Improving of Traffic Capacity for Congested Square in Baghdad City

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الخلاصة

إن الزيادة في حجم المرور في التقاطعات إحدى المشاكلِ المهمة التي تَجعل إدارة وحركةَ المرور في هذه التقاطعاتِ صعبة والتي تؤدي إلى الازدحام في هذه المناطقِ.

تعتبر الطاقة الاستيعابية ومستوى الخدمة اعتبارات مهمةَ ونقاطَ سيطرةِ تحليلِ التقاطعات لتَقييم عملية تشغيل التقاطعِ. إن الدراسة الحاليةَ تَتعامل مع أهداف تقييمِ الاستيعابية ومستوى الخدمة في ساحة المتحف في مدينة بغداد، وتطوير إستراتيجيات التحسينِ البديلة للتغلب على مشاكلِ عملية تشغيل المرور ولتَقديم أفضل اقتراح لتَحسين الأداءِ من وجهة نظر الاستيعابيةَ.

لإنجاز هذه الأهداف، جمع بيانات الحجوم المروريةَ والتخطيطَ الهندسي لساحة المتحف المطلوبة لغرض التحليل المروري والهندسي للتقاطع تم جمعها يدويا ، بينما برنامج المرور SIDRA استخدم لمتطلبات التحليل المروري.

لقد تم استنتاج أن تنفيذ مجسر يربط بين المرور القادم من تقاطع التجنيد باتجاه ساحة دمشق يكون هو الاقتراح الأفضل لتحسين الاستيعابية وعملية تشغيل المرور في ساحة المتحف.

Abstract :

The increase in traffic volumes at intersections is one of the important problems that makes difficulties in the traffic operation management and movement then leads to traffic congestion in these facilities.

Capacity and level of service are important considerations and control points for the analysis of intersections and evaluate the operation of the intersection.

The present paper is dealing with the objectives of the evaluation of the capacity and the level of service at Al-Mat'haf square in Baghdad City, and development of alternative improvement strategies to overcome the traffic operation problems and to present a best proposal to enhance the performance from the capacity point of view.

To achieve these objectives, the traffic volumes data collection and geometric layout for Al-Mat'haf square that required for the traffic and geometrical analysis were gathered manually, while SIDRA traffic program is used for the requirements of traffic analysis process.

It has been concluded that, fly over connect the direction arrived from Al-Tajneed intersection towards Damascus square is the best proposal to improve the capacity and traffic operation ability of Al-Mat'haf square.

Keywords

Traffic Capacity, Traffic Operation, Level of Service (LOS), Saturation Flow.

Introduction:

Traffic congestion is a major problem in cities of all sizes. It's a condition on any intersection as use increases and is characterized by slower speeds, longer trip times, and increased queuing [1].

Al-Mat'haf square is one of the congested locations in Baghdad, this square located in Al-Alawi district, which represents one of the principle center in Al-Karkh side. Al-Mat'haf square represent, a central path of a high traffic volume, because this square located at the main principle ring connected between the capital Baghdad and the western and southern cities those located closely to Baghdad. During this time and due to the closing of the traffic movements on Al-Mua'alaq Bridge and Al-Qadisiyah highway. The main alternative to reach Baghdad center is through Al-Mat'haf square. This results an increase in traffic volume passing through this location. The daily site observation obvious that the vehicle queue at the main approach exceed the distance from Al-Mat'haf square and Damascus intersection. The hourly traffic volume for the approach from Damascus intersection to Al-Mat'haf square is about (5000 veh/hr), the capacity for Al-Mat'haf square is lower than the traffic volume passing through this intersection. This reflects the increasing in the rate of delay in vehicles at this intersection. Accordingly, the LOS is decreased to the lowest level. AL-Alawi area contains different activities, those affect negatively on the LOS of Al-Mat'haf square. These activities can be summarized as:

1. Existing of two parks at the both side of Al-Mat'haf square, the vehicles activity of entrance and exit the parks affect the capacity of the intersection.
2. High pedestrian volume at the study area, pedestrian random passing at the boundary locations and the conflict at the stop line.
3. The random uses of the public transport buses to the "on street parking" at the approaches of Al-Mat'haf square. These vehicles affect badly and directly on the traffic flow in different directions.

Objectives of the Study:

The main objectives of this traffic study are:

a. Estimating and evaluating the LOS for the existing situation at Al-Mat'haf square.

b. Estimating the maximum traffic capacity, average delay and average queue on Al-Mat'haf square at the existing situation.

c. Present proposals of geometric design to achieve a higher traffic capacity at Al-Mat'haf square to solve the existing congestion problem for the base and target years.

Background:

Capacity, delay and level of service are major parameters for evaluating intersection operations.

Capacity is the maximum rate at which vehicles can pass through a given point in an hour under prevailing conditions; it is often estimated based on assumed values for saturation flow. Capacity is determined by a number of factors: the number and width of lanes and shoulders; merge areas at interchanges; and roadway alignment (grades and curves) [2].

Delay in the realm of signalized intersections is associated with the time lost to a vehicle and/or driver because of the operation of the signal and the geometric and traffic conditions present at the intersection. While delay in the HCM 2000 context is defined as the difference between the travel time actually experienced and the reference travel time that would result during ideal conditions; in the absence of traffic control, in the absence of geometric delay, in the absence of any incidents, and when there are no other vehicles on the road. There are several different types of delay that can be measured at an intersection, and each serves a different purpose to the transportation engineer. The signalized intersection capacity and LOS estimation procedures are built around the concept of average control delay per vehicle. Control delay is the portion of the total delay attributed to traffic signal operation for signalized intersections. Delays can be reduced, by improving the traffic operation of the signalized intersection. Intersections improvements rank as one of the most cost-effective energy conservation strategies in urban areas [3,4].

