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Improvement Level of Service for Congested Intersection in CBD Area of Fallujah City

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ABSTRACT

The concept of capacity and level of service are central to the analysis of intersections, as they are for all types of facilities. Both capacity and level of service must be fully considered to evaluate the overall operation of the intersections. The objectives of the present study include the analysis, evaluation level of service and traffic operation of Al- Abasse intersection in the CBD of Fallujah city. Al-Abbasi congested intersection which is located the CBD area of Fallujah are selected to achieve the objectives of the present study. The required traffic and geometrical data gathered manually to estimate the distribution of traffic in different directions. (HCS 2000) program are used for the requirements of traffic analysis process. It has concluded that the second proposal (construct flyover along New street toward Al – Kamaleat intersection) for the mentioned intersections is necessary to enhance the level of service and the traffic operation at Al – Abasse intersection in CBD of Fallujah city.

Keywords: Traffic Operation, HCS, Level of Service (LOS), Delay, Signalized intersection

تحسين مستوى الخدمة لتقاطع مزدحم في مركز مدينة الفلوجة

الخلاصة

مفهوم الاستيعابية ومستوى الخدمة من الأمور المهمة لتحليل التقاطعات، كما هي الحال بالنسبة لجميع أنواع المرافق. كل من الاستيعابية ومستوى الخدمة يجب دراستهما بصورة شاملة لتقييم مستوى تشغيل التقاطع. أهداف هذه الدراسة تتضمن تحليل، تقييم مستوى الخدمة وتشغيل حركة المرور لتقاطع العباسي في مركز مدينة الفلوجة. ويتم اختيار تقاطع العباسي باعتباره واحد من التقاطعات المهمة والمزدحمة في مركز مدينة الفلوجة ليكون حالة دراسية في هذا البحث. تم جمع الحجوم المرورية والبيانات المطلوبة يدويا، بينما تم استخدام برنامج (HCS2000) لمتطلبات عملية تحليل حركة المرور. وخلصت الدراسة إلى أن الاقتراح الثاني (بناء جسر على امتداد شارع الكماليات باتجاه الشارع الجديد) لتحسين مستوى الخدمة وتشغيل حركة المرور في تقاطع العباسي.

Introduction

The underlying objective of level of service analysis is to quantify a roadway's performance with regard to specified traffic volumes (i.e., its ability to efficiently handle a specified volume of traffic). This performance can be measured in terms of travel delay (as the roadway becomes increasingly congested) as well as other factors. The comparative performance of various roadway segments (which is determined from an analysis of traffic) is important because it can be used as a basis to allocate scarce roadway construction and improvement funds (Zegeer, 1986)[1].

Capacity is simply defined as the highest traffic flow that a roadway is capable of supporting. For level of service analysis, a consistent and reasonably precise method of determining capacity must be developed within the definition. Because it can readily be shown that the capacity of a roadway section is a function of factors such as roadway type (e.g., freeway, multilane highway without full access control, or rural road), free-flow speed,

number of lanes, and widths of lanes and shoulders (Khisty and Lall ,1998)[2].

There have been tremendous increasing in road traffic flows since the decade of eighty's. The availability of vehicles to public in Iraq especially in the last three years has resulted in considerable improvements in personal mobility. The social benefits brought about by this increase in mobility and traffic movement are extensive and the gains in travel convenience to society are high.

This high unexpected annual increase of traffic after 2004 in Iraq resulted to a great extend to lower the roadway network efficiency ,safety ,speed ,capacity, and increase fuel consumption and have adverse effect on environment through noise and air pollution.

The local authorities and the traffic engineers are responsible to society and their decisions should reflect the goals and objectives of society, and require the implementation of a new traffic engineering projects. Therefore, every effort is needed to ensure that the new transportation facilities should accommodate the anticipated high traffic volume by introducing free flow policies.

Intersections are an important part of highway network facilities as the performance parameter depend on their geometric design which facilitated the convenience ease and comfort of people traversing the intersection and enhance the efficient movement of vehicles.

