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Evaluation and Improvement of Elba-House Road Intersection in Amman-Jordan

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ABSTRACT

Cities in Jordan, especially the capital, Amman, are witnessing traffic jams due to the increase in the number of cars and the increase in population (whether it is a natural increase or an increase due to successive migrations from the neighboring countries). This study aims to evaluate and improve the level of service (LOS) and delay of the Elba-house intersection in Amman city, Jordan. The required data were collected from the governorate traffic departments and also directly from the field. The intersection was evaluated using SIDRA INTERSECTION 5.1 software. The results show that the level of service is F, and the intersection is crowded with a total delay time of about 285.8 seconds. A tunnel in addition to a roundabout was proposed to decrease the average delay and increase its level of service. The reanalysis of the intersection provided good results whereas the level of service can be increased to B and the average delay reduced to 13.3 seconds.

Keywords: capacity, delay, flow, level of service, signalized intersections, traffic control.

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I. INTRODUCTION

Studying and evaluating the major road intersections in cities is considered one of the most important studies necessary for the future planning of cities as well as for facilitating traffic. Cities in Jordan, especially the capital, Amman, are witnessing traffic jams due to the increase in the number of cars and the increase in population (whether it is a natural increase or an increase due to successive migrations from the neighboring countries). The level of service (LOS) on a road or intersection is a measure of the flow of traffic on the road, the amount of delay on it, and the amount of traffic that the road or intersection accommodates. The level of service is expressed in levels between A and F (Garber & Hoel, 2019; Gross & Scurry, 2017; Reilly, 1997). Investigations should be carried out at specific intervals to study and evaluate the level of service and search for possible improvement.

Various studies have been conducted to evaluate several intersections. Comprehensive research by Al-Jabburi k. and Hamid S. (Karim Al-Jabburi, 2016) was conducted to study the Wadi-Saqra intersection in Amman, Jordan to establish a control model for the traffic flow at this intersection and improve its level of service. Another study by Khliefat I. *et al*. (Khliefat, Naser, Alhomaidat, & Hanandeh, 2021) was carried out to improve the capacity and level of service of the sixth circle-signalized intersection in Amman. VISSIM software and C++ program were used in this study to achieve its aims. Average Annual Daily Traffic (AADT) is the most important factor that can be used in traffic and transportation planning, as well as in any related research, such as air quality, noise, and vibration modeling (Shao, Han, Wu, & G. Claudel, 2019; Shao et al., 2020). The research was done to provide expansion factors for arterials in Amman, including the hourly expansion Factor (HEF), weekly expansion factor (WEF), and monthly Expansion Factor (MEF), which can be used to provide an accurate estimate of AADT from available short-term traffic counts (Al Maaiteh & Imam, 2018; Jrew B., 2009).

Many road intersections were designed a long time ago and are now unable to accommodate traffic, especially since most of them were designed based on three or four-leg entrances, which is what is known as traditional intersections. The use of such a design led to delays and jams at these intersections (Jrew B., 2009). Recently, new techniques are used to analyze the delay and queue length using microscopic simulation for the non-traditional intersection design super street (Mahmud, Ferreira, Hoque, & Tavassoli, 2019; Naghawi, 2014). Most of the signalized intersections in Amman city, Jordan needs urgent evaluation and improvements for the reasons mentioned before (Mohammad, Majed, & Basim, 2014; Msallam, 2014; Msallam M., 2014).

In this study, the Elba-House intersection was selected because of the suffocating traffic congestion and the very large traffic density at this intersection. This intersection is located in the northern part of Amman, it is considered a road that links the north of Amman with the city of Al-Salt, west of Amman, as well as the northern cities in Jordan such as Irbid and Jerash. At the same time, it is the road to the south of Amman. This study aims to evaluate the existing intersection and suggests possible solutions to improve the level of service and solve the traffic congestion at this intersection using the collected data and suitable software.