Level of service is a measure by which transportation planners determine the quality of service on transportation devices, or transportation infrastructure, Levels of service range from A to F; A being the best when drivers are not influenced by other vehicles, and F being the worst, where LOS for signalized intersections are based on average stopped delay time per vehicle as shown in Table(1).

Table (1): Level of Services Criteria [2]

Level of Service (LOS)	Average Delay (Sec.)
A	< 10
B	> 10 – 20
C	> 20 – 35
D	> 35 – 55
E	> 55 – 80
F	> 80

Study Area:

For the purpose of traffic movement study at Al-Mat'haf square, it is necessary to evaluate the proposals, which will be presented in this study by considering the coordination with the other closely intersection. Therefore, and regarding to the abnormal situation of the traffic movement during this period at the most intersections reflects unreal view for the traffic movements at these intersections.

This abnormal traffic movement can be related to the closing of Al-Qadisiyah highway and canceled the real performance of the following intersections; Al-Shakiriyah, Al-Shawa'af, Oman, Al-Tashre'e, Al-kharijyah, Al-Tajneed, Al-senak and Damascus.Accordingly the present study concentrate on Al-Mat'haf square only, and the goal of this study is to improve the LOS at this square and to reach the highest efficiency within the existing situation and considering the future situation if the traffic flow retained to its normal situation. Figure (1) presents the closely intersections and approaches to Al-Mat'haf square, and the direction of the main movements at the intersection.

Figure (1): Satellite Image of Al Mat'haf Square

Traffic Data Collection

As per the international specifications, e.g. U.S and Australian specification .Traffic study for the Intersections required to carryout the following traffic surveys.

A. Traffic Volume Account

Estimate the traffic volume at the intersection, by counting the hourly traffic volume at Al-Mat'haf square for 12 hours from (7:00 am to 7:00 pm) the workday of the week from (10 April to 20 April) 2005. This survey aims to find the peak hour volume, which represent the design hourly volume. The traffic volume measurement are carried out for three times at Al-Mat'haf square and the highest traffic volume where considered and the vehicles are classified in two types small and large, the small vehicles represent passenger cars and minibus. This group can be represented by all the vehicles drives on four tires. While the large vehicles represent the other vehicles for the public transport and the vehicles drive on more than four tires. The most of the large vehicles is the public transport vehicle (large buses), accordingly it proposed to use the passenger car unit equal to (2.0). The traffic survey is carried out from Sunday to Wednesday to achieve the highest daily traffic volume. Table (2) present the traffic volume at Al-Mat'haf square for the daily hours from (7:00 am to 7:00 pm), knowing that the traffic volume is counted

every (15 min.) and the international specification was followed in this process. Figure (2) presents all the movements those mentioned in Table (2).

Table (2): Traffic Volume At Mat'haf Square from 7:00 A.M to 7:00 P.M

Time	mov.1	mov. 2	mov. 3	mov.4	mov.5	mov. 6	mov. 7	mov. 8
7-7:15 a.m	338	237	17	123	35	32	156	40
7:15-7:30	365	249	13	150	52	49	214	37
7:30-7:45	585	287	21	165	59	51	285	49
7:45-8:00	733	315	26	200	98	77	314	71
8:00-8:15	864	404	38	242	151	101	307	74
8:15-8:30	802	451	45	255	174	98	324	68
8:30-8:45	871	399	31	247	158	79	276	87
8:45-9:00	853	382	29	230	146	84	251	79
9:00-9:15	778	360	23	251	136	89	299	91
9:15-9:30	740	354	32	238	133	74	341	79
9:30-9:45	698	337	29	283	155	76	328	95
9:45-10:00	647	349	37	309	184	93	307	81
10:00-10:15	488	351	27	317	173	85	316	83
10:15-10:30	436	301	22	294	199	90	298	79
10:30-10:45	475	284	29	28	178	89	327	75
10:45-11:00	431	279	31	305	165	103	318	80
11:00-11:15	410	307	35	320	174	81	331	86
11:15-11:30	471	298	30	308	153	77	290	97
11:30-11:45	413	255	33	315	168	92	339	90
11:45-12:00	389	271	29	312	152	87	320	87
12:00 -12:15	375	327	26	284	144	91	362	107
12:15-12:30	401	283	19	325	162	104	379	98
12:30-12:45	413	270	28	344	147	98	436	83
12:45-1:00	365	261	24	350	160	85	455	101
1:00-1:15	368	243	27	364	199	94	486	94
1:15-1:30	377	221	25	341	186	105	469	76
1:30-1:45	349	207	21	352	182	88	452	60
1:45-2:00	330	194	19	349	170	74	439	78
2:00-2:15	317	168	22	367	187	69	407	69
2:15-2:30	329	189	27	350	167	61	431	71
2:30-2:45	381	214	18	397	144	72	396	62
2:45-3:00	365	205	25	385	139	65	372	52
3:00 -3:15	316	180	24	392	151	74	335	49
3:15-3:30	289	176	16	381	178	68	347	47
3:30-3:45	270	165	15	377	189	69	350	52
3:45-4:00	235	149	18	369	154	75	321	40
4:00 -4:15	231	138	20	355	136	64	291	42
4:15-4:30	244	148	16	346	19	69	254	53
4:30-4:45	239	129	21	317	121	55	259	47
4:45-5:00	251	142	19	326	118	58	271	48
5:00 -5:15	224	168	14	272	107	49	240	42
5:15-5:30	251	159	17	264	98	40	252	39
5:30-5:45	274	172	16	258	121	56	239	42
5:45-6:00	269	155	12	252	115	52	221	50
6:00 -6:15	279	174	15	244	121	46	217	49
6:15-6:30	291	181	17	262	139	59	240	56
6:30-6:45	288	169	22	260	144	68	239	44
6:45-7:00 pm	305	192	16	236	138	56	241	48

