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The Efficiency Improvement for Traffic Operating and Modifying Delay Time in Al-Kadessah Intersection at AL Ramadi City

***Khalid Hardan Mhana Alwani*[a*]**

[a]*Civil Engineering Department, Engineering College, University of Anbar, Anbar, Iraq*

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ABSTRACT

Traffic movement is considered a compound phenomenon that is impacted by behavioral, economic, and physical aspects. It is performed within the context of an urban system that consists of road networks and crossings, where the movement crouches to depend. The measuring of identifying their size and densities and current problems helps to Improve and development for roads and streets network existing and important intersections for purposes the accessibility, potentiality of future intersections, and network development towards constructing a composition to raise the quality and the efficient performance of roads and streets. The study was dependent on a traffic survey for intersections, areas of urban intersections, and the road network of Al-Ramadi city, as well as the number of vehicles that generated a large volume of traffic flow. The use of the program (HCS 2010) to detect appropriate for purposes decreasing traffic congestion and delayed trip time in the areas based on existing and future districts that generate different types and purposes of journeys to lessen the delay trip time to lessen traffic congestion. Therefore, research looks at both sides: first, a study of the existing intersections of the main road network and urban streets, including an examination of the components and shapes of these intersections in the study area; second, an examination of the importance placed on these intersections by the planning and design process.

1. Introduction

An urban road intersection is a vital component of the overall road network as well as a spot where traffic flows both together and in different directions. It is not difficult for it to bring about traffic congestion, traffic delays, and accidents traffic numbers from other countries indicate that delays caused by intersection traffic congestion account for more than one-third of the total delays caused by urban road traffic, and the same numbers also indicate that some occurrences that take place in the intersection accounts for more than fifty percent of all traffic accidents (Xie and Feng,2013). Consequently, the study of the flow of traffic at intersections phenomenon, investigating the traffic laws at intersections and doing research into the underlying causes of impacts at intersections (Karim, 2011)

Congestion on the roadways is recognized as one of the most significant issues confronting cities of all sizes across the globe (AASSHO, 2009). As a result of an increase in the number of traffic accidents, gas emissions,

* *Corresponding author.*
E-mail address: khalid.hardan@uoanabr.edu.i

and fuel consumption, traffic congestion has a severe influence not only on the quality of life but also on global atmospheric conditions and energy supplies. (Al-Ubaidy et. al, 2010; Cai, 2020; Xie and Feng,2013). Because of its capacity to manage and control the flow of traffic, including that of various kinds of vehicles as well as pedestrians, particularly during peak hours, the intersection is regarded as one of the most significant and complex locations along the road network (Awad et. al, 2010). The provision of a change in the route directions for routes that share a junction with two or more other roads is the primary purpose of the intersection. According to the American Association of State Highway and Transportation Officials (AASHTO, 2009), the level of complexity of intersections ranges from a simple intersection, in which just two roads cross each other, to a more complicated intersection, in which three or more highways cross within the same area. One of the most significant issues that might arise at any point in a transportation network, particularly at junctions, is a delay (Karim, 2011). When determining how long a wait will be at any intersection, the level of service, or LOS, the concept is applied. The Highway Capacity Manual (HCM) defines the level of service (LOS) for signalized intersections based on the delay time (the average halted delay time per vehicle for a 15-minute analysis period). As indicated in Table (1) (HCM, 2010), the LOS ranges from LOS A (free-flow circumstances) to LOS F (long waits).

2. Study problem

In Iraq's Al-Anbar province, the city of Al-Ramadi is widely regarded as one of the province's potential capitals. Al-Kadessah intersection, which is a component of Al-Ramadi city, is a significant location and has large traffic volumes due to the following reasons:

- Al-Kadessah intersection is connected to many different regions.
- There are commercial, educational, and residential activities that are located near the Al-Kadessah intersection.

As a result of these efforts, the Al-Kadessah intersection has experienced a congestion problem, particularly during rush hours; thus, this problem has led to an increase in the amount of delay that occurs at this intersection.

3. Aim and objective

The primary objectives of this research are as follows:

- Establish the peak-hour traffic volume at the Al-Kadessah intersection.
- Determine the peak hour factor, or PHF, for each of the approaches leading up to the Al-Kadessah intersection.
- Evaluate all of the offered solutions to cut down on the wait time at the Al-Kadessah intersection.
- It is necessary to be familiar with the existing line of sight for each approach leading up to the Al-Kadessah intersection.