II. Data Collection and Methodology

A. Data Collection

To evaluate the importance and the level of service for the Elba-house intersection, a lot of information, tables, and drawings related to the volume and the number of passing cars during peak hours are needed. The dimensions of the intersection, the grades of each street on it, and the cycle time length of the signal are also needed. These data were obtained from several sources such as Greater Amman Municipality and the Traffic Control Room of Amman city. The collected data and information for the intersection under consideration are given in Table I. The width of each lane was calculated from the intersection site plan shown in Fig. 1. The total cycle-time length of the signal at the intersection was calculated in the field to be 200 seconds.

Fig. 1. Site plan of Elba-house intersection.

TABLE I: Data and Information about the Elba-House Intersection

Approaches	EB		WB		NB		SB	
Street Names	Thawra Arabia		Rif`ah Alansari		King Abdallah II		King Abdallah II	
Lane Setting	Left	Through	Left	Through	Left	Through	Left	Through
Volume	285	82	470	475	182	2604	425	2258
Number of lanes	1	2	1	2	1	2	2	2
Lane width(m)	3.2	3.2	3	3	3.2	3.2	3.2	3.2
Grades	-8%		1%		2%		-2%	
Yellow (sec.)	3		3		6		6	
All red (sec.)	2		2		2		2	

B. Methodology

SIDRA INTERSECTION 5.1 software was used to analyze the intersection based on the collected data. The software was also used to check the proposed solutions and the level of improvement. Fig. 2 shows the

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input list for the used software.

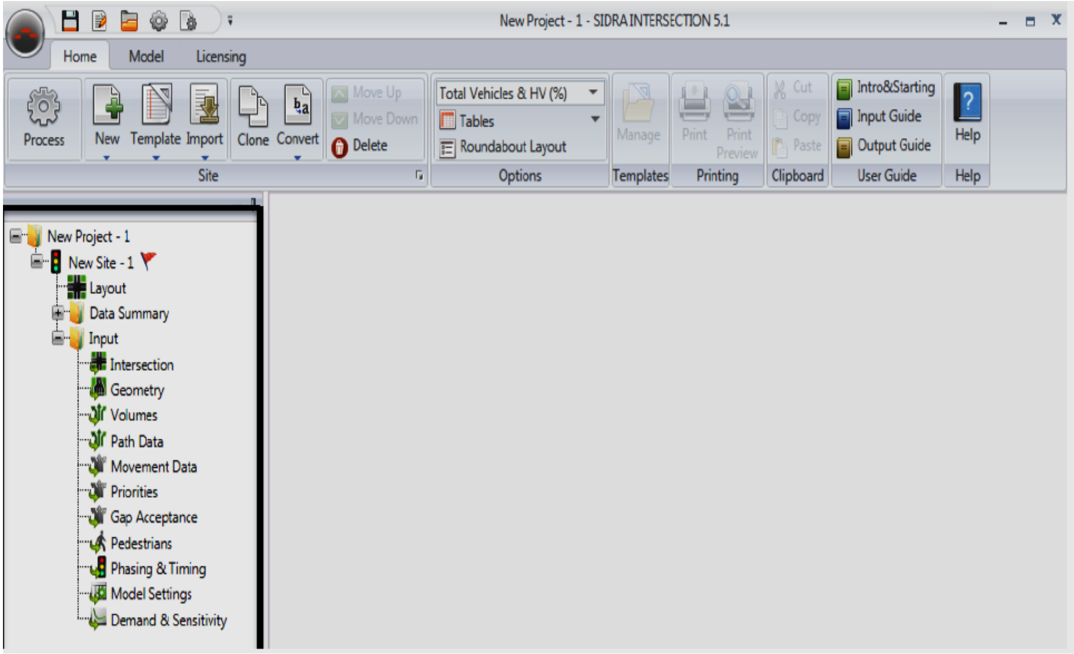

Fig. 2. Input list of SIDRA INTERSECTION 5.1 software.