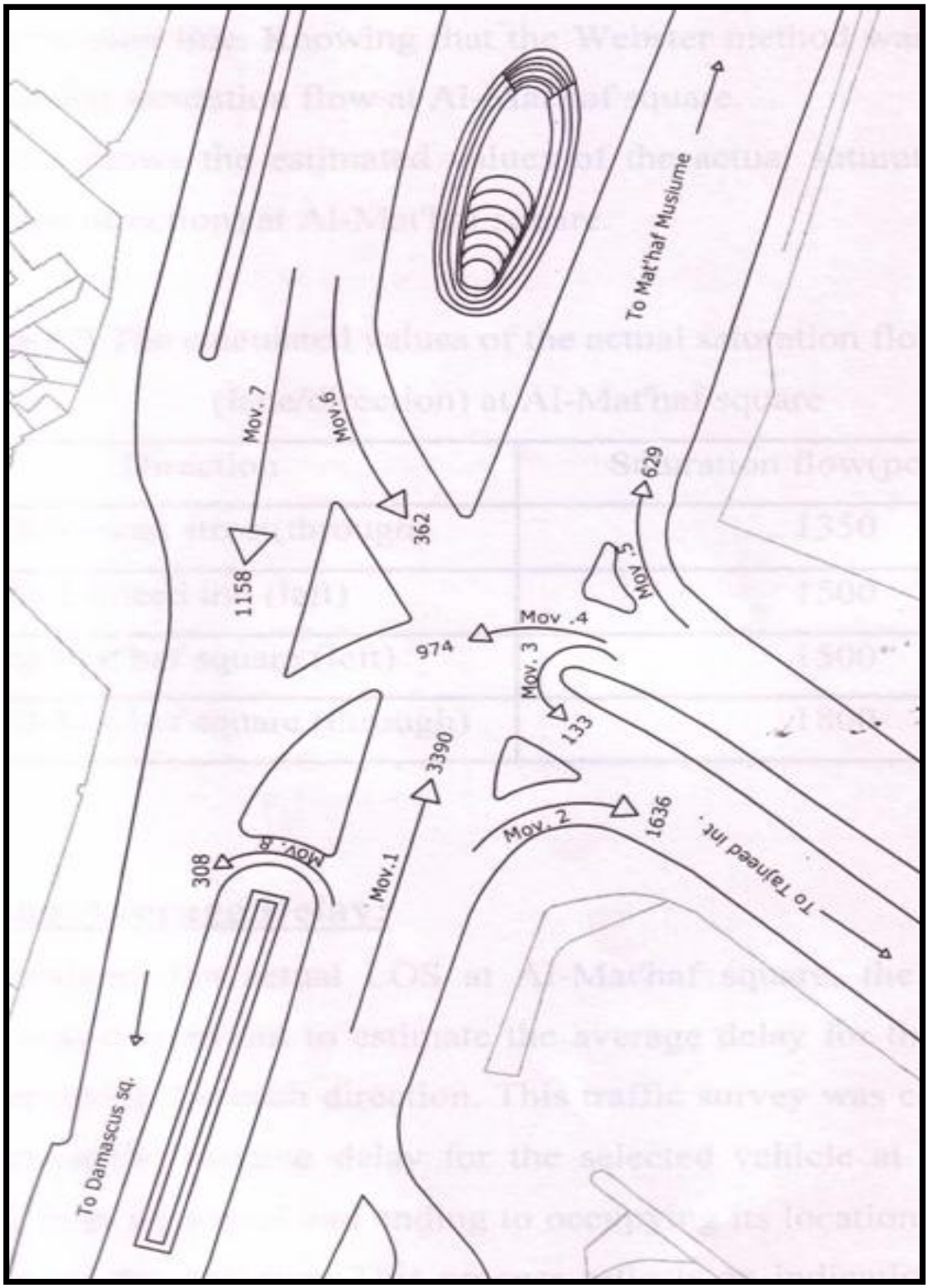


Figure (2): Traffic Volume at Al-Mat'haf Square in Base Year (2005)

B. Saturation Flow

One of the main information that required for this study is the calculation of saturation flow for each direction at the stop line in the specified intersection, on the bases of calculation the actual saturation flow for each lane at the stop line. Knowing that the Webster method was followed to calculate the saturation flow at Al-Mat'haf square. Table (3) shows the estimated values of the actual saturation flow for each (lane/direction) at Al-Mat'haf square.

Table (3): Calculated Values of the Actual Saturation Flow for Each (Lane/Direction) at Al-Mat'haf Square

Direction	Saturation flow(pc/hr/lane)
From Damascus street(through)	1350
From Al-Tajneed int. (left)	1500
From Al-Mat'haf square (left)	1500
From Al-Mat'haf square (through)	1800

C. Existing Average Delay:

To investigate the actual LOS at Al-Mat'haf square, the field traffic survey was carried out to estimate the average delay for the vehicles at the intersection for each direction. This traffic survey was carried out by considering the existing delay for the selected vehicle at this location starting from its arrival and ending to occupying its location at the queue tile passing the stop line. This process reflects an indication to the real average delay for the intersections. The international specification e.g. U.S. specification depends mainly on the real average delay for (10 min.). This process depends on the account of the arrival and departure time for the vehicles and its numbers. According to the calculated data from this method, the real average delay at the intersection was calculated as a sample that can be used to represent the average delay for the vehicles at the intersection. Consider that this method cannot be applied at the intersection with a degree of saturation of (90%) and more. This can be related to the difficulties in calculation of the arrival time accurately, in addition to the high length of queue. Accordingly, it is suggested to apply the method that depends to select random samples for a known numbers of vehicles.

Table (4) presents the average delay at Al-Mat'haf square during the peak hour, which is found to be between (8:00 am to 9:00 am).