4. Description of the site

Al-Kadessah intersection is a right-angle crossroads that can be found in the western part of the city of Ramadi. Because of the huge volume, this influences the flow of traffic, which causes a delay in time. The large volume of traffic at Al-Kadessah intersection can be attributed to the following factors:

- Al-Kadessah intersection is situated in a strategically significant area. It serves as a connection between the four primary compass directions.
- Al-Kadessah Crossroads has a significant amount of daily traffic. It links up different service regions. On the (master plan) for the city of Ramadi, the location of the intersection is shown in Figure (1).

Al-Kadessah Crossroads is composed of four major road directions that diverge from one another as follows:

- The direction from west to east (Al-howes Bridge to Al-Anbar University intersection)
- The direction from east to west (Al-university int. to Al-howes bridge).
- Direction going north to south (from Al-warar bridge to Al-railway entrance).
- Traveling in the south to the north (from Al-railway entrance to Al-warar bridge).

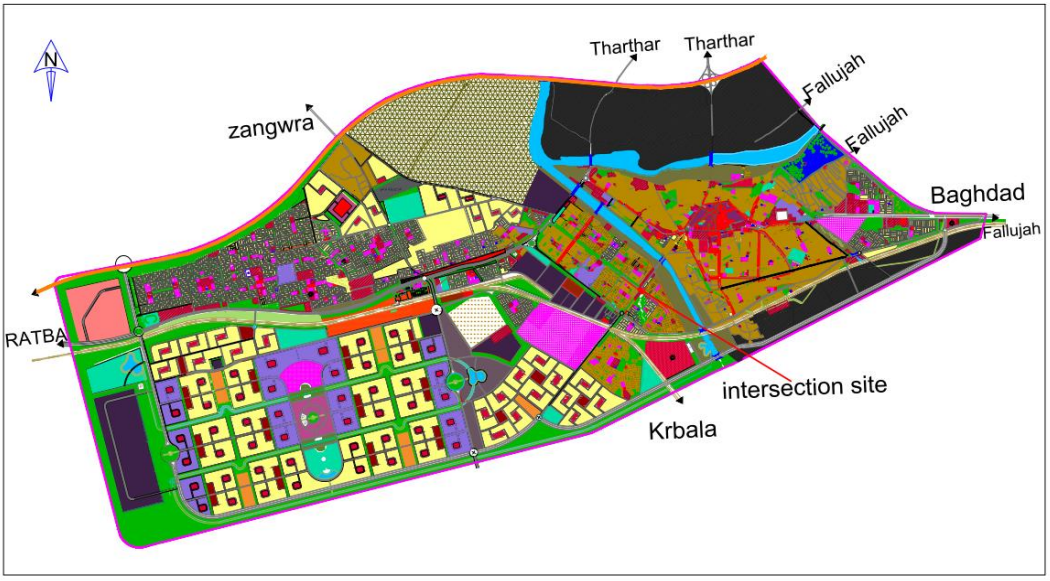

Fig.1 AL-Kadessah intersection site on a master plan for Ramadi city

5. Data collection

5.1. Traffic volume

During the workdays of the week from (15 May to 15 July May 2023), a digital camera was used to count the existing traffic volume for all approaches at Al- Kadessah between the hours of 7:00 AM and 7:00 PM during the period from (15 to 20 May 2023). There are two categories for the different kinds of cars that are counted, and they are as follows:

- All vehicles with four wheels are considered to be passenger cars.
- Heavy vehicles are defined as any automobile that has more than four wheels.

The heavy trucks were transformed into passenger cars by employing a passenger car convert factor of (2.0), which is equal to the number 2. Table 1 presents the results of counting the amount of traffic at each approach for every 15 minutes, while Table 2 presents the results of counting the volume of traffic at the entire intersection for every 15 minutes during the hours of 7:00 AM and 7:00 PM. the volume of traffic coming from each approach as well as the total volume coming through the intersection.