The required input data were the shape of the intersection, title and the intersection ID (Elba house), volume data, intersection (peak flow period=15 min), and the geometry of the intersection. Fig. 3 shows the dialog of the intersection.

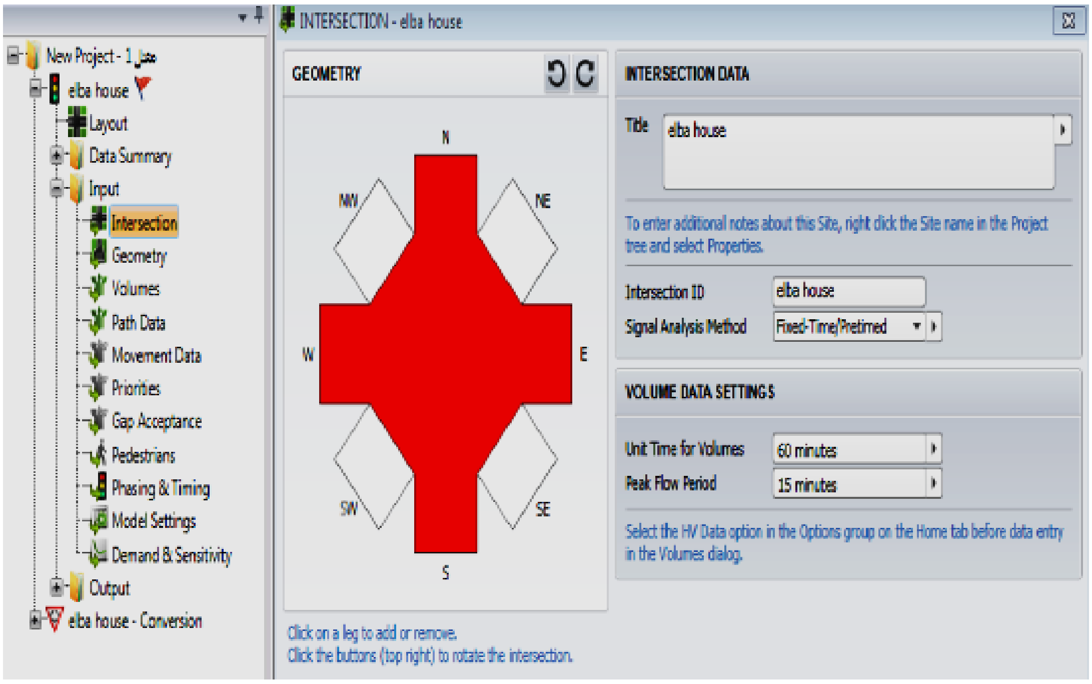

Fig. 3. Intersection dialog.

The geometry option specializes in defining and entering data related to lanes in terms of (a) approach data including the Approach name, median width, and any extra bunching defined in the section, (b) lane movement including the definition of movement disciplines for the selected lane, the lane type, and the lane length. In addition, for short lanes, the utility was selected as Parking or Turn Bay. (c) lane data including the approach and exit lane data such as lane width, grade, and saturation flow rate.

Fig. 4 shows the intersection geometry dialog. To input the volume of vehicles and volume factors such as peak hour factor and growth rate, the volume option was used.

