Improvement and Assessment of Bab Al-Hussein signalized intersection in Hilla city

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Abstract. Increasing traffic loads at intersections is among the major issues causing traffic difficulties and then leads to traffic jams in the following infrastructures, such as the highways and their crossings are the reflection of civilization across every country. And the scale of the progress throughout the highway quality, number and the traffic facilities in the intersection. The stated objectives of this research are to improve and assess the traffic efficiency of the signalized intersection at Bab Al-Hussein in Hilla City, which matches the current situation and spatial characteristics of the intersection. Traffic volume data have been collected for each approach and every movement (Through, Left, Right and U-turn) within peak hour volume in the (a.m. and p.m.) period for the intersection. Traffic volume classification was according to vehicle's type which they are moving to throw the intersections (passenger car, heavy vehicle, motorcycle) In addition to the volume of the pedestrians. Data were collected by using the technique of video recording method then represent in tables and figures. The program SYNCHRO 8 has been utilized to analyze and assess the intersection and to select the optimum alternative. The assessment process results in application of the intersection with service standard (LOS F). Because of recommendations for various solutions, varying from signal optimisation to geometrical enhancements. The study conducted that, when add one lane in each approaches and minimizing the cycle length to (75) sec, thus the service level will be increase from (F to C) LOS. This result is an economical and acceptable solution to increase intersection performance. It was recommended that U-turn be prevented because it causes traffic delays, and thus the lost time increases. From it the traffic volume increases at the intersection also, preventing heavy vehicles from crossing at peak times and allocating a time from 6:00 pm to 6:00 am with the allocation of a special road to cross them, because it obstructs traffic and the risk of their presence in a busy intersection.

Keywords: intersection, signalized, delay, synchro, cycle length.

1. Introduction
Traffic jams in communities of all sizes is a big concern. Individuals go for more trips, so more cars are on the route. Sometimes the street grid becomes overtaxed, allowing roads to crumble. The resulting traffic jam is an expensive waste of time for commuters, and emissions released from old diesel engines damage the atmosphere. So much worse, in an apparent effort to make up for a lost time, congestion even sometimes induces motorists into dangerous behaviour, like going through red lights. Nonetheless, certain fairly quick, low-cost modifications to a traffic signal network will greatly
improve the traffic flow. Traffic signals could even decrease congestion and result in huge savings in time, health effects and safety [1–3].

Human element is a major support in motorway engineering. The needs of drivers need to be fulfilled or other problems adequately conveyed to their standards. This is shown throughout road engineering, as infringements of a driver's expectations without beneficence lead to safety issues or operational inefficiency [4].

2. Intersection

An intersection is described as the specific region where two or more highways, including the roadside and roadway services for traffic inside the city, combine or connect. Every highway that radiates from and forms part of an intersection is an intersection leg. There are four legs of the most famous intersection at which two highways cross each other. It is not advised to have more than four legs at intersection. Intersections are an essential part of a transportation facility, since the performance, health, distance, running costs and capability of the facility depend on its architecture to a large extent. Through intersection requires travel around or cross-traffic on one or more of the highways and can require movement of turns between certain highways. Based on the form of intersection these motions may be enabled by specific architectural architecture and traffic management. The simple intersection forms are triple-leg or T, multi-leg and four-legs. The form of intersection at every specific location is mainly defined by the intersecting legs' number, the topography and the intersecting highways character, speeds, patterns, the volumes of traffic and the form of activity required [5].

Signalized intersections seem to be critical features in the urban transportation system and pass traffic jams of non-motorized and motorized vehicles and pedestrians, which in turn create numerous conflicts between maneuvers to cross, turn and merge. Through traffic demand throughout peak periods will surpass the maximum capacity of the intersection for a number of reasons including vehicle ownership increasing, economic and population. As a result, road flows are increasing, and health threats are growing. Conditions of congested and dangerous traffic increase fuel consumption, emissions, noise and accidents. The life quality of a city, global energy resources and the world conditions of atmospheric are therefore deteriorating [6]

