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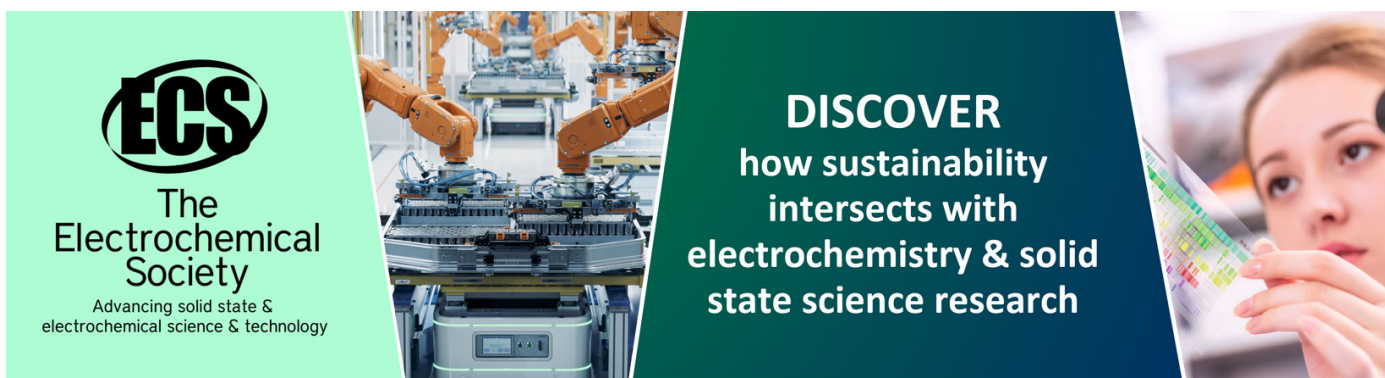
Improvement of traffic *control at intersection sites*

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Improvement of traffic control at intersection sites

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Abstract There is a frequent need for conducting an evaluation to upgrade mobility and safety at intersections. The study goal is to; examine the suitable type of control, demonstrate a typical scenario for evaluation task, and achieve suitable alternatives that solve problems of congestion and their consequences. The optimized choice with a design of traffic operation as well as the geometric layout, are proposed for each studied site. Five individual intersections were studied within Babylon province in Iraq. Three methods are adopted due to; Institute of Highway Transportation IHT, Department of Transportation DoT and Iraqi Highway Design Manual SORB, to identify the suitable control. SYNCHRO 10 software is used for analyzing operational performance for existing conditions and suggested alternatives. Due to SYNCHRO 10, most intersections operate at an unacceptable level of service. Converting the Station and Al-Irjoan intersections from TWSC type to roundabout type decreased the average delay about 97% and 95% respectively. For the signal intersections, Al-Salam and Awlad-Muslim, the indirect left turn is the best alternative with a decrease in delay by about 91% and 92% respectively. For Al-Sadah intersection, installation of a traffic signal instead of AWSC type decreased the delay about 82%. Thereby level of service raised from F to B in; The Station intersection, Al-Salam intersection and Al-Irjoan intersection. LOS also raised from D to A in Awlad- Muslim intersection and from F to C in Al-Sadah intersection.

Key words: IHT; DoT; SORB; intersection.

1. Introduction

Nowadays, transportation system constantly confronts two of the basic and serious issues; safety and congestion [1]. The key objective of this system is normally expressed as providing maximum safety and efficient mobility for both; highway users (i.e. drivers and pedestrians) in first class and the goods [2]. Traffic congestion is basically occurred because of continuous developing urban region in most of global cities making them permanent crowding. Day by day, worldwide urban cities confront this rising issue, which little by little becomes deteriorated and uncontrollable, turning into a noteworthy worry of the general people. Some of traffic congestion impacts are; level of service (represented by delay), air pollution and psychological effects. Delay is one of these impacts, in light of the fact that the number of vehicles utilizing a highway surpasses the capacity of that facility to deal with [3]. The second issue, traffic safety, is an important concern in the design and operation of intersections and highways. Since traffic crashes are a crucial contributor to deaths and injuries for highway users in many nations, traffic safety is a chief focus area of transportation agencies [4].

