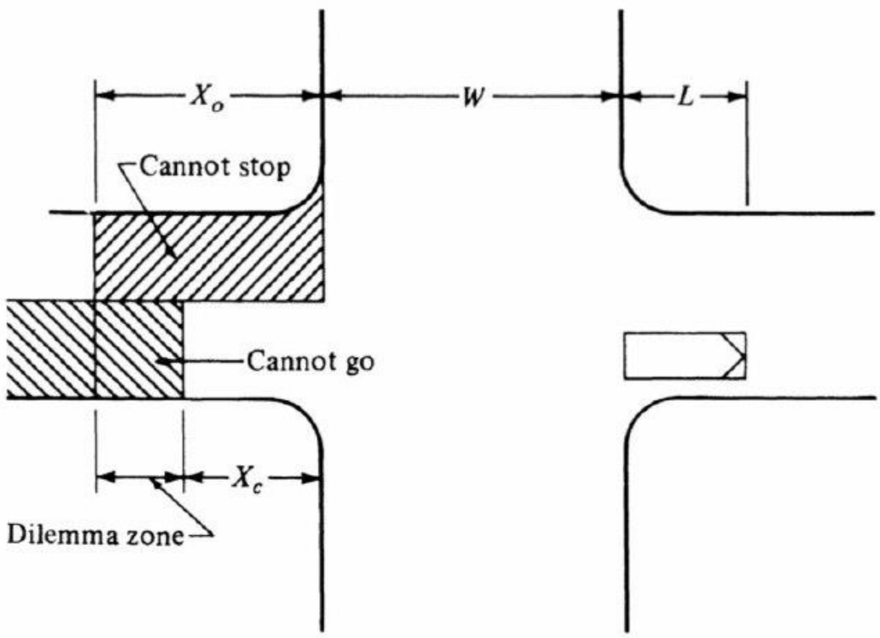


Figure (4.3) Diagram of a Dilemma area at Intersections **(Garber;2019)**

Table(4- 10) Geometric Features for the Selected Intersection

Nodes	Approaches	Approaches width (ft)
Bab Al-Hussian	SB	40.7
	EB	42.7
	WB	49.2
Al –Jamiaa-40 Street	NB	36.1
	SB	36.1
	EB	40.4
	WB	32.8

Minimum yellow interval at Bab Al-Hussin intersection / SB

$$\tau = 1 + \frac{40.7+12}{30*1.47} + \frac{30*1.47}{2\times 11.2} = 4.2 \text{ sec}$$

Minimum yellow interval at Bab Al-Hussin intersection / EB

$$\tau = 1 + \frac{42.7+12}{30*1.47} + \frac{30*1.47}{2\times 11.2} = 4.2 \text{ sec}$$

Minimum yellow interval at Bab Al-Hussin intersection / WB

$$\tau = 1 + \frac{49.2+12}{30*1.47} + \frac{30*1.47}{2\times 11.2} = 4.4 \text{ sec}$$

The Level of Service LOS of the Bab Al-Hussian intersection was of type (D), and Al-Jamiaa-40 Street of type (E), but after process the yellow interval and making improvements, the level of service for each intersections improve as well as safety factors improve too.

Table (4.11) Yellow Interval at Signalized Intersections

Study Area	Approaches	Yellow Interval (sec)
Bab Al-Hussian	SB	4.2
	EB	4.2
	WB	4.4
Al –Jamiaa-40Street	NB	4
	SB	4
	EB	4.2
	WB	4

4.5 Improvement Summary

The study seek to improve the pedestrians crossing movement and safety with the following factors:

- Reorganizing the intersection and crossing areas by providing them with marking and signs.
- Due to the inefficiency of the intersections in terms of the yellow time and its influence on the effective green duration, the yellow time of the intersection has been redesigned through analysis and equations.
- Increasing the safety factors of the intersection by providing it with the necessary lighting that will increase the efficiency of the pedestrians movements in crossing and moving to the two sides of the road
- The study recommended the establishment of efficient and appropriate bridges, as well as that they work efficiently to store energy to provide safe crossing of the intersection approaches and to ensure that the activities of the pedestrians by do not conflict with the movement of the vehicle.