Objective of the study

This study includes traffic data collection, forecasting for Al-Abasse intersection future traffic volumes, analysis of existing and projected traffic volumes using (HCS 2000 Software), and suggestions of the possible geometric solutions to improve the level of service, maximize capacity and minimize the traffic delay.

The main objectives of this study are:

1. Collection of traffic data which includes the counting of traffic volume for each traffic approach.
2. Specify the peak hour at Al-Abasse intersection, which represent the design hour volume in addition to the distribution of traffic volume at peak hour.
3. Calculate the Peak Hour Factor for all approaches in Al-Abasse intersection.
4. Evaluation of the existing level of service (LOS) at Al-Abasse intersection.
5. Evaluation of the level of service for two proposal suggested in this study.
6. Selecting the best proposal for Al-Abasse intersection in which give the best level of service.

Description of Site

Al-Abasse intersection is a four leg intersection type, located in CBD area of Fallujah city. The high traffic volume at this intersection highly effects on the traffic flow especially through traffic .

Al-Abasse intersection is significant locations and highly traffic volume can be related to:

1. Al-Abasse intersection located in an important location. It connects between main directions.
2. The existing of different public activities near Al-Abasse intersection. These activities results a high traffic volume.

Data Collection

Traffic volume

Counting of traffic volumes classified by movements was conducted manually for the four approaches in an average of seven days in good weather conditions starting 4 June, 2011.

The traffic volume for the counting period was recorded for each 15 minutes to calculate the peak hour factor at each approach, the peak hour and traffic volume variation.

Tables (1) and (2) show the traffic volume at each approach and total volume across the intersection.

Table 1. Traffic volume at Al-Abasse intersection form 7:00 a.m to 7:00 p.m for all approaches

Time	From Al–Kamaleat Int.			From New St.			From Maysaloon Sq.			From Al–Mahkama Int.		
	R	TH	L	R	TH	L	R	TH	L	R	TH	L
7:00-7:15 a.m	8	122	35	21	94	43	10	75	55	16	47	24
7:15-7:30	9	126	55	23	102	46	11	82	61	18	55	29
7:30-7:45	9	134	69	24	115	50	11	88	68	23	62	31
7:45-8:00	11	148	87	21	113	53	10	93	65	20	65	38
8:00-8:15	12	155	87	26	128	49	12	100	69	22	72	34
8:15-8:30	12	154	88	27	136	53	13	94	66	24	74	41
8:30-8:45	11	151	87	30	146	60	14	112	71	28	82	45
8:45-9:00	14	146	70	29	143	59	13	102	65	27	81	44
9:00-9:15	14	145	78	35	146	62	16	110	71	29	87	48
9:15-9:30	15	139	83	41	162	67	19	112	69	30	91	50
9:30-9:45	9	138	84	38	156	63	18	113	61	26	96	46
9:45-10:00	12	134	78	30	168	60	14	111	76	23	92	44
10:00-10:15	12	133	71	29	157	66	13	116	69	29	97	41
10:15-10:30	14	133	73	30	161	70	14	118	70	31	94	49
10:30-10:45	17	131	73	24	166	71	11	114	61	29	97	48
10:45-11:00	20	131	73	26	168	66	12	120	65	25	104	47
11:00-11:15	18	131	76	30	164	67	14	113	74	32	100	52
11:15-11:30	18	134	74	32	173	66	15	116	70	24	102	56
11:30-11:45	17	136	74	38	174	73	18	126	81	27	99	54
11:45-12:00	18	138	76	44	170	71	20	120	76	28	107	58
12:00 -12:15	20	138	74	41	191	78	19	135	86	26	114	62
12:15-12:30	20	139	77	42	185	77	20	139	89	27	106	57
12:30-12:45	14	143	57	15	120	62	15	141	93	29	108	56
12:45-1:00	15	146	62	17	131	69	16	139	95	30	107	51
1:00-1:15	14	149	49	17	140	76	13	125	89	31	106	53
1:15-1:30	12	149	43	15	149	73	13	113	74	28	110	60
1:30-1:45	17	152	36	18	160	77	10	75	55	33	116	59
1:45-2:00	18	155	38	20	150	74	11	82	61	29	112	56
2:00-2:15	21	91	38	9	113	41	18	97	68	26	120	62
2:15-2:30	18	118	39	12	128	43	20	94	66	28	115	68
2:30-2:45	17	110	41	14	136	41	17	97	68	37	126	69
2:45-3:00	18	130	42	33	173	66	16	100	73	40	132	73
3:00 -3:15	17	126	83	30	187	69	20	108	70	38	124	68
3:15-3:30	15	122	84	35	182	62	18	112	71	35	127	70
3:30-3:45	14	158	85	38	175	64	20	106	74	28	110	53
3:45-4:00	12	162	85	36	196	69	14	157	91	26	104	42