Table (4): Existing Average Delay at Al-Mat'haf Square for Peak Hour

Direction	Average delay (sec/veh.)	No. of trails
Arrive from Damascus sq.(through)	325	15
Arrive from Al-Tajneed int.(left)	210	15
Arrive from Al-Mat'haf square (left)	125	15

From the above Table, it is obvious that the LOS at Al-Mat'haf square is (LOS-F) which represents the lowest LOS according to the international specifications.

Geometrical Characteristics of The Intersection:

The following information is required to complete the traffic study:

a. Number of lanes.

b. Width of lanes.

As previously mentioned, the existing geometric layout of Al-Mat'haf square is presented in Figure (3).

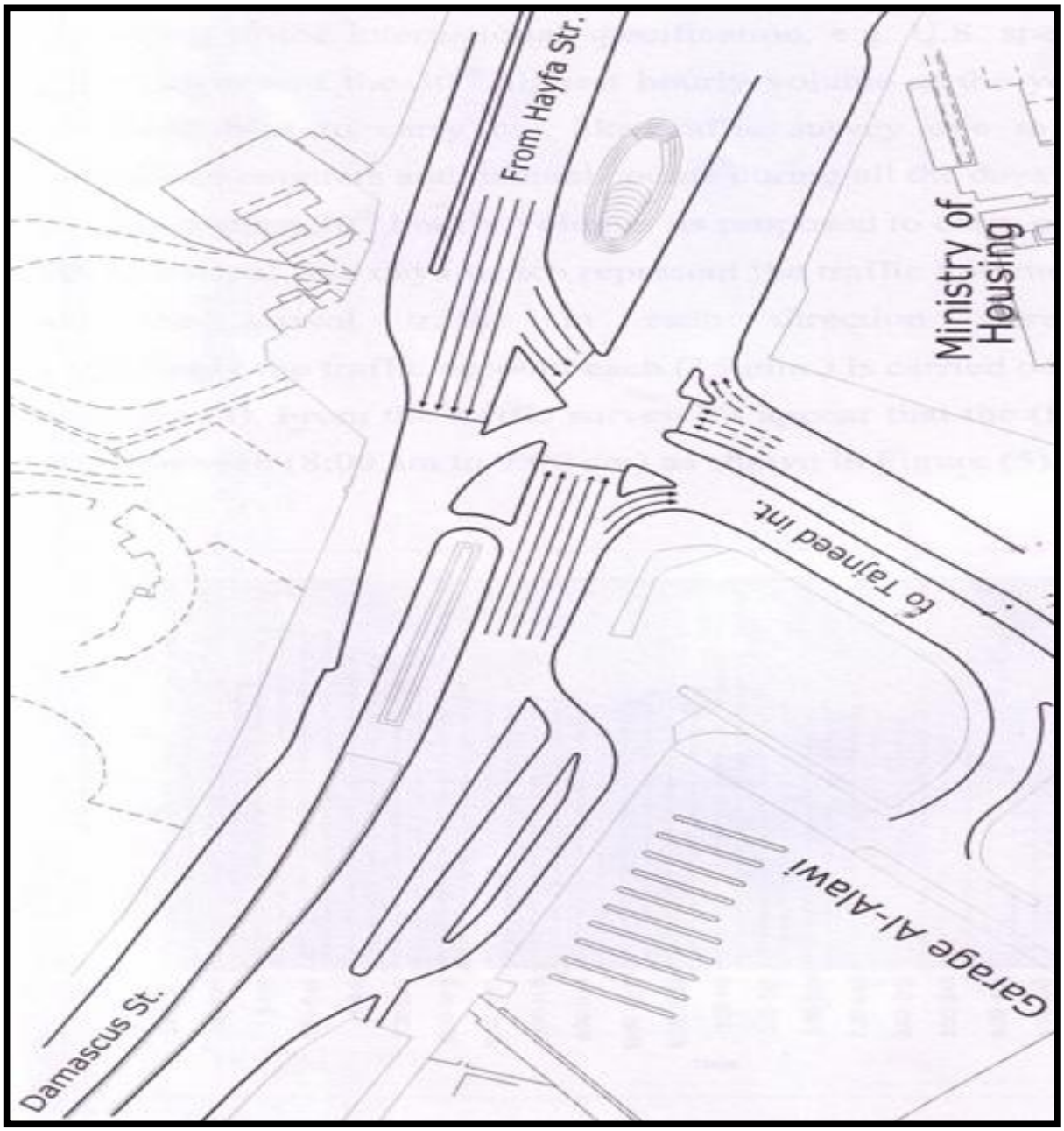


Figure (3): Geometric Layout for Al- Mat'haf Square

Analysis and Results

A. Peak hour

For the purpose of carrying out the traffic study on Al-Mat'haf square. It is important to calculate the design hourly traffic volume (DHV). According to the international specification, e.g. U.S. specifications the (DHV) represent the 30th highest hourly volume at the year. Regarding the difficulties to carry out like traffic survey due to the needs of mechanical counters and manual counts during all the days in the year. To find the highest 30th hourly volume, its proposed to carry out the a counts during normal five days, which represent the traffic volume for one week and the arrival traffic in each direction were considered. Accordingly the traffic account each (15 min.) is carried out, as presented in Figure (4). From the traffic survey it's appear that the (DHV) is found to be between (8:00 am to 9:00 am) as shown in Figure (5).