5.2. Peak hour volume

The following conclusion can be made based on the information shown in Tables (1) (2) and (3). It was discovered that the peak hour occurs between the hours of 8:00 and 9:00 in the morning. Tables (1) and (2) Show that the overall volume during this hour is 3242 pc/hr. During the peak hour, Al- Kadessah intersection saw the highest number of traffic, with 829 vehicles passing through it every hour. On the other hand, Al- Kadessah intersection had the lowest volume, with only 784 vehicles passing through it every hour.

5.3. Peak hour factor (PHF)

The change in the volume of traffic that occurs during peak hours is referred to as the peak hour factor. The peak hour factor can be defined as the ratio of the total hourly volume to the highest rate of flow that can be achieved within an hour over 15 minutes. Utilizing Equation (1), one can determine the peak hour factor as follows:

$$\boldsymbol{PHF = (Hourly\ volume)/(4 * V(15\ min.))} \quad \textbf{(1)}$$

Table 1 – Traffic volume at Al- Kadessah intersection (7:00 AM - 7:00 PM)

	From Al-Howas bridge			From university Intersection			From Al-Warar bridge			From railway		
Time	**R**	**TH**	**L**	**R**	**TH**	**L**	**R**	**TH**	**L**	**R**	**TH**	**L**
7:00-7:15 AM	15	47	40	20	74	28	16	51	44	11	25	47
7:15-7:30	11	53	41	20	84	23	15	68	41	14	29	45
7:30-7:45	15	77	48	19	82	30	14	70	51	14	27	55
7:45-8:00	14	76	43	13	81	34	15	71	47	14	29	50
8:00-8:15	18	116	68	16	116	58	15	113	62	20	126	56
8:15-8:30	20	125	69	14	117	64	14	116	74	17	128	62
8:30-8:45	15	129	61	17	122	69	17	112	68	18	135	66
8:45-9:00	19	125	58	20	111	65	14	117	68	16	128	68
9:00-9:15	14	101	59	26	90	41	8	85	53	16	28	46
9:15-9:30	13	96	62	31	91	44	13	83	52	12	31	58
9:30-9:45	12	98	63	32	95	46	10	83	50	12	35	53
9:45-10:00	8	98	57	23	94	41	8	76	54	15	33	51
10:00-10:15	14	100	53	22	117	50	10	87	52	22	73	40
10:15-10:30	11	103	53	24	123	45	11	84	53	26	69	41
10:30-10:45	8	101	53	26	132	56	10	89	50	19	68	41
10:45-11:00	10	102	53	36	129	47	8	75	46	16	76	39
11:00-11:15	11	102	53	25	131	45	8	92	41	18	73	44
11:15-11:30	10	98	50	28	115	53	8	86	46	14	69	46
11:30-11:45	15	103	48	24	116	58	10	92	50	15	74	48
11:45-12:00	17	99	47	29	113	53	8	83	53	14	86	53
12:00 -12:15	12	102	53	34	110	53	14	101	65	20	86	47
12:15-12:30	17	98	50	32	109	49	15	104	67	20	80	58
12:30-12:45	12	97	33	34	113	47	11	106	70	22	81	61
12:45-1:00	10	92	33	28	106	44	12	101	69	23	80	50
1:00-1:15	10	96	38	16	90	50	13	101	62	23	80	59
1:15-1:30	8	98	23	8	101	32	11	107	58	20	83	60
1:30-1:45	8	100	30	14	100	35	9	94	47	23	84	50
1:45-2:00	11	92	31	8	108	38	11	90	41	20	84	46
2:00-2:15	15	72	29	4	92	24	14	80	44	24	82	56
2:15-2:30	17	75	27	9	91	23	15	74	32	26	74	58
2:30-2:45	14	74	22	8	87	32	13	72	33	19	83	61
2:45-3:00	8	92	26	14	92	53	12	76	47	17	95	63
3:00 -3:15	11	87	55	8	110	51	15	75	53	20	101	55
3:15-3:30	8	90	53	11	114	54	14	75	59	23	98	53
3:30-3:45	7	101	50	14	109	41	15	74	58	21	92	47
3:45-4:00	14	105	47	15	125	47	11	94	69	27	75	59
4:00 -4:15	11	98	60	11	113	25	12	91	65	25	74	63
4:15-4:30	8	108	61	16	114	23	14	101	59	32	65	57
4:30-4:45	7	109	58	8	93	33	11	108	66	20	66	44
4:45-5:00	9	101	54	17	80	35	14	92	68	35	70	47