2.1. Conflicts points at an intersection

Conflicts are common with various forms of collision at a collision. Take a typical 4-legged intersection. The conflicts number in which to compete through movements is four while competing for a right turn and by movement is 8. There are 4 differences with right turn traffic, and Four with left turn and merging traffic. The disputes generated by pedestrians are estimated to be 8, taking all four methods into account. There are still around four problems resulting from diverging flows. So a typical four-legged intersection has about 32 various conflict kinds. It is demonstrated in figure (1). The significance of intersection control is the resolution of these conflicts at the intersection for the efficient and safe movement of both vehicle and pedestrian traffic [7]
3. Definition of Study Area

Hilla is the center of Babel Province, and it is one of the most vital cities in Iraq, and it is located in the center. It is bordered on all sides by the capital, Baghdad, the holy city of Karbala, and the holy city of Najaf, one of the most important cities to bring visitors to Iraq. Because of its historical importance as the Babylonian civilization arose, and therefore attractive to tourists, that is, an increase in the population. Therefore, the increase in cars number due to increasing in the standard of living and vehicle ownership has led to problems of congestion in roads and intersections, which we need to improve to keep pace with the city's population development. The Bab Al-Hussein intersection is one of the most main intersections in the city of Hilla because of its location in the center, and it connects 40th Street and Al-Tayara Street, which is abundant with shops and government departments, etc. So he suffers from the problem of crowding and this is why he chose to study [8].

Figure 1. Conflicts points at an intersection [7]

Figure 2. Map of Al-Hilla city.
3.1. Bab Al-Hussein signalized intersection as a case study.

This intersection in the city of Hilla is a three-legged intersection that acts as a control unit in a fixed time signal and has three phases of the signal and represents one of the most important intersections in the city Centre, where many vital activities occur at this intersection. The East and West approaches are suffering from traffic congestion in the morning due to the vehicles heading to the official working hours in government departments. Also, the south approach suffers from high traffic volume in the evening due to many shop centers, offices, cafe and other activities, as shown in Figure (3).

![Figure 3. Bab Al-Hussein intersection [by drone plane of Eng. Aboother]](image)

![Figure 4. Geometric design of Bab Al-Hussein signalized intersection.](image)

4. Main parameters for assessing intersection operations

4.1. Delay

Delay in the signaled intersection realm is related to the time lost to a vehicle and/or driver due to the conditions of traffic, geometric and signal at the intersection [9](Click, 2003) operation. Whereas a
delay in the context of the HCM 2000 is described as the variation between the travel-time experienced and the time of reference travel which would result in ideal conditions. Throughout the absence of traffic regulation, if there is no spatial pause, if there are no collisions and if there are no other cars on the route [10].

4.2. Capacity
The maximum rate at which vehicles can pass through the intersection under prevailing conditions. It is also the ratio of the time during which vehicles may enter the intersection [11].

4.3. Volume-to-Capacity Ratio
Also known as the degree of saturation is the ratio of demand volume to the capacity for a subject movement [1].

4.4. Level-of-Service
A qualitative measure describing operational conditions within a traffic stream, based on service measures such as speed and travel time, freedom to maneuver, traffic interruptions, comfort, and convenience [12].

5. Data collection methodology
It was important to obtain the traffic volume data for the intersection with the field engineering survey include lane width, No. of lanes and median width of the intersection. These procedures are categorized into three steps for each approach as described below:

- Describe the boundaries of the study area by manual measuring tape.
- Calculating traffic volumes during (a.m. and p.m.) peak hour volume.
- Calculate the traffic signals time and the cycle length by watching.
- Define the specific input data for the selected software program.

5.1. Engineering Survey
This data was collected due to its strong relationship with traffic volume data and traffic signal data. Thus we were able to evaluate and improve the traffic intersection if a new lane was added or the lane width increased or overpass work or underpass. Field measurements were taken using a tape measure to calculate lane width and median width, some of which were obtained from aerial photographs taken by a Drone plane in the year 2018 (by Eng. Aboother) such as radius of a right turn [8].