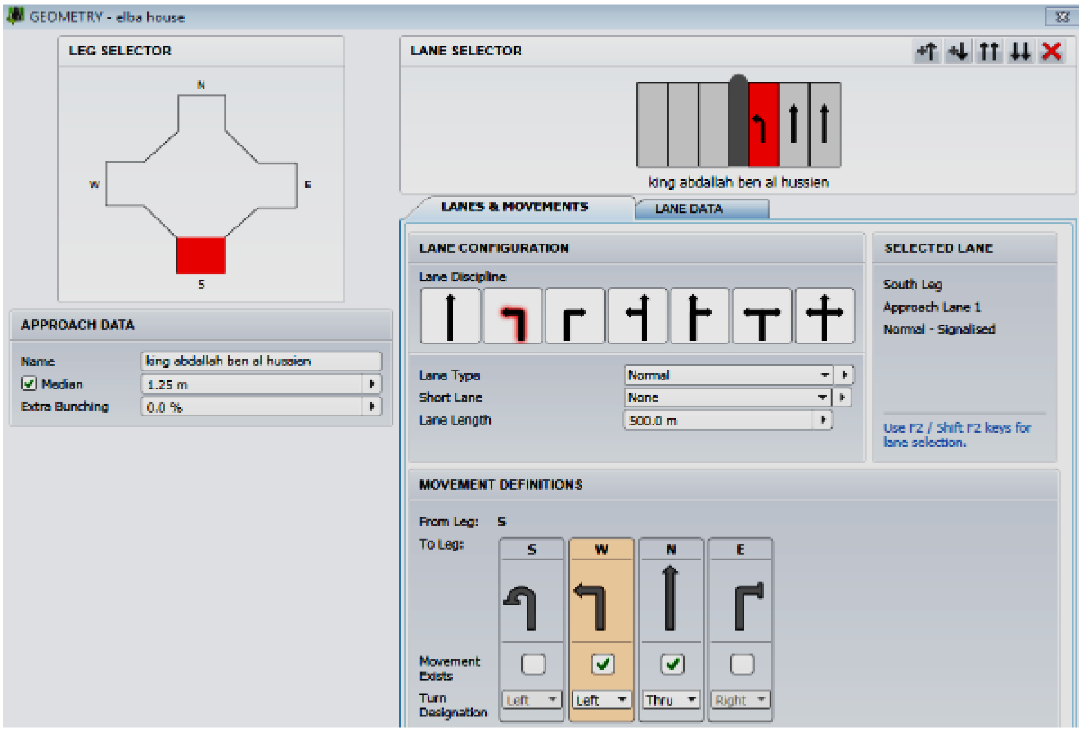

Fig. 4. Intersection geometry dialog.

III. Analysis and Results

Based on the data given in Table I, the peak hour factor (PHF) for each approach at the intersection was calculated using Equation (1). The calculated PHF values are given in Tables II, III, IV, and V.

$$PHF = \frac{Volume\ during\ peak\ hour}{4 * volume\ during\ peak\ 15\ min\ within\ peak\ hour} \tag{1}$$

Approach 1: Thawra Arabeya Street (EB), the PHF value is equal to 367/(4*113) = 81%.

TABLE II: Volume Counts During the Peak Hour at Approach 1

Time	Volume
2:00–2:15	113
2:15–2:30	84
2:30–2:45	100
2:45–3:00	70

Approach 2: King Abdullah II Street (SB), the PHF value is equal to 2683/(4*745) = 90%.

TABLE III: Volume Counts during the Peak Hour at Approach 2

Time	Volume
2:00–2:15	585
2:15–2:30	620
2:30–2:45	733
2:45–3:00	745

Approach 3: Rif`ah Al-Ansari Street (WB), the PHF value is equal to 945/(4*299) = 79%.

TABLE IV: Volume Counts during the Peak Hour at Approach 3

Time	Volume
2:00–2:15	270
2:15–2:30	299
2:30–2:45	200
2:45–3:00	176

Approach 4: king Abdullah II Street (NB), the PHF value is equal to 2786/(4*819) = 85%.

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TABLE IV: VOLUME COUNTS DURING THE PEAK HOUR AT APPROACH 4

Time	Volume
2:00 – 2:15	819
2:15 – 2:30	620
2:30 – 2:45	715
2:45 – 3:00	632

The largest value of PHF (90%) was used to achieve higher safety. The following data was used in the volume dialog option: Total volume on each lane, HV%=0.05, PHF=90% and growth rate=3.5%. The volume dialog is shown in Fig. 5.