The intersections represent the critical part of any highway system, since their different characteristics determine the mobility and capacity of the entire system [5]. Thus, it is necessary to control and regulate traffic conflicts resulting from automobiles by applying convenient strategies. Such strategies rely mainly upon the crossing type and the vehicular volumes. The suitable control type and warrants for traffic signal installation within intersections are still a considerable and very important issue.



The main objective of installation control devices within any highway facility is to give reasonably safety and mobility for motorists and non-motorists. Control devices mostly comprise signalization and signs for warning and guidance [6]. In general, control of intersections takes three shapes; priority shape which is a simple T-intersection or cross highways, signalized or circular type and grade separation (interchange).

Traffic signals are signalizing devices positioned at highway intersections to control and regulate conflicting flows of different highway users. They are considered as one of the most limited forms of control devices that could be applied at crossing [7]. They provide a number of significant benefits such as; increase the capacity of the highway and reducing crushes [8]. But unwarranted signals might cause some problems such as; excessive delay, signal violations and traffic conflicts [9].

2. Graphical Methods of Control Types

Many local and international agencies suggested procedures to determine the suitable control type that should be submitted to an intersection. One of these procedures is the graphical methods which are depending only on the daily approaching traffic volumes.

The UK IHT [10] suggested a layout for different levels of approaching volumes. This layout consists of three regions. A priority type region that will be either a simple three-legged intersection or staggered intersection or crossroads etc. The next region is about either signalization or roundabout control. The last one is concerning with interchange control.

Another layout recommended by the US Department of Transportation DoT comprises four special regions [11]. The simple control region is similar to that in IHT. Ghost island region is a simple intersection with channelization. Single lane dualling region represents the number of traffic lanes and roundabout.

Within the same topic, Iraqi Design Highway Manual SORB [12] suggested its own layout. Similar to DoT layout, SORB layout consists of four regions too. An intersection without an island as region 1, channelization and divisional islands on minor intersecting highways may be suitable for region 2. Providing divisional islands on both major and minor intersecting highways will be convenient for region 3. Lastly, interchange will be proper for region 4. Figure 1 demonstrates the layouts for IHT, DoT and SORB.

