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Study of Basic Traffic Elements for Pedestrians Movement and their Impacted on Level of Service Efficiency in Urban Area

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ABSTRACT

Walking is become a traditional mode of movement between places in many situations, irrespective of cities and countries. People walk with different purposes and activities. This calls for conducting the necessary studies and improvements for walking and crossing 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 Muhrmat Shat Al- Hilla Street 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. The proposals adopted by the study, which were built on the basis of a traffic study and use of the simulation program (PTV VISSIM), scientific analysis using method with design of the crossing areas and sidewalks according to the specifecations as a result to an increase in the level of service for the sidewalks and crossing areas of the LOS (from F to C). Based on the statistical analysis using the (SPSS) software program, as well as studying the relationships between traffic volumes, 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 volumes and pedestrian speed based on the outputs of the values of the correlation coefficient (R), (Adj. R^2) and (SE). The study suggested a comprehensive transportation for pedestrian flow charactristic in Hilla city includes pedestrians environmental within roadways and intersections as a networks to design an appropriate modern environment and safe crossing facilities to reduce traffic accidents that result in death, injury or disability.

Keywords: urban area, pedestrian, sidewalks, SPSS.

INTRODUCTION

Nowadays pedestrians being the most vulnerable road users known for their wide choice of freedom while choosing a part particular walking and crossing pattern, which makes them far more divergent from driver's road users (Habtemichael, 2013). In comparison to different types of vehicles movements, the pedestrians continuously interact with each other and their surrounding environment, which constantly changes their walking flow characteristics.

Effective planning and design of pedestrian facilities requires an understanding of typical pedestrians. A typical pedestrian is within 1.5 km to work and within 1.0 km to catch a bus, and about 80% of the distances pedestrians walk are less than 1.0 km (Officials, 2011). The previous studies of this paper are as following. Tarkowski et al., 2019 show that the worrisome was the procedure used to recreate the bike-car collision, in which both vehicles were moving in the same direction and performing maneuvers at the same time. Left turn and overtaking. Due to conflicting witness testimony, the proceedings were also recorded by fixed video cameras. With the help of this data, we were able to understand vehicle movements and maneuvers over time and identify who caused the accident. Zaranka (2023) study that the rapid increase in the number of vehicles in Lithuania and abroad every year, ensuring road safety for road users and other responsible authorities becomes an increasingly important and relevant aspect. The research uses statistical data and comparative analysis techniques. Calculated

traffic disruptions and resulting damage levels are analyzed according to the type of collision. Benzaman (2022) show that the derived index used to estimate road safety culture had high joint validity as it correlated with state rankings based solely on overall crash fatality rates. Fabianova (2020) demonstrate the application of the VISSIM program in designing and testing models of traffic light-controlled intersections. Jurecki et al. (2017) proved instructions for testing drivers in simulators. Young drivers are more prone to collisions, so this investigated how young drivers behave in simulated road conditions on highways. Emergency maneuvers performed by the driver in simulated road conditions were determined based on the results. This study shows that the vehicle environment can have a significant impact on the type of emergency maneuver and the driver's reaction time.

The importance of this study lies in the fact that it is one of the few studies that deal with pedestrian traffic flow and the facilities their crossing and movements, as most of the designs are deal with the path of the road, the cross and longitudinal sections, and alignment, but pedestrian designs largely neglected. This study came to shed light on the problem of pedestrians and try to find some options and solutions that would contribute to improving safety, efficiency and convenes. However, the current study aim to evaluate the impact of pedestrian characteristics, traffic flow in addition to walking speed on the efficiency of pedestrian level of service (LOS) within study area with the added 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 exists designs of sidewalk and walkway used in the study area, as well as studying the efficiency of at grade and stairway crossing in other location of the study area.

METHODS

Pedestrian flow characteristic

Pedestrian flow characterization studies that were conducted focused primarily on measuring basic parameters, building relationships between them, and understanding the factors that influence pedestrian walking speed. Pedestrian flow characteristics are known to vary by facility type, latitude, gender, and location (Banerjeel et al., 2018).

The study conducted the following:

- Pedestrians in Saudi Arabia, Iraq, Bangladesh, Indonesia and Sri Lanka were significantly slower on sidewalks than those in the US, UK and Canada.
- This slowdown was due to their build (height), culture (dress), attractiveness (presence of street vendors on the sidewalk), friction (from parked vehicles), purpose of trekking, and environmental conditions.
- Moreover, the minimum and maximum pedestrian speeds observed were (52 m/min) and (98 m/min) respectively.