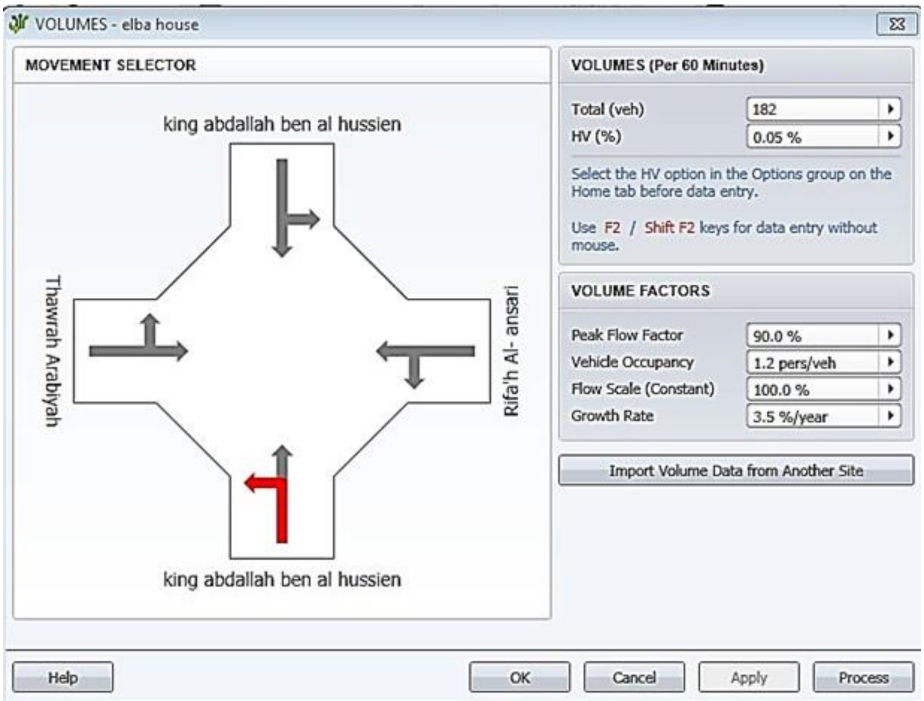

Fig. 5. Volume dialog.

Finally, the phasing and timing option is used for the intersection to obtain the phasing time dialog shown in Fig. 6.