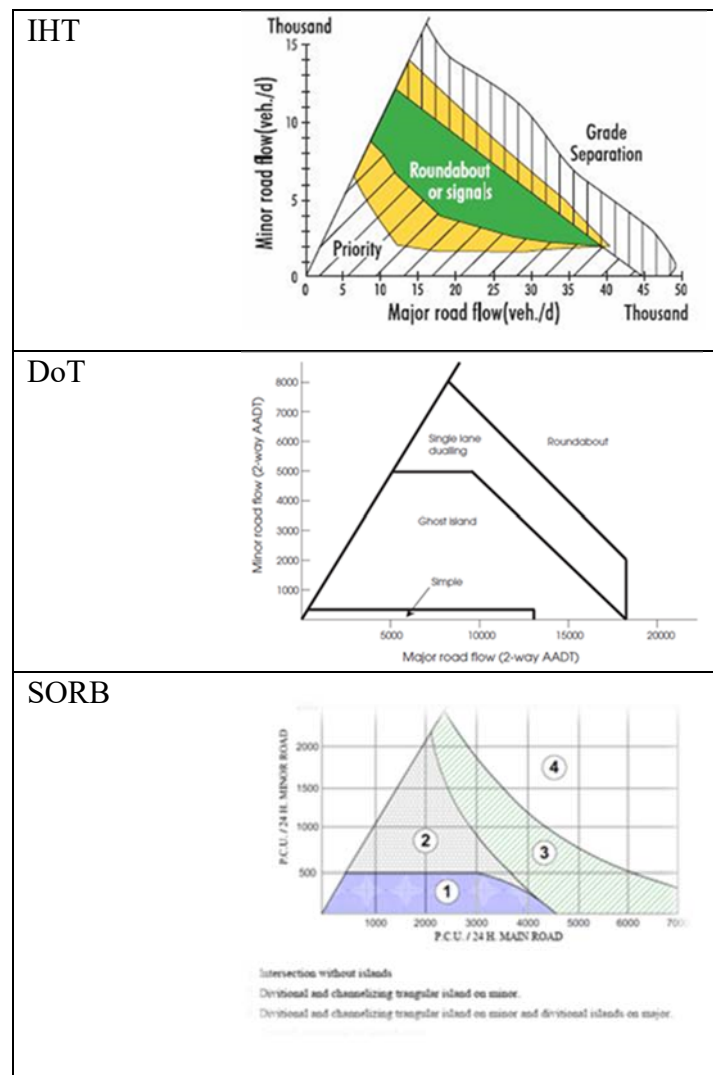


Figure 1. IHT, DoT and SORB layouts

3. Study Area

This study included five intersections which are all situated in the northern part of Babylon province in Iraq, distributed mainly on both Al-Musayib and Alexandria cities as illustrated in Figure 2. The study area represents a strategical location by connecting four provinces together; Baghdad, Babylon, Al-Anbar and Karbala. Two sites of three-legged intersections in Alexandria city are studied. One of them is an unsignalized (The Station intersection) and the other is a signalized type (Al-Salam intersection) under Baghdad-Babylon fly-over highway as shown in Plate 1. Furthermore, in Al-Musayib city, two unsignalized (Al-Irjoan intersection) with three legs and (Al-Sadah intersection) crossroad whereas the last is a signalized three-legged (Awlad-Muslim intersection).



Figure 2. Map of the selected five intersections, Babylon, Iraq.



Plate 1. Al-Salam fly-over intersection, Alexandria city, Iraq.

4. Methodology

Study data are essentially represented by two parts.

4.1 Traffic Data

Traffic data include; traffic volumes, selecting the peak hour, and traffic signal characteristics. Video techniques are basically utilized in this part for collecting vehicular volumes within the present study area in a six-hour period over two discrete weekdays per intersection. The two days are providing an appropriate sample to cover most ranges of traffic circumstances under the usual traffic circumstances; with no crash, no unusual occasions, and sunny weather condition. The video technique is considered as a reliable method for several reasons. Firstly, the films can be reviewed at any time. Secondly, human mistakes are lessened to a minimum. Finally, they are frequently situated in high vantage points which make them not noticeable by highway users (see plate 2). Consequently, highway users will not be getting distracted. As a result, the extracted films will be more accurate and reliable to a large extent but

this technique is still facing some challenges most importantly the security approval. Video recordings are continued in three periods during a specified weekday; Morning (7:00 - 9:00), Noon (1:00 - 3:00) and Evening (5:00 - 7:00). Table 1 lists the extracted hourly volumes from Al-Salam intersection.



Plate 2. A screenshot by using the video technique at Al-Salam intersection ,October, 2018

Table 1. A sample of abstracted hourly volumes at Al-Salam intersection during morning

		EB		NB		SB	
Time		Left	Right	Left	Through	U-turn	Right
7:00	7:15	173	136	129	141	21	180
7:15	7:30	195	120	127	152	25	175
7:30	7:45	227	201	220	180	37	311
7:45	8:00	270	227	232	216	46	343
8:00	8:15	245	191	200	183	34	293
8:15	8:30	266	201	194	197	41	283
8:30	8:45	233	213	187	171	44	266
8:45	9:00	257	237	203	186	43	289

4.2 Geometric Data

The main geometric data include; traffic lane number and the width of physical median and design speed. Initially, the update satellite images are used for obtaining the required data that cannot be get easily such as; corner radius, the angle of intersection and so on. ATAK (Android Tactical Assault Kit) application which is developed by the US Army is used in this purpose [13]. Also obtaining extra data are done by the related local municipalities within the study area. Lastly, traditional manual methods characterized by using a measuring tape are also used in this study.

5. Analysis and Results

This section consists of two parts. The first part is about the investigation of the proper type of control for each intersection based on the daily approaching flow. The second part is concerning with checking the operational performance with SYNCHRO software 10 for each intersection during the existing conditions and for the future alternative scenarios. These scenarios are analyzed and evaluated for short, mid and long term evaluation.

5.1 Control Type Investigation

All hourly collected volumes for the five intersections are firstly transformed to average daily traffic volumes. This transformation is done by using Hilla-Baghdad highway expansion factors [14] as listed

in Table 2. The summation of daily traffic volumes for major and minor highways for each study intersection are used to identify the proper traffic control due to the IHT, the DoT and the SORB.