Chapter Five

Conclusions and Recommendations

5.1 conclusions

According to field survey for engineering and traffic facilities the study conducted the following information :

5.1.1 the result of analysis conducted level of service (LOS D) for pedestrian crossing within bab Al-Hussin signalized intersection which is indicate random movement many confident points between vehicles and pedestrians.

5.1.2 for Al jamiaa-40 street signalized intersection the level of service (LOS E) for pedestrian crossing This exacerbates pedestrian crossing problems within intersection according to highway capacity manual method (2010).

5.1.3 yellow interval increase pedestrian crossing problem let to become pedestrian two signalized intersection hazard location in movement and crossing.

5.1.4 The study suggested the development of the signalized intersections in terms of equipping the intersections with marking and signing signals that would allow the regulation of the movements of the pedestrian in crossing and movement and thus increasing the safety factors in crossing for the users of the intersection from the pedestrians, and this leads to an improvement in the performance of the service level at the intersection.

5.1.5 redesign yellow interval within each tow intersection in study area increase safety and clearance time for pedestrian and vehicle

The analyses study indicate (4.5)sec for bab Al-hussen, while (4)sec for Al-jamiaa- 40 street

5.2 Recommendations

The study suggested the following recommendations:

5.2.1 The study recommends conducting al Hilla transportation comprehensive study of the pedestrians , including traffic volumes, speeds, densities at signalized intersections and un signalized intersections, as well as road sections due to the lack of suitable designs or facilities for their crossing and movement.

5.2.2 Make designs and studies for roads and intersections, including studies of pedestrians, their environment, movements and crossing by specialized engineering consulting offices, because pedestrians are an essential component of the road, to increase safety, efficiency and appropriateness factors at intersections and road networks in the city of Hilla

5.2.3 The study suggested designing efficient and appropriate pedestrian bridges providing with moving stairway within the approaches and before the intersection area. Providing the stairway with electrical energy conservation technology to be economically and technically appropriate.

References

AASHTO, (2010), "Highway Safety Manual", American Association of State Highway and Transportation Officials, 1st Edition, Washington D.C.

AASHTO , (2011), "A Policy on geometric design of highways and streets, 6th Edition,

Asadi-Shekari, Mehdi Moeinaddini,Muhammad Zaly Shah, (2014) " Apedestrian level of service method for evaluating and promoting walking facilities on campus streets"

FHWA, (2009) "Manual on Uniform Traffic Control Devices for Streets and Highways", US Department of Transportation.

FHWA, (2013),"Signalized Intersections Informational Guide", US Department of Transportation, FHWA-SA-13-027.

Highway Capacity Manual (2010), Transportation Research Board, TRB, National Research Council, Washington, D.C.

Highway design manual (2005) republic of Iraq ministry of housing &construction state organization of roads & bridges .

Hubbard, S. M. L. , Awwad, R. J. , and Bullock, D. M. . (2007), Assessing the Impact of Turning Vehicles on Pedestrian Level of Service at Signalized Intersections: A New Perspective. In Transportation Research Record: Journal of the Transportation Research Board, No.

2027, Transportation Research Board of the National Academies, Washington, D.C., pp. 27–36.

Kadali, Perumal Vedagiri, (2015)" Pedestrian Quality of Service AT Unprotected Mid-Block crosswalk locations under mixed traffic Conditions: Towards Quantitative Approach

Miller, J.S., Bigelow, J.A., Garber, N.J. (2000), *Calibrating Pedestrian Levelof-Service Metrics with 3-D Visualization*, Transportation Research Board, Washington, D.C. pp. 9-15.

Muraleetharan, T. , Adachi, T. , Hagiwara, T. , and Kagaya, S. (2005). Method to Determine Pedestrian Level-of-Service for Crosswalks at Urban Intersections. Journal of the Eastern Asia Society for Transportation Studies, Vol. 6, pp. 127–136..

Nicholas J.Garber lester A. hoel (2009) traffic and highway engineering, fourth edition.