Time	From Al–Kamaleat Int.			From New St.			From Maysaloon Sq.			From Al–Mahkama Int.		
	R	TH	L	R	TH	L	R	TH	L	R	TH	L
4:00 -4:15	12	160	90	32	191	73	16	152	96	23	101	40
4:15-4:30	11	163	95	27	151	43	18	156	99	24	92	35
4:30-4:45	8	162	94	21	94	43	17	158	84	16	47	24
4:45-5:00	9	144	98	23	102	46	15	163	86	18	55	29
5:00 – 5:15	21	188	101	51	220	87	18	166	93	34	163	47
5:15 – 5:30	20	226	105	57	229	95	15	159	89	33	159	48
5:30 – 5:45	18	222	102	53	235	102	24	166	79	37	167	47
5:45 – 6:00	18	228	105	51	222	91	27	175	93	38	170	52
6:00 – 6:15	31	234	106	57	233	105	25	172	90	37	183	51
6:15 – 6:30	24	238	107	53	242	100	34	173	98	40	183	56
6:30 – 6:45	23	228	108	56	236	111	30	164	90	46	189	45
6:45 – 7:00 p.m	25	226	106	57	228	102	44	177	90	38	177	56

Table 2. Traffic volume at Al-Abasse intersection form 7:00 a.m to 7:00 p.m for all approaches for each (15) min

Time	Volume	Time	Volume
7:00-7:15 a.m	550	1:00-1:15	862
7:15-7:30	617	1:15-1:30	839
7:30-7:45	684	1:30-1:45	808
7:45-8:00	724	1:45-2:00	806
8:00-8:15	766	2:00-2:15	704
8:15-8:30	782	2:15-2:30	749
8:30-8:45	837	2:30-2:45	773
8:45-9:00	793	2:45-3:00	896
9:00-9:15	841	3:00 -3:15	940
9:15-9:30	878	3:15-3:30	933
9:30-9:45	848	3:30-3:45	925
9:45-10:00	842	3:45-4:00	994
10:00-10:15	833	4:00 -4:15	986
10:15-10:30	857	4:15-4:30	914
10:30-10:45	842	4:30-4:45	768
10:45-11:00	857	4:45-5:00	788
11:00-11:15	871	5:00 – 5:15	1189
11:15-11:30	880	5:15 – 5:30	1235
11:30-11:45	917	5:30 – 5:45	1252
11:45-12:00	926	5:45 – 6:00	1270
12:00 -12:15	984	6:00 – 6:15	1324
12:15-12:30	978	6:15 – 6:30	1348
12:30-12:45	853	6:30 – 6:45	1326
12:45-1:00	878	6:45 – 7:00 p.m	1326

Peak Hour Volume

By considering the traffic volume account that previously presented in Table (1), an Excel program is used to determine the peak hour, which is found to be between (6:00 - 7:00 p.m.). Figure (1) and Figure (2) show the peak hour in addition to the variation of flow every 15 min during the peak hour. From the traffic account, the following conclusions were drawn:

1. The total traffic volume during the peak hour for all approaches is (5324) pc/h. This peak hour is found to be between (6:00 - 7:00 p.m),
2. It was found that the traffic comes from New street has the highest volume of traffic while the traffic comes from Al–Mahkama Intersection has the lowest volume during the hours of the counting.