5:00 – 5:15	19	88	71	23	83	31	10	77	46	15	27	50
5:15 – 5:30	21	90	68	25	88	33	10	79	48	14	30	53
5:30 – 5:45	8	92	62	27	90	35	8	83	55	14	32	52
5:45 – 6:00	11	98	69	23	80	38	7	81	58	18	35	49
6:00 – 6:15	14	115	45	10	94	50	8	99	46	14	92	46
6:15 – 6:30	15	109	53	12	83	47	11	98	47	17	95	54
6:30 – 6:45	16	109	44	15	92	40	14	92	50	14	109	59
6:45 – 7:00 PM	14	104	50	14	102	38	9	96	49	13	117	63

Table 2 – Total traffic volume at al-Kadessah intersection (7:00 AM - 7:00 PM) for each(15)min

Time	Traffic volume	Time	Traffic volume	Time	Traffic volume
7:00-7:15 AM	490	11:00-11:15	643	3:00 -3:15	641
7:15-7:30	444	11:15-11:30	623	3:15-3:30	652
7:30-7:45	502	11:30-11:45	653	3:30-3:45	629
7:45-8:00	478	11:45-12:00	655	3:45-4:00	688
8:00-8:15	784	12:00 -12:15	697	4:00 -4:15	648
8:15-8:30	820	12:15-12:30	699	4:15-4:30	658
8:30-8:45	829	12:30-12:45	687	4:30-4:45	623
8:45-9:00	809	12:45-1:00	648	4:45-5:00	622
9:00-9:15	567	1:00-1:15	638	5:00 – 5:15	540
9:15-9:30	586	1:15-1:30	609	5:15 – 5:30	559
9:30-9:45	589	1:30-1:45	594	5:30 – 5:45	558
9:45-10:00	558	1:45-2:00	580	5:45 – 6:00	567
10:00-10:15	640	2:00-2:15	536	6:00 – 6:15	633
10:15-10:30	643	2:15-2:30	521	6:15 – 6:30	641
10:30-10:45	653	2:30-2:45	518	6:30 – 6:45	654
10:45-11:00	637	2:45-3:00	595	6:45 – 7:00 PM	669

Table 3 – PHF values for Al- Kadessah intersection approaches

Approach	Movement	PHF
From Al-Howas bridge.	L	0.93
	TH	0.95
	R	0.90
From university Int.	L	0.92
	TH	0.96
	R	0.85
From Al-Warar bridge.	L	0.92
	TH	0.99
	R	0.88
From railway int.	L	0.92
	TH	0.96
	R	0.89

6. Saturation flow

To determine the current saturation flow, the HCS 2010 application is utilized. The current saturation flow at the stop line for all approaches is outlined in Table 4, which may be found below.

Table 4 – Saturation flow for Al- Kadessah intersection

Approach	saturation flow	No. of lanes	Approach
From Al-Howes bridge	5638	3	East
From the university int.	5591	3	West
From Al- Warar bridge	5479	3	North
From the railway int.	5623	2	South

To conduct an analysis of the existing LOS for the entire intersection, it was necessary to have information regarding the number of lanes and the movement patterns in each of the approaches leading up to the intersection. The existing geometric layout for each approach in Al- Kadessah intersection is depicted in Figure 2, which can be found below.

7. Analysis and results

7.1. Existing (LOS) at Al-Kadessah intersection

To analyze traffic conditions and accomplish the existing capacity, volume-to-capacity ratio, and calculation of predicted delay for each traffic flow at each approach, the Highway Capacity Software (HCS) has been selected as the appropriate tool. After determining the peak hour that will be used to represent the design hour volume, the next step is to estimate the level of service (LOS) that will be provided at Al-Kadessah intersection by using the geometric design and traffic flow that is currently in place. To get an idea of the LOS It is necessary to compute the average delay at Al-Kadessah intersection under the current conditions. This is because the average delay is the primary factor that determines the length of service (LOS). According to the Highway Capacity Manual, the level of service (LOS) at signalized crossings can be categorized into six different classes based on the average amount of delay, as shown in Table (5).