5.2. Traffic volume data
The intersection was experienced for two months, and through a questionnaire for road users from the police, owners of nearby stores, taxi drivers, etc., and they were asked about the peak time, thus knowing the morning and evening peak time for the intersection, are three different periods, morning peak period (7:30 - 9:30) AM, noon peak period (12:30 - 2:30) PM and evening peak period (4:30 - 6:30) PM where traffic volumes were collected in two weeks and calculated using video recording technology by cameras in the intersection. Which was obtained from the Police Department of Babel Governorate and the filming at a time of dry weather was not rainy, and there are no official holidays and within the working days, Monday, Tuesday and Wednesday every week to calculate the largest traffic volume possible.

Traffic volumes were calculated every quarter of an hour due to the accuracy of the calculation and the exact time of congestion, as shown in the figure below. This data includes calculating the traffic volumes extracted from video recording for each approach in an intersection, also, traffic composition (passenger cars, heavy vehicles, motorcycles) and traffic movement volume (through, left, right, and U-turn).
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Figure 6. Traffic volume at Bab Al-Hussein signalized intersection.

5.3. Traffic Signal Data
The cycle length, including green time, red time, yellow time and all red time were calculated according to the observations in the intersection during peak hour periods

- **Cycle length**: is the amount of time it takes a signal to go through its entire sequence once and return to the same place [13,14].
- **Green time**: The duration, in seconds, of the green indication for a given movement at a signalized intersection [11].
- **Yellow Change Interval**: An indication warning users that the green indication has ended and the red indication will begin [11].
- **Red Change Interval**: The period following a yellow period indicating the end of a phase and stopping the flow of traffic [12].

5.4. Data Abstraction
Data were calculated from the recorded videos every 15 minutes for the following reasons:

- To accurately calculate traffic volumes and know more than a quarter of an hour in which vehicles are congested, and causes are addressed.
- The traffic flow must be effectively stable during the period without accidents.
- Calculate the peak hour factor PHF to see the extent to which the intersection operates.

5.5. Application of SYNCHRO 8 Software Input Data
The data for the selected intersection has been applied in the Synchro8 program to evaluate and simulate the intersection and know the delay, service level and V/C of the intersection, able to know the reasons leading to traffic congestion. And to suggest improvements and their application in the program, and note the results to reach the best result taking into account the economic and environmental situation of the city.

The results presented in Table (1) indicated that most of the intersection approaches are suffers from a crowded condition with high total delaying time and undesirable service level (LOS F).
Table 1. Performance Analysis for Intersection of Bab Al-Hussein.

| Intersection Name | Approaches         | Traffic Volume (veh/hr.) | LOS | Average (sec) | Delay |
|-------------------|--------------------|---------------------------|-----|---------------|-------|
| Bab Al-Hussein    | 40 street          | 1828                      | E   | 71.2          |       |
|                   | Bab Al-Tayara Street | 2236                    | F   | 107.9         |       |
|                   | City Center        | 1300                      | F   | 82.2          |       |

Summary
- Cycle Length = 144 sec
- Delay Average = 89 sec
- LOS (F)
- V/C = 1.25

6. Improvement of Intersection

There are many strategies to improve the performance of the intersection and can be classified into two classes. The first category is called (Traffic signal Improvement), which includes the optimization cycle length, splits optimization, and the second class is called (Geometric Improvement), which includes pavement widening, construction overpass.

6.1. Traffic signal Improvement
This category can be applied directly to the Synchro8 program when clicking on the type of optimization, and it chooses optimization cycle length for intersection and optimization splits to reduce delaying time and improved service level for an intersection.

The Natural Cycle length is the lowest acceptable cycle length for an intersection operating independently. The natural cycle length appears on the TIMING Settings.

The Optimize → Intersection - Cycle Length command will set the intersection to the Natural Cycle Length.

The Natural Cycle Length will be one of three possibilities.

- Shortest Cycle Length that clears the critical percentile traffic.
- Cycle Length with the lowest Performance Index provided the lowest PI cycle is less than the cycle found in (1). This option is used to give reasonable cycles for intersections overcapacity.
- If no cycle can clear the critical percentile traffic, but a shorter cycle can give satisfactory v/c ratios, the shorter cycle length will be used. This is a special case to handle near capacity intersections with permitted left turns.