Fig. 1 Traffic volume at Al-Abasse intersection form 7:00 a.m to 7:00 p.m for all approaches for each (1 hr)

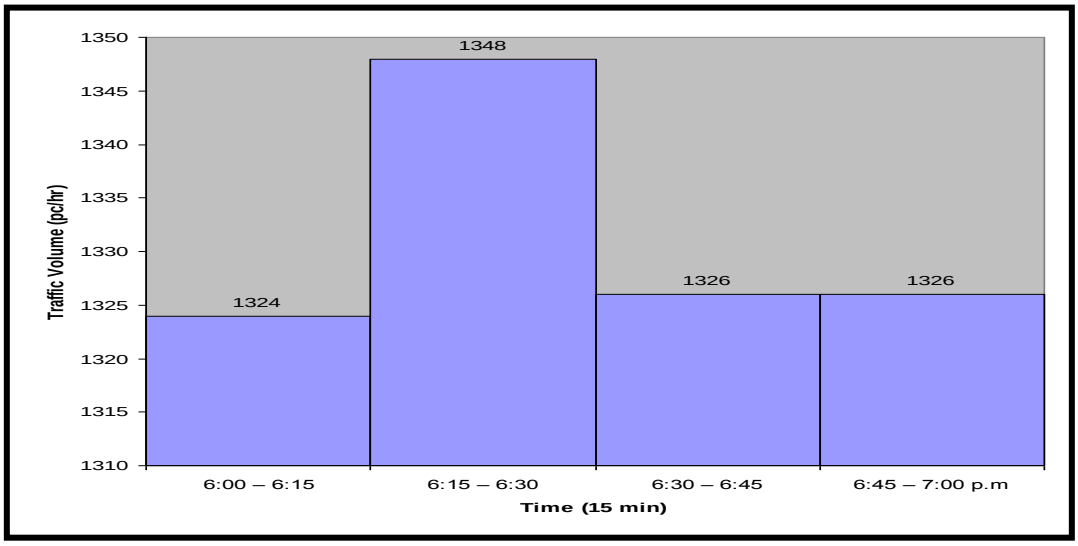

Fig. 2 Traffic volume at Al-Abasse intersection form 6:00 p.m to 7:00 p.m for all approaches for each (15 min)

Peak Hour Factor

The peak hour factor is defined as the ratio of total hourly volume to the maximum 15- min rate of flow within the hour.

The peak hour factor is calculated for each movement in each direction in Al-Abasse intersection by using the data mentioned in Table (1). Results of PHF are shown in Table (3) below.

Table 3. PHF values for Al-Abasse intersection approaches

Approch	Movement	PHF(%)
From Al–Mahkama Int.	L	93
	TH	97
	R	88
From Maysaloon Sq.	L	94
	TH	97
	R	76
From Al–Kamaleat Int.	L	99
	TH	97
	R	83
From New St.	L	94
	TH	97
	R	98

Table 4. Saturation flow for Al-Abasse intersection approaches

Approch	Saturation flow
From Al–Mahkama Int.	4337
From Maysaloon Sq.	4314
From Al–Kamaleat Int.	4217
From New St.	4242

Saturation Flow

Saturation flow represents one of the main parameter in which has a major affect in the capacity of intersection (TRB, 1985). The existing saturation flow is calculated by using (HCS 2000 Software). Table (4) shows the calculated saturation flow at the stop line for all approaches in Al-Abasse intersection by using HCS Software.

Existing Geometric Design

The evaluating of existing level of service needs to specify the number of lanes in addition to the direction of each movement. Fig. (3) shows Existing geometric layout for Al-Abasse intersection.