Table 5 – Level of service definitions based on delay (HCM method)

LOS	Control delay/ V in Sec
A	$d \leq 10$
B	$10 < d \leq 20$
C	$20 < d \leq 35$
D	$35 < d \leq 55$
E	$55 < d \leq 80$
F	$d > 80$

The average delay for existing geometric at Al-Kadessah intersection is (62.5) seconds per vehicle when using the HCS program, and the United States Highway Capacity Manual states that Al- Kadessah intersection will function in LOS (E) when utilizing the HCS program. Tables (6) and (7) illustrate the traffic operation of Al-Kadessah intersection for all approaches that are associated with this Intersection in their current state respectively. Table (6) displays the average delay and LOS while Table (7) displays the LOS.

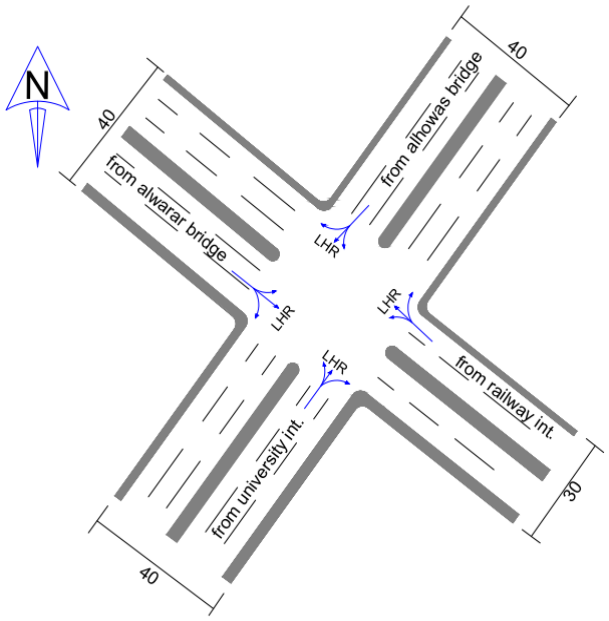

Fig.2 Geometric layout and traffic movement for Al-Kadessah intersection

Table 6 – Existing LOS at Al- Kadessah intersection

Approach	Average Delay (sec/veh)	(LOS)
From Al–Howes bridge.	87.7	F
From university int.	73.4	E
From Al–Warar bridge.	43.2	D
From railway int.	45.1	D
Int. Average Delay	62.5	E

Table 7 – Properties of existing traffic operation at Al- Kadessah intersection

Approach	Movement	Volume	HV	PHF	No. of Lanes	Phase No.	Cycle Length (sec)	
							G	Y
From Al-Howas bridge.	L	72	0.04	0.93	3	1	24	3
	TH	495	0.06	0.95				
	R	256	0.02	0.90				
From university Int.	L	67	0.03	0.92	3	2	24	3
	TH	466	0.05	0.96				
	R	256	0.07	0.85				
From Al-Warar bridge.	L	60	0.06	0.92	3	3	24	3
	TH	458	0.08	0.99				
	R	272	0.03	0.88				
From railway int.	L	61	0.05	0.92	2	4	24	3
	TH	517	0.06	0.96				
	R	252	0.04	0.89				
Total								120

8. Suggestions for improvement Al- Kadessah intersection

8.1. Proposal No. 1

This suggestion includes an improvement to the junction by the addition of a few parameters to enhance LOS:

Altering the timing of the phasing for the intersection. At Al-Kadessah intersection, the anticipated average delay will be 57.2 seconds per vehicle, which indicates that the intersection will be in the line of sight (E). Tables (8) and (9) indicate the average delays and LOSs at Al-Kadessah intersection, and Table (9) shows how the traffic flows at this intersection when proposal No.1 is implemented for all approaches that connect to this crossroads.

Table 8 – LOS at Al- Kadessah intersection by adopting proposal No.1

Approach	Average Delay (sec/veh)	(LOS)
From Al–Howes bridge.	67.4	E
From university int.	59.4	E
From Al–Warar bridge.	49.2	D
From railway int.	52.3	D
Int. Average Delay	57.2	E

Table 9 – Properties of traffic operation at Al- Kadessah intersection by adopting proposal No.1