Nicholas J.Garber lester Lester A. hoel (2019) traffic and highway engineering, fifth edition.

National cooperative highway research program NCHRP (2008) "Multimodal level of service analysis for urban street".

National cooperative highway research program NCHRP (2013) "active traffic management for arterials".

Nowar Raad1 and Matthew Burke2 (2017) Pedestrian Levels-of-Service tools: problems of conception, factor identification, measurement and usefulness.

Noorance Al-Mukaram, Sarah Safaldeen Musa (2020), Determination of Pedestrian Level of Service on Sidewalks in Samawah City.

Petritsch, Theodore, Landis, Bruce, Huang, Herman, Dowling, Richard, (2008). Pedestrian Level-of-Service Model for Arterials. Transportation Research Record: Journal of the Transportation Research Board, 2073, pp 58-68.

P. k. Bhuyan & Minakshi Sheshadri Nayak (2013) A Review on level of service Analysis of urban street .

Roger p. roess, Elena S. prassas, William R. mcshane , (2004) traffic engineering international edition. Third edition.

Rastogi, R.,et al,(2011), Pedestrian Flow Characteristics in Mixed Traffic Conditions. Journal of Urban Planning and Development, Vol. 136, No. 1, pp. 23–33.

Raghuram Bhadradri Kadali ,P. Vedagiri;2016 " Review of Pedestrian Level of Service".

San Francisco planning Department. 2019, (Better Market Street Project Eir Volume I PLanning Department CASE NO. 2014.0012E State Clearinghouse NO. 2015012027.

Sarah Marie Lillo, Hubbard. (2021), A New Perspective on Pedestrian Level of Service at Signalized Intersections.

Sisiopiku, V. P. , and Byrd, J. E. . (2007), Pedestrian Level of Service Comparison. Proc., World Conference on Transport Research, Berkeley, Calif.

Venkat Chilukuri, Mark R. Virkler, December (2005), Validation of HCM Pedestrian Delay Model for Interrupted Facilities

Witold Czajewski, Paweł Dąbkowski and Piotr S Olszewski. 2013, (Innovative solutions for improving safety at pedestrian crossings**)**. Transport system telematics, Vol. 6, Issue. 2.

Yingying Ma, Siyuan Lu and Yuanyuan Zhang. 2020 (Analysis on Illegal Crossing Behavior of Pedestrians at Signalized Intersections Based on Bayesian Network). Journal of advanced Transportation, vol. 2020, Article ID 2675197, 14 pages.

Ying Ni, Yninging Cao, Keping. 2017, (Pedestrians' Safety Perception at Signalized Intersections in Shanghai). Transportation Research Procedia, Volume 25, Pages 1955-1963.

Yongqing Guo, Xiaoyuan Wang, Xinqiang Meng, Jie Wang, Yaqi Liu. 2019, (Pedestrians’ Speed Analysis for Two-Stage Crossing at a Signalized Intersection). Civil engineering journal, Vol. 5, No. 3.

Ziwen Ling, Christopher Robin Cherry (2015) Evaluating Pedestrian Level of Service at Signalized Intersections in China

Appendix

استمارة استبيان

تقوم الباحثة بإنجاز متطلبات رسالة الدبلوم العالي بعنوان :

Study of Pedestrians Movement at Some Intersections in Hilla City

وان لآرائكم وملاحظاتكم سوف تضفي على البحث العلمية والواقعية وتفضلكم بأنجاز الاستبيان التالي الذي من شانه ان يساهم في تحسين خصائص العبور للسابلة في بعض التقاطعات المجهزة بالإشارات الضوئية لمدينه الحلة .