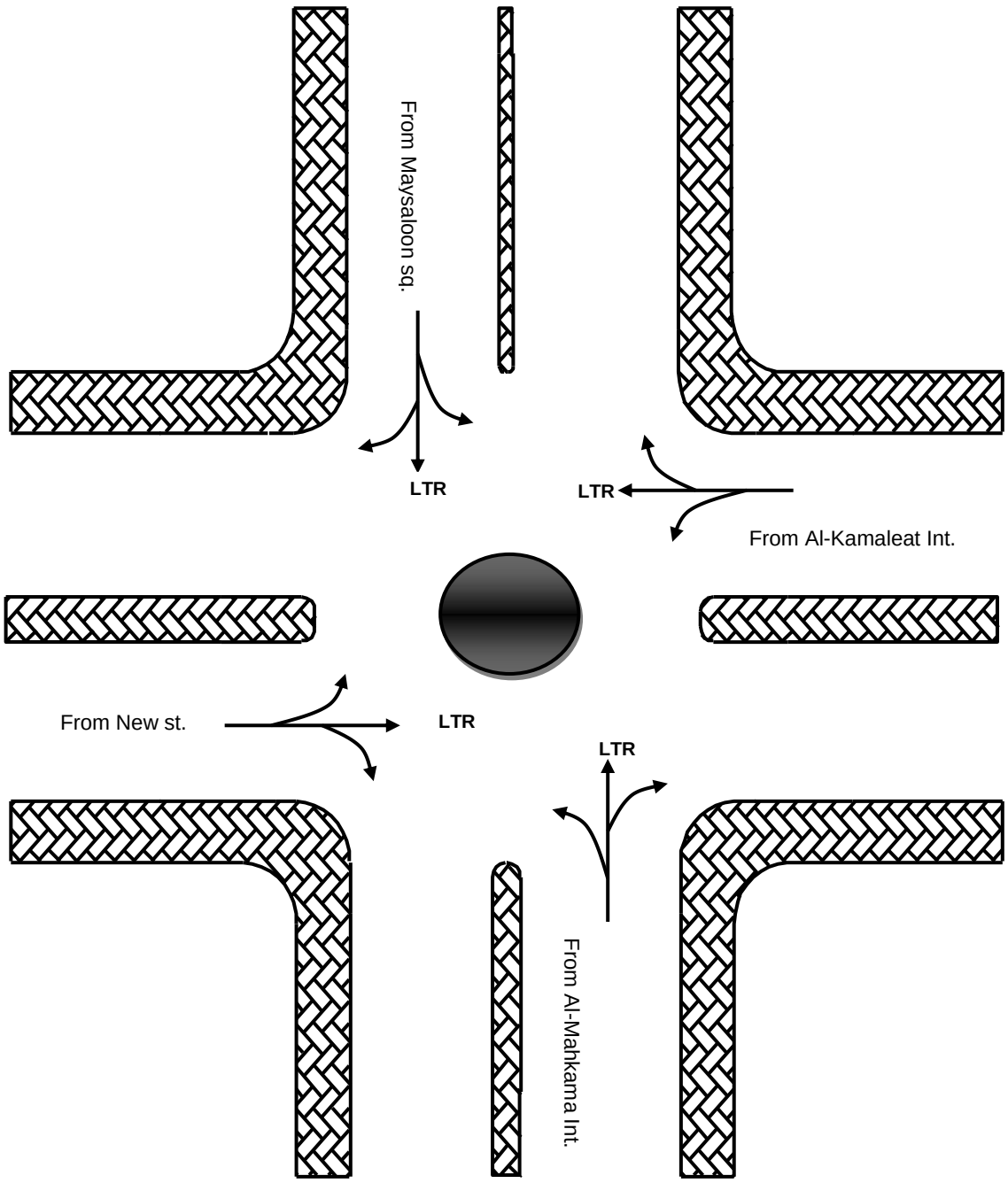

Fig 3. Geometric layout and traffic movement for Al – Abasse intersection

ANALYSIS and RESULTS

Existing (LOS) at Al-Abasse Intersection

The Highway Capacity Software (HCS 2000) is adopted to analyze traffic conditions and achieved the existing capacity, volume to capacity ratio and calculation of estimated delay for each traffic movement at each approach.

After specifying the peak hour which represents the design hour volume, it is very important to estimate the level of service (LOS) at Al-Abasse intersection with existing geometric design and traffic flow.