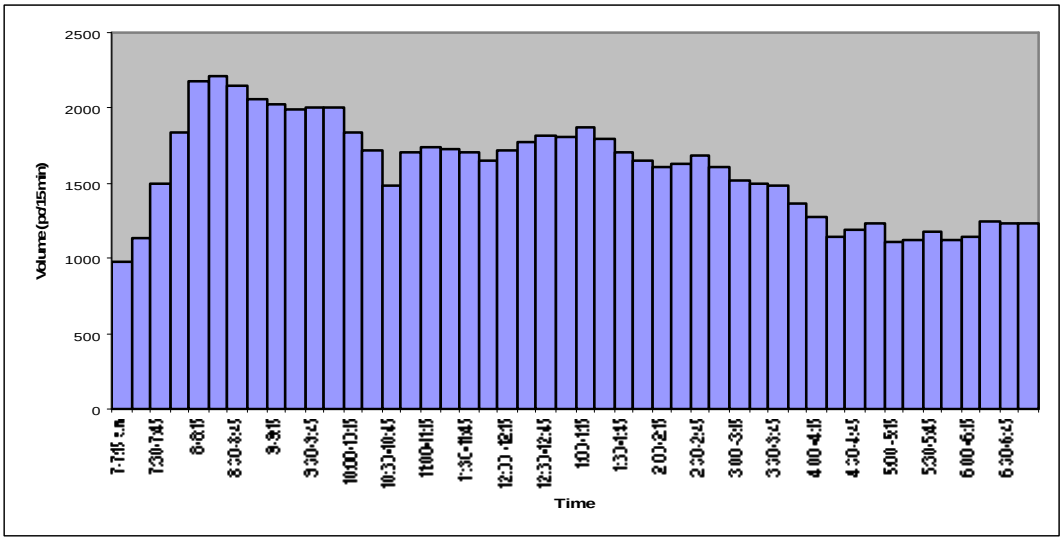
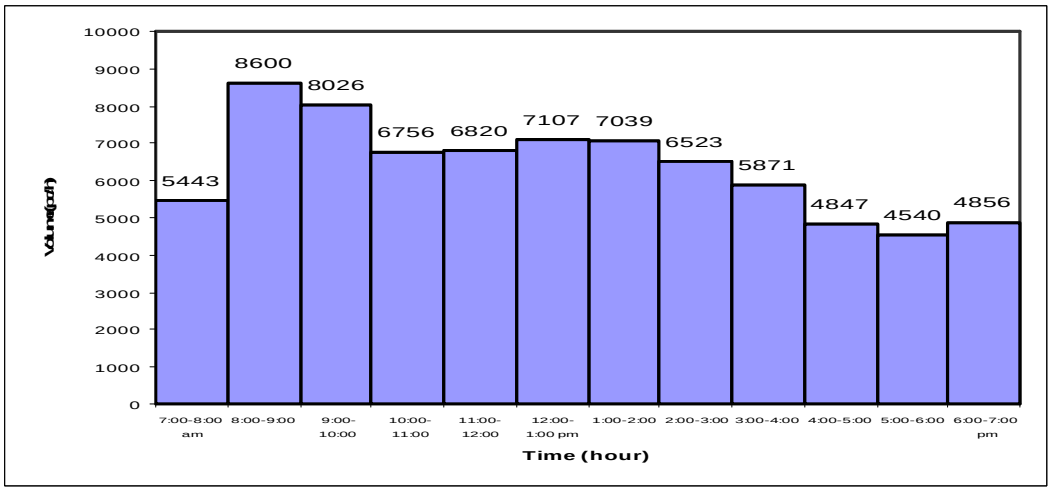


Figure (4): Traffic Accounts Each (15 Min.)



Figure(5):Variation of Traffic Flow at Al-Mat'haf Square

B. Calculating of a peak hour factor (PHF)

The main coefficients used to evaluate the LOS at the intersection are depends practically on the value of the (PHF). According to the significant role of this factor the traffic account every (15 min.) at the intersection is used to calculate the (PHF). Table (5) represents the values of (PHF) for each direction at Al-Mat'haf square.

Table (5): (PHF) Values of Al-Mat'haf Square.

Direction	PHF
Arrival from Damascus square	0.95
Arrival from Al-Tajneed intersection	0.94
Arrival from Al-Mat'haf square	0.92

C. Existing Level of Service

For the purpose of LOS evaluation at Al-Mat'haf square, it is required to calculate the average delay, which represent the main factor to evaluate the LOS at the intersection that operate with a traffic signal. A specific computer programs for traffic engineering are used to calculate the existing LOS at Al-Mat'haf square. It is obvious that there is a high level of congestions at the intersection now ,which result a bad performance, and the intersection is operated in LOS (F). Knowing that the international specification divided the LOS at the intersections to six levels. LOS(A) represent the best where the average delay for the vehicle is less than (5sec/veh), while LOS (F) represent the lowest LOS where the average delay for the vehicle is more than (85 sec/veh), from the analysis process for the existing traffic volume at the Al-Mat'haf square it is appear that the average delay at the intersection is (135.8 sec/veh). In addition to the average delay there is other significant coefficients, those required to complete the evaluation process of the saturation efficiency at the intersection .These coefficients includes, degree of saturation, average stop delay, spare capacity and the total delay.

Table (6) shows the results of the obtained coefficients. . While Table (7) presents the results of significant coefficients required to evaluate the efficiency at Al-Mat'haf square at the existing situation.

Table (6): Existing LOS at Al-Mat'haf Square

Direction	Average delay (sec/veh)	Degree of saturation	LOS
Arrival from Damascus square	223.5	1.092	F
Arrival from Al-Tajneed intersection	81.6	0.946	F
Arrival from Al-Mat'haf square	33.9	0.383	C

Table (7): Results of Significant Coefficients to Evaluate the Efficiency at Al-Mat'haf Square at the Existing Situation.

Factors	Value
Average delay	135.8 (sec/veh)
Stop rate	1.78
Performance index	964.43
Practical spare capacity	-18%
Total delay	312.52(veh.h/hr)

Proposal No.1:

To enhance LOS at Al-Mat'haf square, it is required to increase the flow capacity for the intersection to be higher than the existing traffic volume. To achieve this aim and due to the difficulties in the application of extend at grade geometric design, the fly over is suggested to be the proposal No.1. This proposal includes a construction of a fly over within the path of the existing road from Damascus square to Al-Mat'haf area. Although there are many limitations and disadvantages, this proposal will be studied in details to show its efficiency and its effect on the LOS of Al-Mat'haf square.