The Optimize → Intersection-Splits command will automatically set the splits for all the phases. Time is divided based on each lane group's traffic volume divided by its adjusted saturated flow rate. The Split Optimizer will respect Minimum Split settings for each phase whenever possible. [8]

Table 2. Effective Measurement for Intersection of Bab Al-Hussein created by Synchro8 program.

| Kind of Improvement       | Length of Cycle | V/C | Delay Average | LOS |
|---------------------------|-----------------|-----|---------------|-----|
| Base Condition            | 144             | 1.25| 89            | F   |
| Cycle Length Optimization | 140             | 1.08| 69.2          | E   |
| Splits Optimization       | 144             | 1.08| 69.3          | E   |
Table (2) shows that making the improvements of the first part is useless because LOS (E) of the intersection is low and despite the prevention of movement U-turn and also the allocation of a specific time and specific place for heavy vehicles and therefore we must search for other solutions and move to the second part of the improvements.

6.2. Improvements of Geometric

Because the first part of the improvements did not improve the performance of the selected intersection, so we apply the second part of the improvements, which is (Geometric Improvement) as shown in table (3).

Table 3. Effective Measurement for Intersection of Bab Al-Hussein created by Synchro8 program.

| Kind of Improvement         | Length of Cycle | V/C | Delay Average | LOS |
|-----------------------------|-----------------|-----|---------------|-----|
| Base Condition              | 144             | 1.25| 89            | F   |
| Pavement widening           | 144             | 0.94| 38.8          | D   |
| Overpass                    | 84              | 0.65| 10.4          | B   |

In Table (3), the best improvement is construction overpass because LOS (B), but is this the best and most economical solution? Perhaps if we try to use more than one solution together that will lead to a satisfactory result, that is, we try to try the previous solutions together and combine the two parts of the improvements as demonstrated in the following Table (4).

It has been noticed in Table (4) that the first solution is acceptable because the level of service(C) and this solution is more economical and easier applied than construction overpass is LOS (B) because this solution only requires adding a new lane with the choice of the cycle length optimization to reduce the delay for intersection with a better flow.

Table 4. Effectiveness Measure for Intersection of Bab Al-Hussein created by Synchro8 program.

| Kind of Improvement                               | Cycle Length | V/C | Delay Average | LOS |
|---------------------------------------------------|--------------|-----|---------------|-----|
| Base Condition                                    | 144          | 1.25| 89            | F   |
| Pavement widening + Cycle Length Optimization     | 75           | 0.89| 25.7          | C   |
| Pavement widening + Splits Optimization           | 144          | 0.82| 36.2          | D   |
Conclusions

1. The Bab Al-Hussein intersection suffers from congestion with all approaches, even though it added traffic lights and isolated the right in previous years to improve the traffic process, but due to the increase in vehicles, congestion returned, and the delay was about an hour to get out of the intersection and LOS (F), so we tried to find other ways.

2. Before applying any of the improvements, it is necessary to know the cause of congestion and establish laws for some vehicles or movements that delay the flow of vehicles, one of which prevents heavy vehicles from an intersection in daylight times. And allocating time from 6:00 pm to 6:00 am to avoid crossings with other vehicles because it takes more place and a longer time when turning or allocating roads for heavy vehicles away from the intersection if they must pass during the daylight hours.

3. Preventing the movement of U-turn from the intersection because it causes delay to other movements.

4. The experience of the improvements in a Synchro8 program will be published in terms of the cycle length optimization and the splits optimization, but there was a little change that we did not reach to an appropriate level of service, and they are from LOS(C) and above.

5. When the intersection improved in two ways (pavement widening + cycle length optimization) together, we noticed, a big difference can occur in the level of service towards the best, and we reach for LOS(C). Still, when experimenting with the construction of an overpass we reached a much higher level of service which is LOS (B), so we have two options, and the result is improved it by (pavement widening + cycle length optimization) because it is a more economical solution and easy applied and in addition to that the construction of the overpass requires a large and sufficient area in the intersection, and this is not available at the intersection of Bab Al-Hussein.
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