To estimate the LOS For existing condition, the average delay at Al-Abasse intersection must be calculated because the average delay represents the main parameter for LOS estimation.

According to Highway Capacity Manual, the (LOS) of signalized intersections can be classifies into six types depending on the value of average delay as shown in Table (5).

By using HCS program, the average delay for existing geometric at Al-Abasse intersection is (242.2) sec/veh and according to the U.S Highway Capacity Manual, Al-Abasse intersection will operate in LOS (F). Table (6) shows the average delay and LOS's while Table (7) show traffic operation of Al-Abasse intersection for all approaches connected with this intersection at existing condition.

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

Level of service (LOS)	Control delay per vehicle 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	$80 < d$

Table 6. Existing LOS at Al-Abasse intersection

Approch	Average Delay (sec/veh)	Level of Service (LOS)
From Al–Mahkama Int.	116.9	F
From Maysaloon Sq.	168.2	F
From Al–Kamaleat Int.	296.5	F
From New St.	337.1	F
Intersection Average Delay	242.2	F

Table 7. Properties of existing traffic operation at Al-Abasse intersection

Approch	Movement	Volume	HV (%)	PHF (%)	No. of Lanes	Phase No.	Cycle Length (sec)	
							G	Y
From Al–Mahkama Int.	L	208	3	93	3	1	27	3
	TH	732	5	97				
	R	161	7	88				
From Maysaloon Sq.	L	368	4	94	3	2	27	3
	TH	686	6	97				
	R	133	2	76				
From Al–Kamaleat Int.	L	427	7	99	3	3	27	3
	TH	926	9	97				
	R	103	5	83				
From New St.	L	418	6	94	3	4	27	3
	TH	939	8	97				
	R	223	3	98				
Total							120	

Proposals for Improvement Al – Abasse Intersection

Proposal (1)

This proposal contains improvement of intersection by adding some parameter to enhance LOS of this proposal .These Parameters are:

1. Changing phasing time for the intersection.

The expected average delay at the at Al-Abasse intersection will be (84.9) sec/veh, which means the intersection, will be in LOS (F). Table (8) shows the average delay and LOS's while Table (9) show traffic operation of Al-Abasse intersection for all approaches connected with this Intersection by adopting proposal No.1.

Table 8. Level of service for Al-Abasse intersection by adopting proposal No.1

Approch	Average Delay (sec/veh)	Level of Service (LOS)
From Al–Mahkama Int.	73.8	E
From Maysaloon Sq.	108.2	F
From Al–Kamaleat Int.	70.1	E
From New St.	88.5	F
Intersection Average Delay	84.9	F

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

Approch	Movement	Volume	HV (%)	PHF (%)	No. of Lanes	Phase No.	Cycle Length (Sec)	
							G	Y
From Al–Mahkama Int.	L	208	3	93	4	1	23	3
	TH	732	5	97				
	R	161	7	88				
From Maysaloon Sq.	L	368	4	94	4	2	23	3
	TH	686	6	97				
	R	133	2	76				
From Al–Kamaleat Int.	L	427	7	99	4	3	31	3
	TH	926	9	97				
	R	103	5	83				
From New St.	L	418	6	94	4	4	31	3
	TH	939	8	97				
	R	223	3	98				
Total							120	

Proposal (2)

This proposal contains improvement of intersection by adding some parameter to enhance LOS of this proposal .These Parameters are:

1. Changing phasing time for the intersection.
2. Execution of flyover along New street – Al – Kamaleat intersection approaches.

For this proposal the expected traffic volume at ground level in Al-Abasse intersection will be as shown in Figure (4). The expected traffic volume, which will be use the proposed flyover, will be as follow:

- About (939) (veh /h) along New street to Al – Kamaleat intersection in peak hour.
- About (926) (veh/h) along Al – Kamaleat intersection to New street in peak hour.