The fly over in this proposal includes a construction of three lane road in each direction on the central path of the road connected between Damascus square and Al-Mat'haf as shown in Figure (6).The traffic analysis of this proposal for peak hour volume appear that the LOS of Al-Mat'haf at grade intersection will be "LOS-C" at the base year as shown in Table (8). While Table (9) present the value of other factors affecting the performance at the intersection.

Table (8): LOS's for Al-Mat'haf Square at The Base Year (2005).

Direction	Average delay (sec/veh.)	Degree of saturation	LOS
Arrival from Damascus square	33	0.842	C
Arrival from Al-Tajneed intersection "left"	40.9	0.820	D
Arrival from Al-Mat'haf square "left"	40.2	0.572	D

Table (9): Main Factors Affecting the Performance of Al-Mat'haf Square at the Base Year (2005).

Factor	Value
Average delay	22.50 sec/veh
Average stop	60%
Performance index	222.67
Practical spare capacity	7%
Total delay	32.1 veh.hr/hr

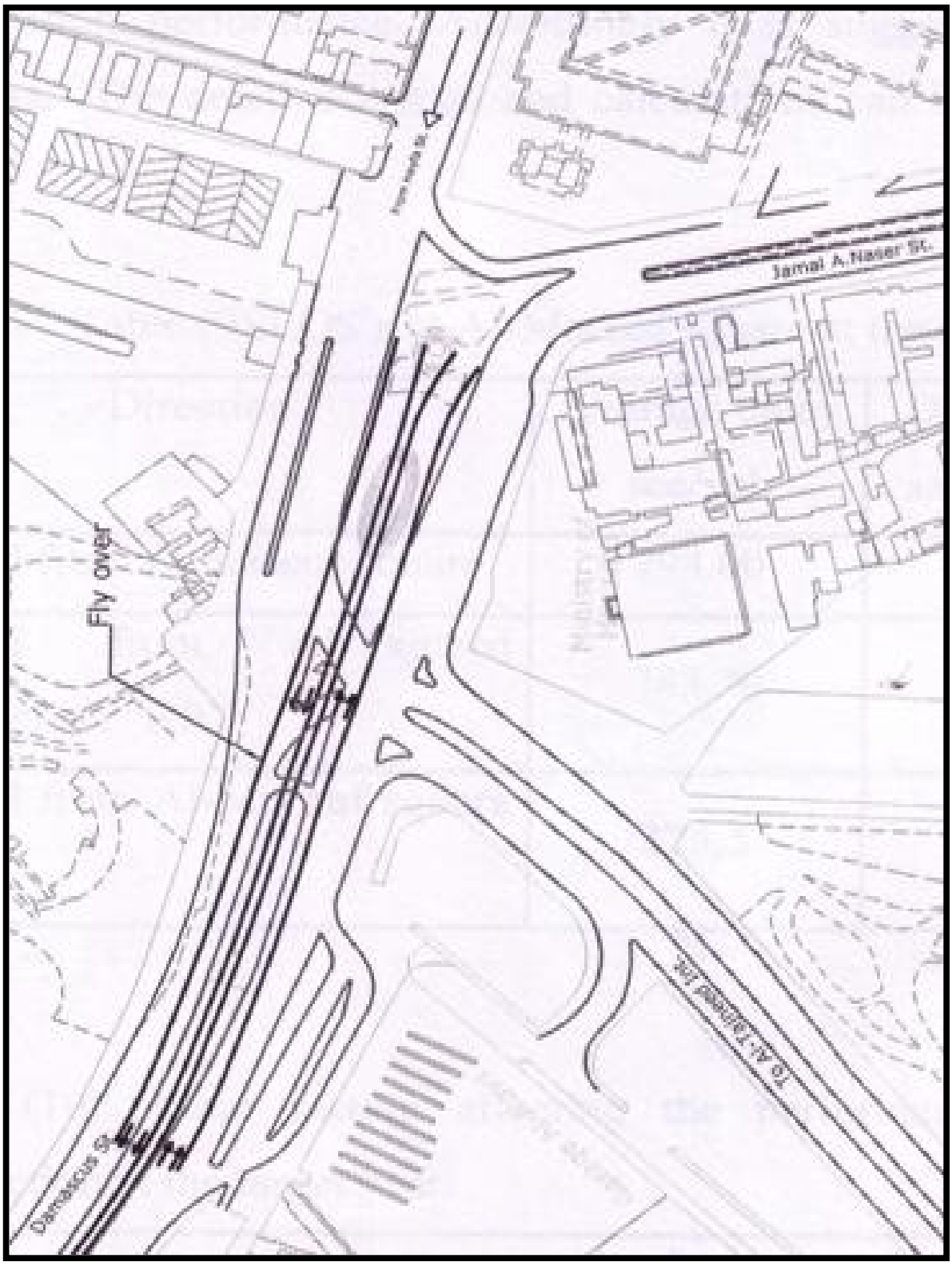


Figure (6): Proposal No.1 for Mat'haf Square

During the evaluation of the intersection LOS at the target year which is proposed to be (20)years from now and with rate of growth of 3% ; it appears that the LOS at the intersection will be "LOS F" as shown in Table (10) and the other effective factors on the performance can be seen in Table(11), while the expected traffic volume for the target year is shown in Figure (7).From the above-mentioned results, this proposal appears to be insufficient and will present the disadvantage on the intersection performance. Accordingly it is suggested to cancel this proposal .