Table 2. Daily P.C.U volumes for the study intersections (vehicle /day)

Intersection Name	Major Highway	Minor Highway
The Station	18450	2936
Al-Salam	25163	17235
Al-Irjoan	19913	3699
Awlad-Muslim	11261	2467
Al-Sadah	5336	4470

Table 3 summarizes the estimation results of the suitable sort of traffic control for the five crossings within the adopted graphs; IHT, DoT and SORB.

Table 3. Results of control type selection for the study intersections

Intersection Name	Existing Condition	Proposal recommended		
		IHT	DoT	SORB
The Station	Priority	Priority	Roundabout	Control or Interchange
Al-Salam	Signal	Grade Separation	Roundabout	Control or Interchange
Al-Irjoan	Priority	Circular or Signal	Roundabout	Control or Interchange
Awlad-Muslim	Signal	Priority	Ghost island	Control or Interchange
Al-Sadah	Priority	Priority	Ghost island	Control or Interchange

As listed in Table 3, there is a clear difference in the proposed results for the same intersections. The suggested recommendations from the graphical methods will be checked with SYNCHRO 10 software for selecting the suitable control type for each intersection

5.2 SYNCHRO 10 Application

The second part of this study is about testing; the existing operational performance for each intersection, checking the graphical methods recommendations and the proposed alternative improvement scenarios along three different terms (5, 10 and 25 years). In this study, 2023, 2028 and 2043 are taken as a target year. The annual rate of traffic growth (r) is taken as 2.5% (according to Traffic Police Directorate of Babylon Province), the value of TFF (Traffic Forecast Factor) will result as to be (1.131), (1.280) and (1.853) correspondingly.

5.2.1 Base Traffic Flow Evaluation

The maximum degree of saturation, level of service and average control delay will be the main performance indices in the evaluation process with SYNCHRO software. Table 4 lists the results of analysis process with SYNCHRO of the study intersections. It's obvious that most intersections operate at unacceptable level of service.

Table 4. SYNCHRO 10 analysis results of the study intersections

Intersection	Degree of Saturation (v/c)	Average control Delay (sec/veh.)	LOS
The Station	5.3	315	F
Al-Salam	1.52	98.1	F
Al-Irjoan	3.68	203.2	F
Awlad-Muslim	0.95	42.1	D
Al-Sadah	1.37	100	F

5.2.2 The Improvement Scenarios of the five Study Intersections

For Al-Salam intersection (as a detailed example), within this intersection, it runs as nearly two minutes as average delay and LOS of (F) (see Figure 3-a). The intersection was beyond traffic capacity and considered as unsafe thus an enhancement scenario must be made. Three proposal scenarios were proposed for this purpose.

Starting by creating an optimization to existing cycle length with creating several changes on the geometric layout of the intersection as the first proposed scenario (see Figure 3-b). The optimized cycle length was 75 secs instead of 92 secs with two phases; NBT and EBL. Geometric changes were made by creating all existing lanes 3.6 meters instead of 3.5 meters. After that, additional through lane was added to the same approach (three lanes instead of two). Again, the LOS raised from (F) to (C) with average delay around 24 secs each automobile and saving per cent approximately 75%.

A U-turn Michigan method was inspired to be the second scenario (see Figure 3-c). The goal of this design was avoiding the straight left turning movements. This is done by executing a midblock U-turn. it needs around 18 m (wide median) and forces travelling vehicles to make a midblock U-turn [15]. within this intersection, This design was applicable because there was an island under the existing fly-over of almost 16 meters (in width) and an existing 7 meters as U-turn within the same highway situated around 50 m away from the crossing (a safe high of around 4 m).

The main changes on the geometric layout for NB highway were; altering all left movements into indirect straight movements, additional through lane was added and all traffic lanes were widen (3.6 meters) instead of (3.5 meters). Within EB highway, an additional left lane was added (3 lanes in total with 3.5 meters in width). On behalf of SB, another through lane was added (three lanes instead of two in total). The base U-turn similarly was widen to be three traffic lanes instead of 2 in one direction for serving extra local traffic needs.

The proposed alternative was consisted of 4 individual nearby crossings through the modelling in SYNCHRO [16]. Nodes with numbers two and four were proposed as a signal intersection whereas the reaming intersections were priority control type.