Approach	Movement	Volume	HV	PHF	No. of Lanes	Phase No.	Cycle Length (sec)	
							G	Y
From Al-Howas bridge.	L	72	0.04	0.93	3	1	26	3
	TH	495	0.06	0.95				
	R	256	0.02	0.90				
From university Int.	L	67	0.03	0.92	3	2	26	3
	TH	466	0.05	0.96				
	R	256	0.07	0.85				
From Al-Warar bridge.	L	60	0.06	0.92	3	3	26	3
	TH	458	0.08	0.99				
	R	272	0.03	0.88				
From railway int.	L	61	0.05	0.92	2	4	26	3
	TH	517	0.06	0.96				
	R	252	0.04	0.89				
Total							120	

8.2. Proposal No. 2

This proposal includes an enhancement of the intersection by the addition of certain parameter to improve the line of sight of this proposal. These parameters are as follows: 1. modifying the phasing time for the intersection; and 2. adding another lane to the intersection that runs in the east-west direction during the base year. The anticipated level of pedestrian and vehicular traffic, which. The findings of the analysis indicate that the average delay will be (47.5) seconds per vehicle during the base year, and that the intersection will function at LOS (D). Table (10) and Table (11) indicate the typical delays and travel times at Al-Kadessah intersection for all approaches that are connected to this intersection when proposal No.2 is used as the base year. Table (10) shows the average delay, while Table (11) shows the travel times.

Table 10 – LOS at Al- Kadessah intersection by adopting proposal No.2

Approach	Average Delay (sec/veh)	(LOS)
From Al–Howes bridge.	44.5	D
From university int.	43.6	D
From Al–Warar bridge.	49.2	D
From railway int.	52.3	D
Int. Average Delay	47.4	D

Table 11 – Properties of traffic operation at Al- Kadessah intersection by adopting proposal No.2

Approach	Movement	Volume	HV	PHF	No. of Lanes	Phase No.	Cycle Length (sec)	
							G	Y
From Al-Howas bridge.	L	72	0.04	0.93	4	1	28	3
	TH	495	0.06	0.95				
	R	256	0.02	0.90				
From university Int.	L	67	0.03	0.92	4	2	28	3
	TH	466	0.05	0.96				
	R	256	0.07	0.85				
From Al-Warar bridge.	L	60	0.06	0.92	4	3	28	3
	TH	458	0.08	0.99				
	R	272	0.03	0.88				
From railway int.	L	61	0.05	0.92	4	4	28	3
	TH	517	0.06	0.96				
	R	252	0.04	0.89				
Total							120	

8.3. Proposal No. 3

This proposal includes an enhancement of the intersection by the addition of certain parameters to improve the line of sight of this proposal. These parameters are as follows: 1. modifying the phasing time for the intersection; and 2. adding another lane to the intersection that runs in the east-west direction during the base year. 3. The execution of the flyover via Al-Howes bridge to the approaches of the Al-university crossroads

According to this proposition, the anticipated volume of ground-level traffic in Al-Kadessah intersection will be similar to what is depicted in Figure (3). The following is an anticipated breakdown of the traffic volume that will utilize the proposed flyover:

Approximately (790) vehicles per hour (veh/h) along Al-howes bridge to Al-university intersection in (PH). Approximately (830) vehicles per hour (veh/h) along the Al-university intersection to Al-Howes bridge in (PH).

The findings of the analysis indicate that the average delay will be (26.8) seconds per vehicle during the base year and that the intersection will function at LOS (C). Table (10) and Table (11) indicate the typical delays and travel times at Al-Kadessah intersection for all approaches that are connected to this intersection when proposal No.2 is used as the base year. Table (10) shows the average delay, while Table (11) shows the travel times.