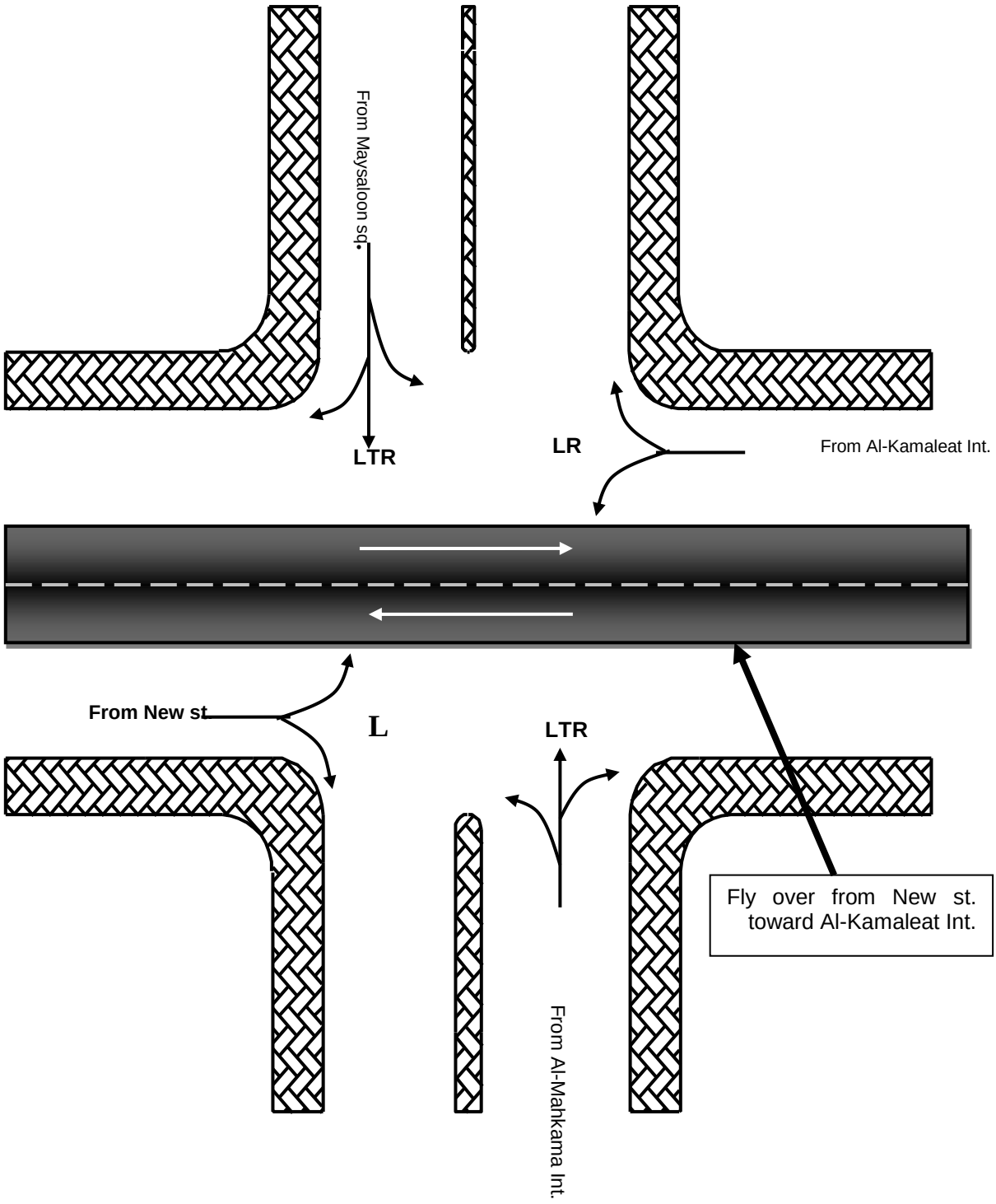

Fig.4 Proposal No. 2 for Al-Abasse intersection

For the base year, the results of analysis show that the average delay is (35.9) sec/veh, and the intersection will operate at LOS (D). Table (10) show the average delay and LOS's while Table (11) show traffic operation of Al-Abasse intersection for all approaches connected with this Intersection by adopting proposal No.2 at the base year.