Pedestrian level of service studies

Polus et al. (1983) studied properties of a pedestrian flow on sidewalks. Calculation of pedestrian level of service was depending on the pedestrian density and sidewalk width (Mori and Tsukaguchi, 1987). A system was developed for pedestrian level of serivce by using visual methods (Miller et al., 2000). A study about analyzing problems related to pedestrian level of service of crosswalk (Kadali and Vedagiri, 2015).

Nagraj and Vedagiri (2013) described the pedestrian level of service crosswalks and the factors which affect them.

Principles of pedestian flow

Pedestrian speed-density relationships:

$$V_{Pedestrian} = S_{Pedestrian} \times D_{Pedestrian} \quad (1)$$

where: $V_{Pedestrian}$ – unit flow rate (p/min/ft);
$S_{Pedestrian}$ – pedestrian speed (ft/min);
$D_{Pedestrian}$ – pedestrian density ($p/ft2$).

Another more convenient formula uses the inverse of density or space, as follows:

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

where: M – space of pedestrian ($ft2/p$).

RESULTS AND DISCUSSION

Definition of study area

The study chose one area in Hilla city, Babylon, Iraq in order to identify the pedestrian problems so 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 provide solutions that assist to reduce the effects of pedestrian problem.

The area study

Muhrmat Shat Al-Hilla Street in Babylon, Iraq, It is a multi-lane road withone direction traffic, it's width 11.25 m. Side walks width on both sides 1.5 m. This road extends from Al-Fayhaa Bridge in the north to the Imam Ali Street Bridge in the south. The roadway length is 2 km, it is characterized by an increase in traffic volumes and densities of pedestrian activities, it's 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 decrease

Table 1. Classification of vehicle and traffic volume variation, study area 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 2. Classification of vehicle and traffic volume variation, study area 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

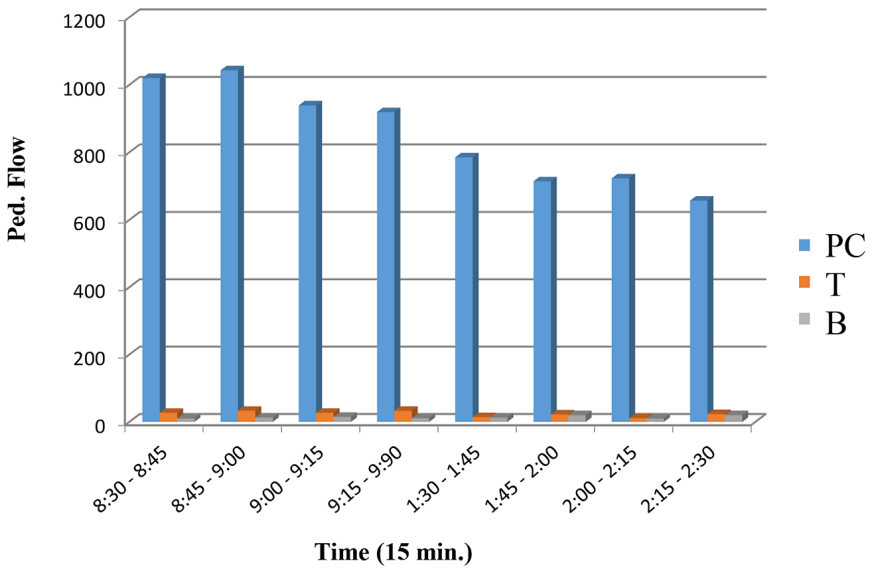

Figure 1. Classification of vehicle and traffic volume variation, study area according to a.m. & p.m. peak hour

Table 3. Traffic parameters for pedestrian movement, study area according to a.m. peak hour

Study area	Time	Pedestrian traffic volume (Ped./15 min.)	Pedestrian average walking speed (ft./min.)	Pedestrian density (Ped./ft2.)
Muhrmat Shat Al-Hilla Street	9:30–9:45	600	138	4.347
	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 4. Traffic parameters for pedestrian movement, study area 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