The travelling automobiles on the chief highway were permitted to make a left turn (U-turn movement) at intersection number 3 in this design. Subsequent by additional left turn in intersection number 4 to Karbala province while the automobiles which travelling from Karbala towards Baghdad should make only one left turn movement at intersection number 2.

Intersection number 2 was selected as a critical intersection or node for comparing purposes [16]. So, this intersection was an index to how successful proposed scenario was. The signal intersection (node with number 2) was operating with two phases (NBT and EBL) and with cycle length of 60 secs. The LOS was B and the control delay was around ten secs for each automobile and saving percent of approximately 91%.

Lastly a ramp interchange was recommended for long term connecting Baghdad and Karbala provinces passing over the existing fly-over (see Figure 3-d). This ramp was consisted of two lanes of 3.6 meters. There were only two crossing movements SBR and NBL under the existing overpasses and this crossing was proposed as a signal intersection. The cycle length was 60 secs consisted with two phases. The LOS was (A) and the average delay was around a second for each travelling automobile with saving percent of almost 99%.

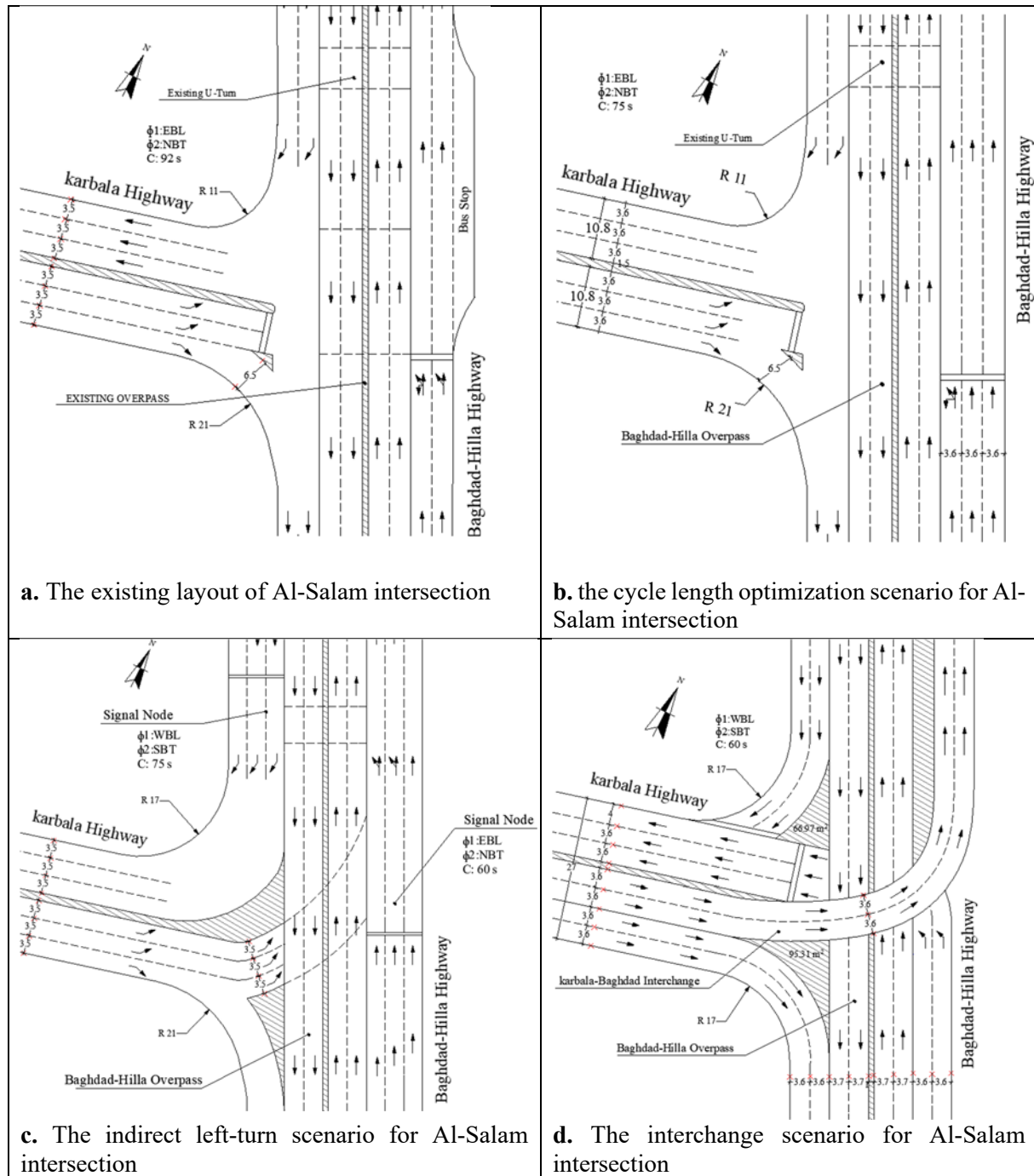


Figure 3. The existing and the suggested improvement layouts for Al-Salam intersection.

Table 5 shows the (MOE) gained from SYNCHRO software for the proposed previous scenarios for the five study intersections for 2023, 2028 and 2043 respectively. The scenario named in bold style within this Table, represents the suitable suggesting alternative.

Table 5 The five study crossings MOE using SYNCHRO after the specified target years

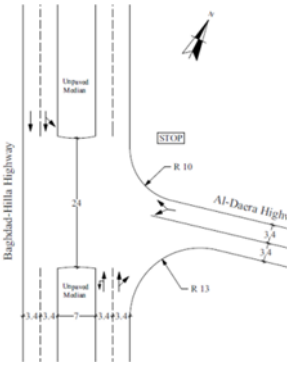
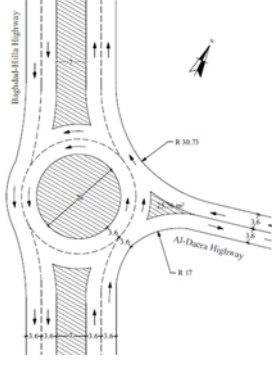
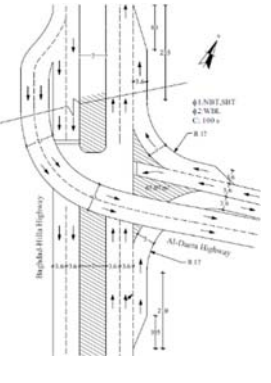
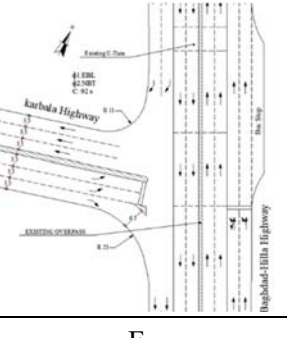
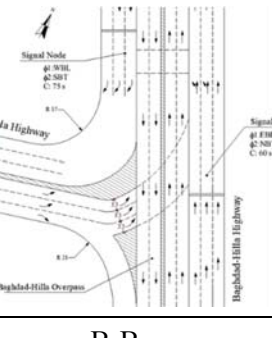
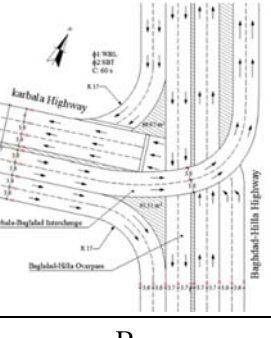
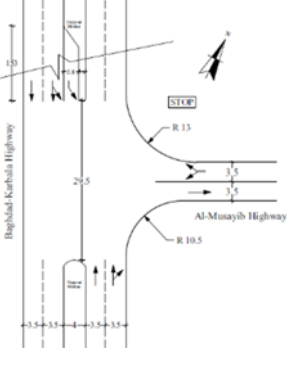
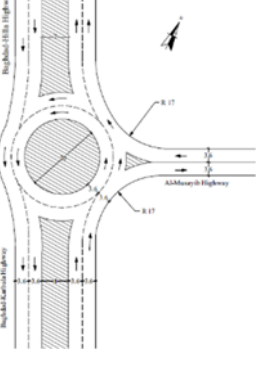
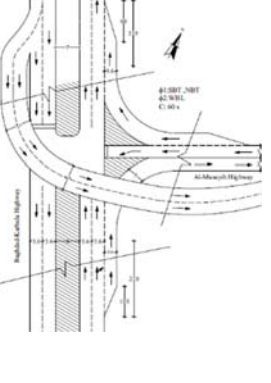
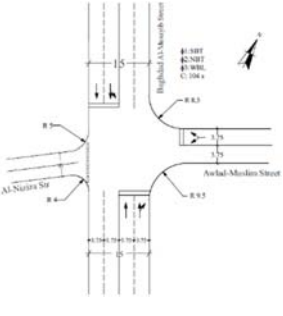
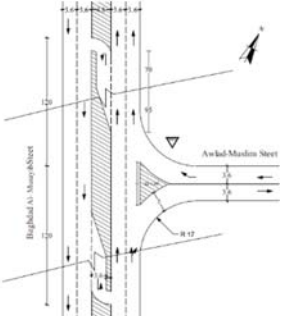
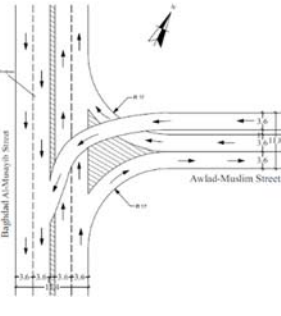
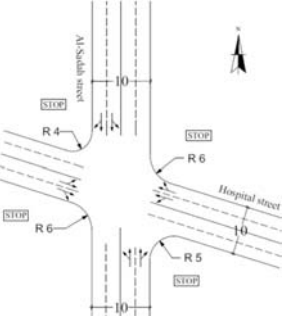
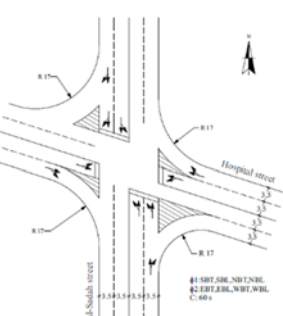
Inter. Name	Character. Analysis	Existing Year (Base) 2018	Short- Mid Term (5-10 yrs) 2023-2028	Long Term (25 yrs) 2043
The Station	Geometr. Layout			
	LOS	F	B-C	D
Al-Salam	Geometr. Layout			
	LOS	F	B-B	B
Al-Irjoan	Geometr. Layout			
	LOS	F	B-C	C