Table (10):LOS's at Al-Mat'haf Square at the Target Year

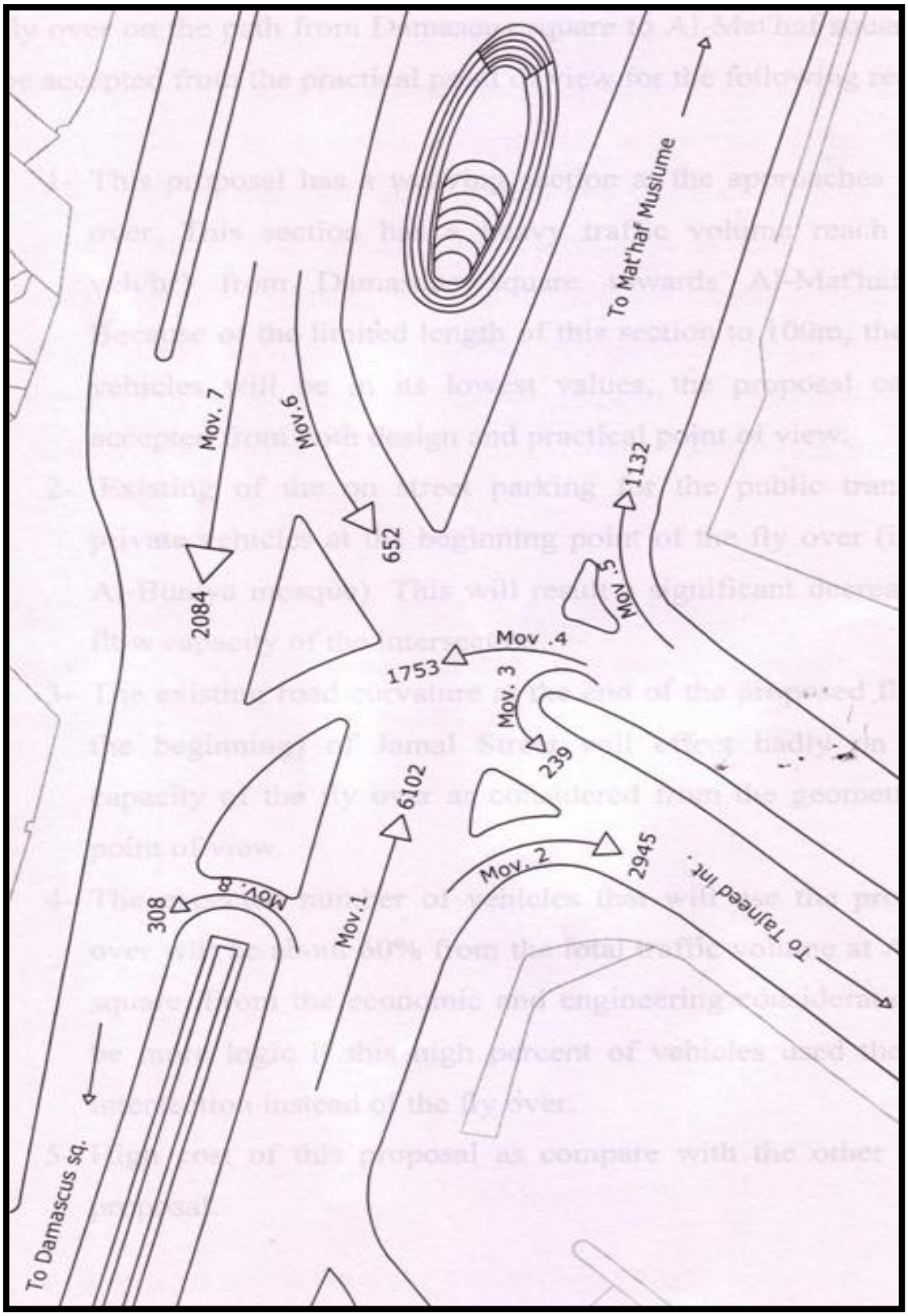
Direction	Average delay (sec/veh.)	Degree of saturation	LO S
Arrival from Damascus square	794.00	1.418	F
Arrival from Al-Tajneed intersection "left"	743.70	1.383	F
Arrival from Al-Mat'haf square "left"	125.5	0.964	F

Table (11): Main Factors Affecting The Performance of Al-Mat'haf Intersection at the Target Year.

Factor	Value
Average delay	555.3 sec/veh.
Stop rate	400.38%
Performance index	3009.74
Practical spare capacity	-37%
Total delay	1425.14 veh.hr/hr

In addition to the mentioned results those obtained from the traffic analysis and present previously in Tables (8, 9, 10 and 11) ,the construction of fly over on the path from Damascus square to Al-Mat'haf square can not be accepted from the practical point of view for the following reasons:

1- This proposal has a weaving section at the approaches of the fly over. This section has a heavy traffic volume reach to (5000 veh/hr) from Damascus square towards Al-Mat'haf Square. Because of the limited length of this section to 100m, the speed of vehicles will be in its lowest values, the proposal can not be accepted from both design and practical point of view.
2- Existing of the on street parking for the public transport and private vehicles at the beginning point of the fly over (in front of Al-Buniya mosque). This will result a significant decrease for the flow capacity of the intersection.
3- The existing road curvature at the end of the proposed fly over (at the beginning) of Jamal Street will effect badly on the flow capacity of the fly over as considered from the geometric design point of view.
4- The expected number of vehicles that will use the proposed fly over will be about 60% from the total traffic volume at Al-Mat'haf square .From the economic and engineering consideration ,It will be more logic if this high percent of vehicles used the at grade intersection instead of the fly over.
5- High cost of this proposal as compare with the other following proposal.