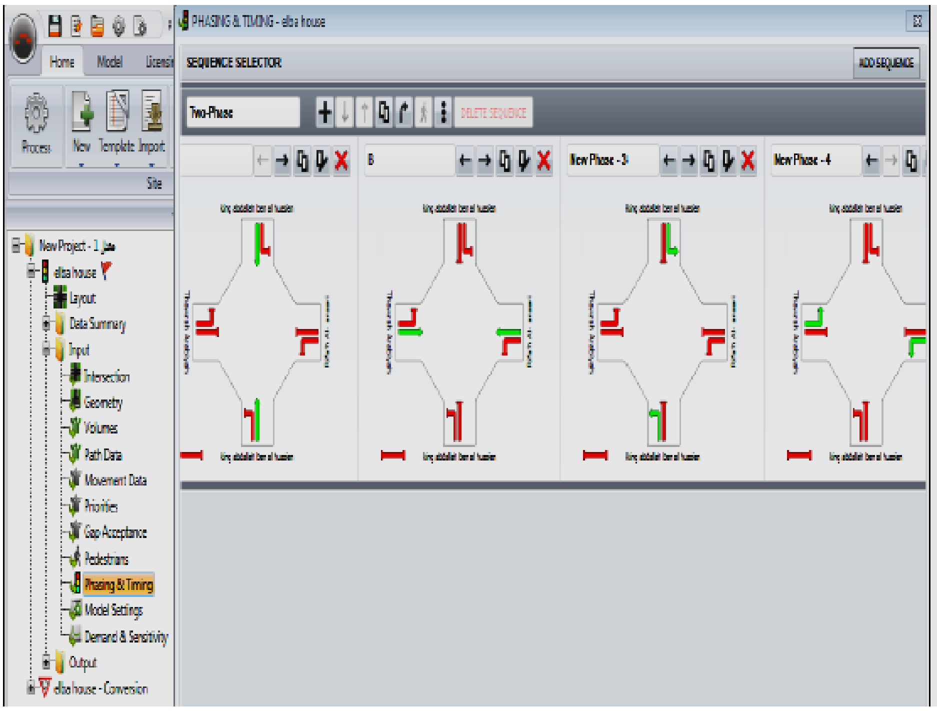

Fig. 6. Phasing time dialog.

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A. Output Reports

Detailed summary: This report shows the summary of the input and the output for different parameters as links listed in the table, such as traffic signal, movement, lanes, flow rates, and demand analysis.

Intersection summary: This report shows the intersection performance for the vehicles and the persons according to many performance measures such as demand flows, delay, travel distance, travel speed, cost, and environmental measurements.

Movement summary: This report shows the movement performance for each lane and views the summary for all lanes. Also, it gives an indication of the level of service, the average delay, the demand flow, and the average speed. In this case (Elba-house Intersection), the average delay equals 285.8 seconds which is a high value to deal with without being under making accident risk.

The level of service for each lane is shown in the report, which equals F and for the intersection, the level of service is classified as F which means that intersection LOS is not applicable for signal. The movement summary is given in Fig. 7.

Movement Summary - elba house

MOVEMENT SUMMARY Site: elba house

elba house
Signals - Fixed Time Cycle Time = 200 seconds (Optimum Cycle Time - Minimum Delay)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: king abdallah ben al hussien											
1	L	202	0.1	1.322	268.7	LOS F	31.7	222.0	1.00	1.17	7.2
2	T	2893	0.0	1.531	325.0	LOS F	264.2	1849.7	1.00	1.64	6.0
Approach		3096	0.0	1.531	321.3	LOS F	264.2	1849.7	1.00	1.61	6.0
East: Rifa'h Al- ansari											
4	L	522	0.0	1.543	361.2	LOS F	93.5	654.4	1.00	1.31	5.5
5	T	528	0.0	1.485	332.4	LOS F	45.5	318.7	1.00	1.38	5.9
Approach		1050	0.0	1.543	346.7	LOS F	93.5	654.4	1.00	1.34	5.7
North: king abdallah ben al hussien											
7	L	472	0.0	1.543	367.4	LOS F	41.9	293.6	1.00	1.25	5.4
8	T	2509	0.0	1.327	230.4	LOS F	204.0	1428.3	1.00	1.47	8.1
Approach		2981	0.0	1.543	252.1	LOS F	204.0	1428.3	1.00	1.43	7.5
West: Thawrah Arabiyah											
10	L	317	0.0	0.926	110.5	LOS F	34.0	238.2	1.00	0.95	14.9
11	T	91	0.0	0.254	91.2	LOS F	4.2	29.2	0.97	0.73	16.7
Approach		408	0.0	0.926	106.2	LOS F	34.0	238.2	0.99	0.90	15.3
All Vehicles		7534	0.0	1.543	285.8	LOS F	264.2	1849.7	1.00	1.47	6.7

Level of Service (LOS) Method: Delay (HCM 2000).

Fig. 7. Movement summary.

Lane summary: This report shows the demand flow for each lane, the total number of vehicles per hour, the degree of saturation, the average delay, and the level of service on each lane.

LOS summary: This report shows the summary of the level of service of each lane at the intersection on the layout shown in Fig. 8.

Fig. 8. LOS summary.

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B. Proposed Solution

The purpose of this study is to improve the intersection by decreasing the average delay and increasing the level of service. The proposed solution to improve the Elba-house intersection is to use a tunnel and a roundabout above. Using the convert option of the used software and the same data given in Table I, the section was reanalyzed, assuming the LOS of the tunnel equals A, the movement summary, and the LOS for each street is obtained as shown in Fig. 9 and Fig. 10.