التقاطع :

الموقع :

اليوم : / / الوقت :

الجنس: ☐ ذكر ☐ انثى

العمر : ☐ 10-20 سنه ☐ 20-30 سنه ☐ 30-40 سنه ☐ 40-50 سنه

☐ 50-60 سنه ☐ اكبر من 60

مارأيك بحاله وكفاءه المماشي الجانبية المخصصة لعبور السابلة في التقاطع :

☐ رديء ☐ متوسط ☐ جيد ☐ جيد جدا

هل ان العبور والانتقال عبر مقتربات التقاطع تتم بانسيابيه : ☐ نعم ☐ كلا

هل ان المماشي الجانبية في التقاطعات توفر عوامل الأمان والملائمة للسابلة :

☐ نعم ☐ كلا

مامدى كفاءه التقاطع من التخطيط المروري والإنارة

☐ رديء ☐ متوسط ☐ جيد ☐ جيد جدا

هل ان الازمان المتاح لعبور السابلة كافيه لعبور وانتقال المشاة في التقاطع

☐ نعم ☐ الى حد ما ☐ كلا

الخلاصة

تعتبر حركة المشاة وتنقلاتهم وعبورهم وبيئتهم وتداخل حركتهم مع عمليات المرور المختلفة من العناصر المهمة التي من الواجب اخذها بنظر الاعتبار في تصاميم الطرق والتقاطعات ، وبالتالي تسعى الدراسة إلى تقييم مستوى الخدمة (LOS) للسابلة وتقديم الحلول والمعالجات وفق منهجية علمية قائمة على اساس دراسة مرورية وتحليلية.

تم دراسة التقاطعين المجهزين بإشارات ضوئية في مدينة الحلة مع دراسة أداء منشآت المشاة وهم (باب الحسين ، الجمعية- شارع 40).تم جمع البيانات باستخدام كاميرا الفيديو بمساعدة دائرة المهندس المقيم لمشروع الكاميرا. شمل المسح الملموس هندسة المرور مثل حجم حركة المرور للمركبات والمشاة ، وشملت سرعة المشاة ,عدد المراحل وطول الدورة والزمن الأصفر والوقت الضائع.

تم إجراء مسح هندسي لكل تقاطع ضمن منطقة الدراسة أيضًا ، بما في ذلك عدد الممرات والعرض ومتوسط العرض ومتوسط السيارة مع كل هذه البيانات التي تم جمعها خلال يوم العمل (اثنين- ثلاثاء –اربعاء) وفقًا لحجم ساعة الذروة (PHV).

تم إعداد البيانات باستخدام الأشكال والجداول مع برنامج excel (2019) . تم تحليل البيانات باستخدام طريقة HCM (2010) للوصول إلى مستوى الخدمة للمشاة داخل كل تقاطع مجهز بإشارات ضوئية ، تم التحقق من مستوى الخدمة لكل تقاطع باستخدام طريقه Webster.

توصلت الدراسة إلى الاستنتاجات التالية: مستوى الخدمة داخل تقاطع باب الحسين المجهز بإشارة من نوع (LOS D) ؛ بالنسبة لتقاطع الجمعية- شارع 40 المزود بإشارات ضوئية مستوى الخدمة (LOS E) لعبور المشاة مما يدل على حركة عشوائية والتداخل للعديد من النقاط بين المركبات والمشاة. اقترحت الدراسة تطوير التقاطعات من حيث تجهيز التقاطعات بالإشارات والعلامات وإعادة تصميم الزمن الأصفر داخل كل تقاطع في منطقة الدراسة ، مما يؤدي إلى زيادة السلامة ووقت التخليص للمشاة والمركبات.

بالنسبة للحوادث المرورية اثناء العبور ، اقترحت الدراسة بناء مجسرات مجهزة بالسلالم المتحركة للمشاة داخل المقتربات وقبل منطقة التقاطع ، وتجهيز السلالم بتقنيات حفظ الطاقة الكهربائية.

جمهورية العراق

وزارة التعليم العالي والبحث العلمي

جامعة بابل / كلية الهندسة

قسم الهندسة المدنية

دراسة حركة السابلة في بعض تقاطعات لمدينة الحلة

رسالة

مقدمة الى كلية الهندسة - جامعة بابل وهي جزء من متطلبات نيل شهادة الدبلوم العالي في الهندسة المدنية / هندسة المواصلات

من قبل

ثمر وائل عبد الكاظم

بأشراف

أ.م. عبد الكريم ناجي عبود