Table 5 The five study crossings MOE using SYNCHRO after the specified target years (continued)

Inter. Name	Character. Analysis	Existing Year (Base) 2018	Short- Mid Term (5-10 yrs) 2023-2028	Long Term (25 yrs) 2043
Awlad-Muslim	Geometr. Layout			
	LOS	D	A-A	A
Al-Sadah	Geometr. Layout			
	LOS	F	C-E	E

6. Conclusions

- Previous selection of the proper type of traffic control may have many economic impacts and saving time for any evaluation studies in intersection sites.
- The adopted graphs methods of; IHT, DoT and SORB are used to identify the proper type of control showed different results for similar intersections.
- Optimization for suitable control of each site due to the three methods should be conducted in view of restriction of area and budget.
- Due to operational analysis results
 - For short and mid-term evaluation, The Station, Al-Salam and Al-Irjoan intersections concur with the recommendations due to the DoT and IHT recommendations. MUTCD recommendations are compatible with Al-Sadah intersection only.
 - All five intersections agree with the recommendations for long term evaluation.
- About 97% and 95% of delay are decreased due to changing type of control from two way stop control TWSC to a signalization and a roundabout, about 91% and 92% of delay are decreased due to changing type of control from signalization to indirect left turn and 82% of delay is decreased due to changing type of control from all way stop control AWSC to a signalization. Thereby level of service raised from F to B in; The Station intersection, Al-Salam intersection and Al-Irjoan intersection. LOS also raised from D to A in Awlad- Muslim intersection and from F to C in Al-Sadah intersection.

7. Recommendations

- Converting the following intersections for short term evaluation:
 - The Station intersection into a signalization type.
 - Al-Salam intersection into indirect left turn.
 - Al-Irjoan intersection into a roundabout.
 - Awlad-Muslim intersection into indirect left turn.
 - Al-Sadah intersections into a signalization type.
- Converting all studied intersections into an interchange for long term evaluation.
- Enforcement measures should be applied at intersections to prevent illegal parking and movements.
- Conducting permanent and accessible surveillance cameras system on all traffic facilities in Al-Musayib district equipped with modern counting devices for calculating flow characteristics of automobiles and pedestrians data which will help in future traffic studies.

8. References

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