Movement Summary - elba house - Conversion

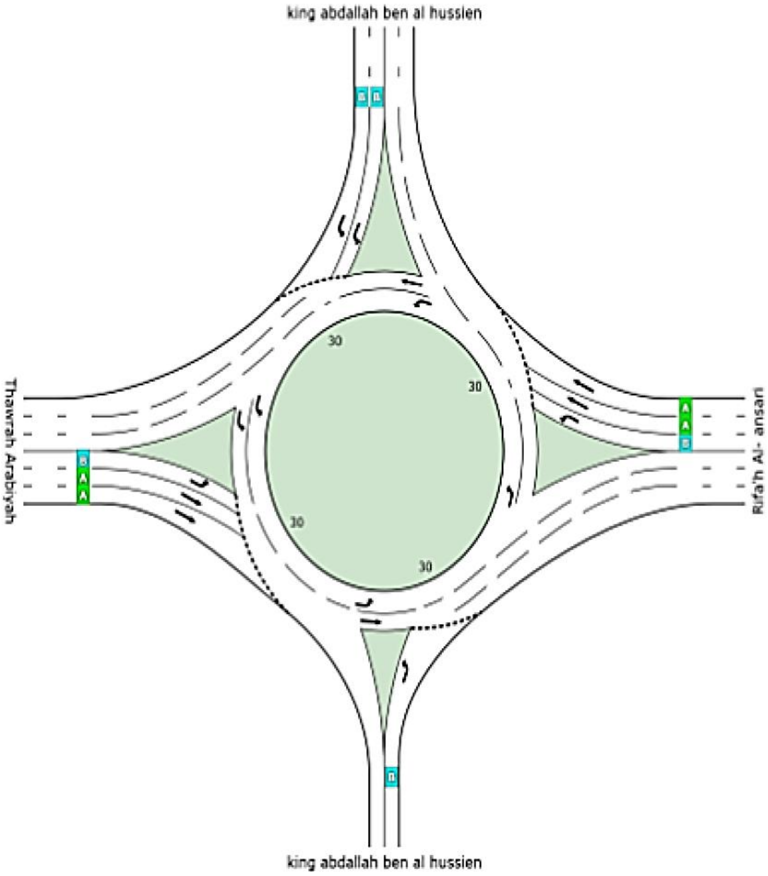
MOVEMENT SUMMARY Site: elba house - Conversion

elba house
Roundabout

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: king abdallah ben al hussien											
1	L	202	0.1	0.300	15.6	LOS B	1.6	11.1	0.74	0.92	43.0
Approach		202	0.1	0.300	15.6	LOS B	1.6	11.1	0.74	0.92	43.0
East: Rifa'h Al- ansari											
4	L	522	0.0	0.417	13.7	LOS B	3.4	23.5	0.73	0.76	43.6
5	T	528	0.0	0.281	7.3	LOS A	1.9	13.1	0.69	0.67	48.3
Approach		1050	0.0	0.417	10.5	LOS B	3.4	23.5	0.71	0.72	45.8
North: king abdallah ben al hussien											
7	L	472	0.0	0.422	18.5	LOS B	2.9	20.4	0.88	1.01	40.9
Approach		472	0.0	0.422	18.5	LOS B	2.9	20.4	0.88	1.01	40.9
West: Thawrah Arabiyah											
10	L	317	0.0	0.315	14.9	LOS B	2.3	15.8	0.82	0.86	43.3
11	T	91	0.0	0.060	8.4	LOS A	0.3	2.4	0.74	0.70	47.9
Approach		408	0.0	0.315	13.4	LOS B	2.3	15.8	0.80	0.82	44.2
All Vehicles		2132	0.0	0.422	13.3	LOS B	3.4	23.5	0.77	0.82	44.0

Fig. 9. Movement Summary table after intersection converting.