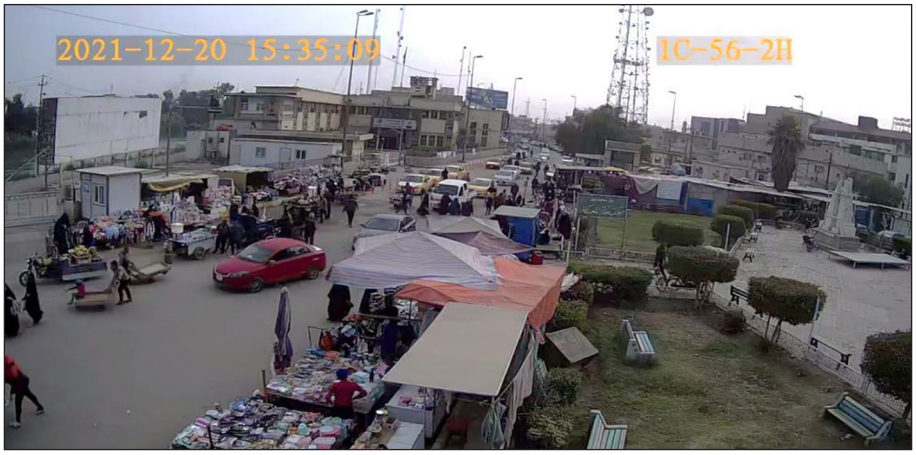

Figure 2. Muhrmat Shat Al- Hilla Street, study area

Table 5. 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.)
Muhrmat Shat Al-Hilla	37.125	One direction	2	-	4.95	18.56

in the safety and convenience factors as a result of the increase in the critical points between vehicles and pedestrians. Listed in Figure 1 and Tables 1–5 Figure 2 show the charactristic of study area.

Evaluate (LOS) for roadway section within study area

The study conducted an assessment of the level of service in the studied road sections. Using Council (2010) for the purpose of showing the extent of its impact on the characteristics of pedestrian traffic flow and crossing in the study area. The Table 6 displays the results of the analysis.

Table 6. Level of service (LOS) criteria within study area

Location	Flow rate V_p (p/min/ft.)	Pedestrians sidewalk LOS
Muhrmat Shat Al-Hilla	42.1	F

Determine effective sidewalk width (WE)

The study determines sidewalk effective width for each section within study area. The information listed in Table 7.

Determine pedestrian flow rate (p/min/ft) for each section of the study area selected by Equation 3 as follow:

Table 7. 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.)
Muhrmat Shat Al-Hilla	4.95	Vending stands	4.0	0.95

Table 8. Level of service cratria for pedestrians sidewlak within study area

Location	V_p (p/min/ft.)	($S_{ped.}$) (ft./min.)	(M) (ft^2./ped.)	Pedestrian walkway LOS
Muhrmat Shat Al-Hilla	42.1	172	4.098	F

Table 9. Pedestrian walkway LOS within study area

Study area	LOS type	Note
Muhrmat Shat Al-Hilla	E	Form observation

$$V_P = \frac{V_{15}}{15 \times W_E} \quad (3)$$

where: V_P – pedestrian unit flow rate (p/min/ft);
V_{15} – peak 15-min flow rate (p/15-min);
W_E – effective walkway width (ft.).

According to flow rate of pedestrian's studies with respect to the sidewalks characteristic, the level of service was calculated for each sections of the study area then included in Table 8.

From the Table 8, it is clear that the level of service 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 study evaluate walkway for pedestrian in order to determine LOS for their walking within study area. It must be determine pedestrian space (M) (ft2./ped.). The criteria listed in Table 9.

Suggested some alternative to improve pedestrian movement

Given the low level of service for the sidewalks and pedestrian crossing facilities, the study proposed some solutions and alternatives to improve their environment and provide safety factors, convenience and efficiency, led to increase level of service for the study area, as a result to reducing the rate of traffic accidents and increasing the efficiency of walking and crossing.

The study suggested the following alternatives (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 show in Figure 3.