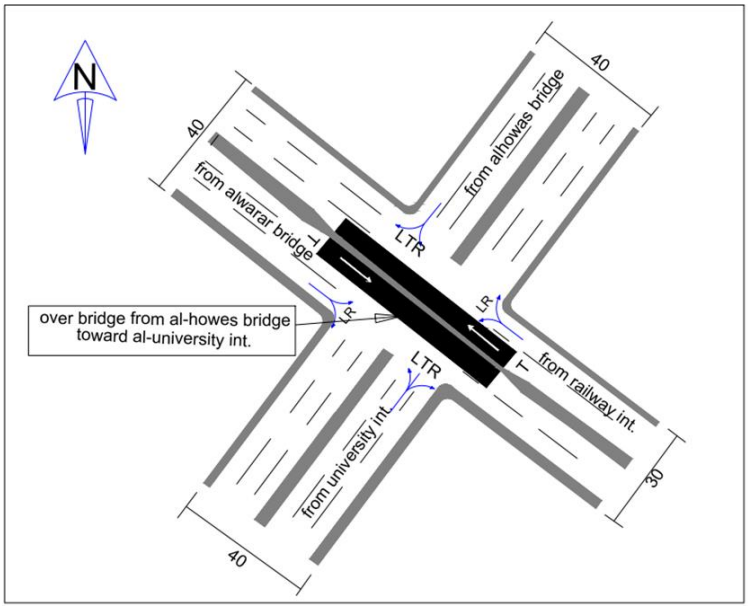

Fig. 3 Proposal No. 3 for Al- Kadessah intersection

Table 12 – LOS at Al- Kadessah intersection by adopting proposal No.3

Approach	Average Delay (sec/veh)	(LOS)
From Al–Howes bridge.	26.7	C
From university int.	26.4	C
From Al–Warar bridge.	27.5	C
From railway int.	27.2	C
Int. Average Delay	26.8	C

Table 13 – Properties of traffic operation at Al- Kadessah intersection by adopting proposal No.3

Approach	Movement	Volume	HV	PHF	No. of Lanes	Phase No.	Cycle Length (sec)	
							G	Y
From Al-Howas bridge.	L	72	0.04	0.93	4	1	28	3
	TH	495	0.06	0.95				
	R	256	0.02	0.90				
From university Int.	L	67	0.03	0.92	4	2	28	3
	TH	466	0.05	0.96				
	R	256	0.07	0.85				
From Al-Warar bridge.	L	60	0.06	0.92	3	3	28	3
	TH	-	-	-				
	R	272	0.03	0.88				
From railway int.	L	61	0.05	0.92	2	4	28	3
	TH	-	-	-				
	R	252	0.04	0.89				
Total							120	

8.4. Proposal No. 4

For the goal year (after 30 years with a 3% annual growth rate), it is anticipated that the total volume of traffic will. The typical wait time at the intersection will be (145.5) seconds per vehicle, and it will function at LOS (F). Tables 14 and 15 indicate the average delay and level of service at Al-Kadessah intersection, respectively, for all approaches that are connected with this Intersection if proposal No.4 is adopted at the target year. Table 14 also shows how traffic operates at this intersection.

Table 14 – LOS at Al- Kadessah intersection by adopting proposal No.4

Approach	Average Delay (sec/veh)	(LOS)
From Al–Howes bridge.	195.1	F
From university int.	168.3	F
From Al–Warar bridge.	55.0	D
From railway int.	46.6	D
Int. Average Delay	145.5	F

Table 15 – Properties of traffic operation at Al- Kadessah intersection by adopting proposal No.4

Approach	Movement	Volume	HV	PHF	No. of Lanes	Phase No.	Cycle Length (sec)	
							G	Y
From Al-Howas bridge.	L	136	0.04	0.93	4	1	28	3
	TH	940	0.06	0.95				
	R	486	0.02	0.90				
From university Int.	L	127	0.03	0.92	4	2	28	3
	TH	885	0.05	0.96				
	R	486	0.07	0.85				
From Al-Warar bridge.	L	114	0.06	0.92	3	3	28	3
	TH	870	0.08	0.99				
	R	516	0.03	0.88				
From railway int.	L	116	0.05	0.92	2	4	28	3
	TH	982	0.06	0.96				
	R	478	0.04	0.89				
Total							120	

9. Conclusions

It was discovered through site observation and traffic records that the capacity of this intersection is lower than the volume of traffic that it experiences during peak hours. Because of this, the construction of a bridge at this location is of the utmost importance; hence, it is essential to carry out a traffic study to propose the necessary upgrade to alleviate the traffic congestion that exists at Al-Kadessah crossroads. After taking into account the results that were discussed earlier and going through both of the provided solutions, it has been determined that proposal number two is the superior option for enhancing the level of service offered at Al-Kadessah intersection in the city of Ramadi (based on LOS results). The third proposition calls for the construction of a flyover along Al-Warar on the route to Al-Railway intersection, as well as the addition of one lane to each approach and the modification of the phasing in at grade at Al-Kadessah intersection. With the implementation of this suggestion, the at-grade intersection will function properly in LOS (F) for the target year.

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