	South	East	North	West	Intersection
LOS	B	B	B	B	B

Fig. 10. LOS Summery after intersection converting.

IV. Conclusion

This study aimed to evaluate and improve the LOS and delay of the Elba-house intersection in Amman city/ Jordan. The required data were collected from the governorate departments and the field. The intersection was evaluated using SIDRA INTERSECTION 5.1 software. The results of the evaluation showed where the level of service was F, the intersection was crowded, and the time of delay was high. To improve the intersection by decreasing the average delay and increasing the level of service of it, a tunnel, and a roundabout above it were proposed. The reanalysis of the intersection gives good results. The LOS is increased to B and the average delay was reduced to an acceptable time.

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Conflict of Interest

The authors declare that they do not have any conflict of interest.

References

Al Maaiteh, M., & Imam, R. (2018). Determination of expansion factors to estimate average annual daily traffic for arterials in Amman. *Jordan Journal of Civil Engineering*, 12(3), 383–401.

Garber, N. J., & Hoel, L. A. (2019). *Traffic and highway engineering: Cengage Learning*. Nelson Education Limited.

Gross, F., & Scurry, K. (2017). *Highway Safety Improvement Program (HSIP) Evaluation Guide*. Retrieved from https://rosap.ntl.bts.gov/view/dot/41309.

Jrew B., a. A. M. (2009). Evaluation and improvement of Wadi-Sabra signalized intersection in Amman city. *Paper presented at the The Forth Conference in Scientific Research in Jordan*, Amman, Jordan.

Karim Al-Jabburi, S. H. (2016). *Optimum management of signalized intersection: Case study Amman-Jordan*. [M.Sc. Isra University].

Khliefat, I., Naser, M., Alhomaidat, F., & Hanandeh, S. (2021). Improving the capacity and level of service at the sixth circle in Jordan by using traffic signals and roundabout metering approach. *The Open Transportation Journal*, 15(1), 69–80. doi:10.2174/1874447802115010069.

Mahmud, S. S., Ferreira, L., Hoque, M. S., & Tavassoli, A. (2019). Micro-simulation modelling for traffic safety: A review and potential application to heterogeneous traffic environment. *IATSS research*, 43(1), 27–36.

Mohammad, A., Majed, M., & Basim, J. (2014). Evaluation and improvement of signalized intersections in Amman city in Jordan. *Journal of Environment and Earth Science*, 4, 21.

Msallam, M. (2014). Evaluation and improvement of signalized intersections in Amman city in Jordan. *Evaluation*, 4(21), 156–169.

Msallam M., A., M., Abu-Khurma M., and Jrew B. (2014). Evaluation and improvement of traffic flow of signalized intersections on part of Zarqa expressway in Zarqa city in Jordan. Paper presented at the *The Fourth Jordan International Conference and Exhibition for Roads and Transport: "High Priority Issues in the Future Transport Sector"*, Amman, Jordan.

Naghawi, H. (2014). Analysing delay and queue length using microscopic simulation for the unconventional intersection design Superstreet. J*ournal of the South African Institution of Civil Engineering*. /*Joernaal van die Suid-Afrikaanse Instituut van Siviele Ingenieurswese*, 56(1), 100–107.

Reilly, W. (1997). H*ighway capacity manual 2000* (4 ed.). Washington, DC, USA: Transport Research Board.

Shao, Y., Han, X., Wu, H., & G. Claudel, C. (2019). Evaluating signalization and channelization selections at intersections based on an entropy method. *Entropy*, 21(8), 808.

Shao, Y., Luo, Z., Wu, H., Han, X., Pan, B., Liu, S., & Claudel, C. G. (2020). Evaluation of two improved schemes at non-aligned intersections affected by a work zone with an entropy method. *Sustainability*, 12(14), 5494.