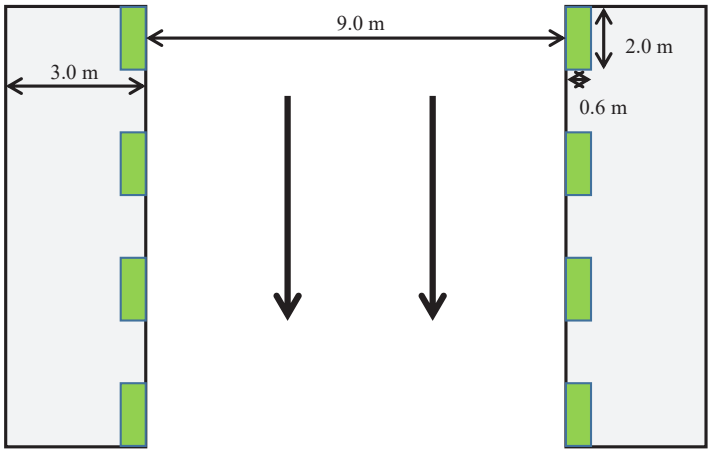

Figure 3. Top view for suggested improvement alternative in study area

Table 10. LOS for ped. sidewalk with avaliable improvement

Location	Flow rate V_p (p/min/ft.)	Pedestrians sidewalk LOS
Muhrmat Shat Al-Hilla	42.1	C

After carrying out the proposed development of the study area, the level of service for the side pedestrians and pedestrian crossing areas was analyzed (Table 10).

Simulation criteria by using PTV VISSIM software

PTV VISSIM simulation model where many researchers used the micro-simulation VISSIM to evaluate safety at different traffic facilities where the (Council, 2010; Cunto and Saccomanno, 2008; Ghanim and Shaaban, 2019). So VISSIM is a valuable and effective tool for transportation engineering (Atamo, 2012).

The Simulation steps as follow:

- Step 1 – streets specify on the network;
- Step 2 – setting up links and connectors;
- Step 3 – setting up a pedestrian crossing area;
  - 3-1 – pedestrian area gray;
  - 3-2 – footpath (no intersection);
- Step 4 – setting up conflict areas;
- Step 5 – setting up areas;
  - 5-1 – a step of establishing pedestrian routes;
  - 5-2 – a step of establishing pedestrian inputs;
- Step 6 – setting up vehicle inputs;
- Step 7 – setting up configuration;
- Step 8 – setting up simulation.

Speed is adopted to determining LOS for the chosen street from the study area. And compared with LOS from the arithmetic method according to the Equation 3 and choose the worst.

Statistical analysis for pedestrian parameters within study area

In order to ensure (Council, N. R. 2010) method, with the aided of (SPSS) software programe the stude examin to type of equation (Linear & 2nd Order) to estimate pedestrian flow, speed and density relashinship as show in Table 11.

Form Table 11 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 (R2), standard error of estimate and F test value). The summary of statistical analysis shows in Appendix.

CONCLUSIONS

The study found, based on the evaluation of the current situation, that the level of service (for the study area is (E), while the level of service for pedestrians sidewalk and walkway is (F), that indicates the aggravation of the pedestrians problems wıthın 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 as well as increase conflict points. Led to reduction in safety factors, convenience and efficiency for them in the study area.

The alternatives adopted by the study, which were built on the basis of a traffic study, as well as the simulation made wıth the aided of (PTV VISSIM) software program and scientific analysis using (Council, 2010) method with design of the crossing areas and sidewalks according to (Officials, 2011) specifications resulting, 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 coefficient (R), the coefficient of determination (Adjusted R2) as well as the

Table 11. Statistical regression analysis discribe bedestrian flow, speed & density relationship in study area

Study area	Equation	Relationship	Coefficient of correlation *R*	Adjusted R^2	Standard error of estimate	*F* test
Muhrmat Shat Al-Hilla	Linear	Speed/density	0.989	0.975	3.619	274.012
	2nd order	Flow/speed	0.990	0.972	1.268	120.902

standard error of estimate (SE) in the study area according to the statistical parameter values.

Manual counting that conductıng in the study is a valabile to ensure the pedestrian flow characteristic, as well as flexible to occur during the A.M. & P.M. peak hour volume and represent actual pedestrian's facilities demand for walking & crossing. Recommendations are following: activate strict laws and regulations to limit encroachments on sidewalks for pedestrians and crossing facilities with not allow random parking on both sides of the roadways to prevent obstructions to the path of pedestrian movement and reduce critical points between vehicles and pedestrians; conduct a comprehensive transportation study for pedestrian flow charactristic in Hilla city includes pedestrians environmental within roadways and intersections as a networks to design an appropriate modern environment and safe crossing facilities to reduce traffic accidents that result in death (F) and personal Injry (PI). 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 studıes and sutable convenıent design to ensure safety elements for the main compenent that is considered in traffic facilities.

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