For target year (after 20 years with 2% annual increasing rate). The average delay will be (41.6) sec/veh and the intersection will operate at LOS (D). Table (12) show the average delay and LOS's.
Table (13) show traffic operation of Al-Abasse intersection for all approaches connected with this Intersection by adopting proposal No.2 at the target year.

Table 10. Level of service for Al-Abasse intersection by adopting proposal No.2 at the base year

.Approch	Average Delay (sec/veh)	Level of Service (LOS)
From Al–Mahkama Int.	33.2	C
From Maysaloon Sq.	33.5	C
From Al–Kamaleat Int.	40.6	D
From New St.	41.7	D
Intersection Average Delay	35.9	D

Table 11. Properties of traffic operation at Al-Abasse intersection by adopting proposal No.2 at the base year

Approch	Movement	Volume	HV (%)	PHF (%)	No. of Lanes	Phase No.	Cycle Length (Sec)	
							G	Y
From Al–Mahkama Int.	L	208	3	93	4	1	41	3
	TH	732	5	97				
	R	161	7	88				
From Maysaloon Sq.	L	368	4	94	4	2	42	3
	TH	686	6	97				
	R	133	2	76				
From Al–Kamaleat Int.	L	427	7	99	2	3	28	3
	R	103	5	83				
From New St.	L	418	6	94	2			
	R	223	3	98				
Total							120	

Table 12. Level of service for Al-Abasse intersection by adopting proposal No.2 at the target year.

Approch	Average Delay (sec/veh)	Level of Service (LOS)
From Al–Mahkama Int.	38.7	D
From Maysaloon Sq.	41.3	D
From Al–Kamaleat Int.	44.7	D
From New St.	45.1	D
Intersection Average Delay	41.6	D

Table 13. Properties of traffic operation at Al-Abasse intersection by adopting proposal No.2 at the target year

Approch	Movement	Volume	HV (%)	PHF (%)	No. of Lanes	Phase No.	Cycle Length (Sec)	
							G	Y
From Al–Mahkama Int.	L	308	3	93	4	1	41	3
	TH	1088	5	97				
	R	328	7	88				
From Maysaloon Sq.	L	547	4	94	4	2	42	3
	TH	1020	6	97				
	R	198	2	76				
From Al–Kamaleat Int.	L	636	7	99	2	3	28	3
	R	153	5	83				
From New St.	L	621	6	94	2			
	R	331	3	98				
Total							120	

Design of Flyover at Target Year

Direction from New Street toward Al–Kamaleat Intersection

(SF: saturation flow, v/c : flow rate to capacity, $f_{HV:}$ adjustment factor for heavy vehicles in traffic stream, f_w: adjustment factor for lane width, N: number of lanes).

$(1 + r)^n = (1 + 0.02)^{20} = 1.486.$

(r: annual growth rate, n: number of years)

SF = 939*1.486 =1396 pc/h

Assume LOS (D)

v/c = 0.80

f_{HV} =1.0

f_w = 0.93 (use standard lane with 1 ft obstruction on both sides)

N = (1396 / (1900 * 0.8 * 0.93 * 1.0 * 1.0)) = 0.98 lanes

So use one lane.

Direction from Al–Kamaleat Intersection toward New Street

SF = 926*1.486 =1377 pc/h

Assume LOS (D)

v/c = 0.80

f_{HV} =1.0

f_w = 0.93 (use standard lane with 1 ft obstruction on both sides)

N = (1377 / (1900 * 0.8 * 0.93 * 1.0 * 1.0)) = 0.97 lanes

So use one lane.

CONCLUSIONS

By considering the previous mentioned results, and throughout the presented two proposals, it is concluded that proposal No. (2) is the best proposal to improve the level of service in Al-Abasse intersection in Fallujah city.

This proposal include construct flyover along New street toward Al – Kamaleat intersection and changing the phasing in at grade Al-Abasse intersection.

This proposal make the at grade intersection work in LOS (D) for target year. The results for base and target year are accepted according to the international traffic specification.

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