Figure(7): Traffic Volume at Al- Mat'haf Square in Target Year

Proposal No.2:

As per the present results for the first proposal, especially for the target year, it is necessary to apply a design with a high degree of efficiency at the present time and to achieve an acceptable level at the target year. Accordingly, it is proposed to construct a fly over from Al-Tajneed intersection towards Al-Mat'haf square and Damascus square with a two lane and canceled of the at grade intersection as shown in Figure (8). Throughout this proposal, the left movement which arrived from Al-Mat'haf square will be canceled and the vehicles can be achieving this movement by using Damascus intersection and this movement will be U-turn movement. By applying of this geometric design, the flow capacity will be at its highest value.

Performance of the fly over in proposal No.2:

The following analysis present that the two lane fly over will operate with accepted LOS on the base and the target year.

Base Year (2005):

LOS = C.
(V/C) = 0.67.
SF =974 pc/hr.
C_J = 2000 pc/hr.
f_w = 0.83.
f_p = 1.0.
f_{Hv} = 1.0.
N = {974 / (2000*0.67*0.83*1.0*1.0)} = 0.87 lane

Target year:

(After 20 Year)
LOS = D.
(V/C) = 0.8.
C_J = 1900 pc/hr.
SF =1753 pc/hr
f_w = 0.83.
f_p = 1.0.
f_{Hv} = 1.0.
N = {1753/(1900*0.8*0.83*0.83*1.0*1.0)} = 1.39 lane.

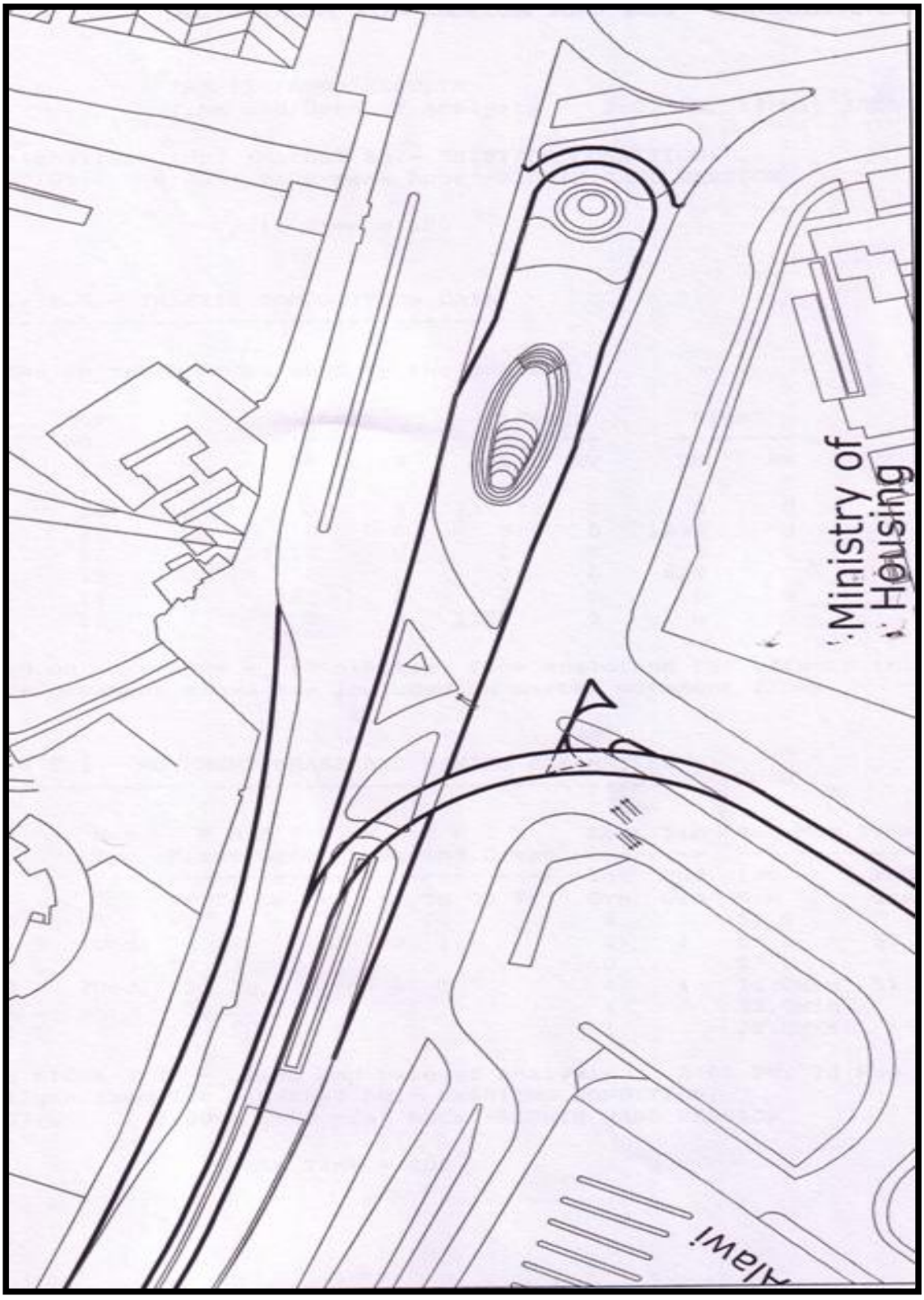


Figure (8): Proposal No.(2) for Al- Mat'haf Squar

CONCLUSIONS

As per the present results from the submitted proposals, these following points can be concluding:

1. Canceling proposal No.1as shown in Figure (6), where this proposal appears to be insufficient and will present the disadvantage on the intersection performance.
2. Applying proposal No.2, which includes the execution of fly over to connect the direction arrived from Al-Tajneed intersection towards Damascus square as shown in Figure (8).
3. Canceling the at-grade intersection at Al-Mat'haf square by using the proposed geometrical design as appear in Figure (8), this geometric design will results a highest flow capacity and lowest average delay.

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