Analysis of Traffic Operation for AL-Kafa’at Signalized Intersection in Al-Kut City

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ABSTRACT
Traffic Studies Aims (Traffic analysis) to estimate some of the important indicators to determine the level of service (LOS) at intersections in the cities. That's where the increase in traffic volumes at intersections is one of the main problems that make traffic in this difficult intersections and which rise to congestion in these areas. The objective of this research is to evaluate the operational capacity of intersection (AL-Kafa’at) in AL-Kut city and show better proposals to improve the performance in terms of capacity.

To achieve these objectives traffic information has been collected using digital camera to various directions for the purposes of analysis and traffic engineering while HCS traffic program is used for the purposes of traffic analysis process. The operational analysis of the existing conditions of this intersection indicates that the LOS is (F) with an intersection delay value of 105.1 sec./vehicle. Because of the reasons above, it is important to enhance the performance of AL-Kafa’at Intersection by increasing number of lane to right turn for Alhaidariya Approach. The results indicate that the intersection LOS is hanged to (D) with a cycle time of 91 sec. and an intersection delay of 38.1 sec./vehicle.

Keywords: Traffic Operation, Traffic volume, Saturation flow, Peak hour factor (PHF), Level of Service (LOS).

تحليل التشغيل المروري لتقاطع الكفاءات في مدينة الكوت

تهدف الدراسات المرورية (Traffic analysis) إلى تقدير بعض المؤشرات المهمة لتحديد مستوى الخدمة (LOS) على التقاطعات داخل المدن. حيث أن الزيادة في الحجوم المرورية في التقاطعات هي أحد المشاكل المهمة التي تجعل حركة المرور في هذه التقاطعات صعبة والتي تؤدي إلى الإزدحام في هذه المناطق.

أن الهدف من هذا البحث هو تقييم القدرة التشغيلية (기술적 지표) في تقاطع الكوت وعرض أفضل المترشحات لتحسين البناء من حيث القدرة الاستيعابية للمدينة الكوت. هدف هذه الدراسة هو تحقيق هذه الأهداف فقد تم جمع المعلومات المرورية

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INTRODUCTION

Transportation Engineering is the application of technology and scientific principles to the planning, functional design, operation, and management of facilities for any mode of transportation in order to provide for the safe, rapid, comfortable, convenient, economical, and environmentally compatible movement of people and goods.

Traffic engineering is that phase of transportation engineering which deals with the planning, geometric design and traffic operation of road, street, and high-ways, their network, terminals, abutting lands, and relationships with other modes of transportation [1].

An intersection is defined as the general area where two or more highways join or cross, including the roadway and roadside facilities for traffic movements within the area. Intersections are an important part of a highway facility because, to a great extent, the efficiency, safety, speed, cost of operation, and capacity of the facility depends on their design. Each intersection involves through- or cross-traffic movements on one or more of the highways and may involve turning movements between these highways. Such movements may be facilitated by various geometric design and traffic control, depending on the type of intersection [2].

The concept of capacity, level of service and delay are central to the analysis of intersections, as they are for all types of facilities, therefore that both capacity and level of service must be fully considered to evaluate the overall traffic operation of the intersections [3]. While the delay is one of problems that occur in any facility of traffic. AL-Kafa’at intersection in AL-Kut city is an important congested intersection due to its critical location on major streets. This intersection has the following characteristics:

1. It has a very high traffic volume in two approaches.
2. It is located on Major Street which intersects with two minor streets.
3. Many activities are located around this intersection.

Study Area

AL-Kafa’at signalized intersection is one the most important intersections located in the center of AL-KUT city, AL-Kafa’at signalized intersection consists of three major streets:

1. Baghdad Street
2. AL-Kafa’at Street
3. Alhaidariya Street

AL-Kafa’at signalized intersection is a significant location and a highly volume this can be related to:

1. AL-Kafa’at signalized intersection located in an important location. It connects between main directions from AL-Kafa’at Street toward Alhaidariya Street.
2. The existing of different public activities near AL-Kafa’at signalized intersection. These activities resulted in a high traffic volume and lead to create a high delay especially at peak hour. Figure (1) shows a satellite image for AL-Kafa’at signalized
intersection and the boundary of the study area (directorate of statistics in the AL-KUT city, 2010).

Figure (1): Satellite Image for AL-Kafa’at Signalized Intersection in AL –KUT City

Objectives of the Study

The main objectives of this study are:

1. Specify the peak hour volume and calculate the peak hour factor (PHF) for all approaches at AL-Kafa’at signalized intersection.
2. Evaluate the existing level of service (LOS) at the studied intersection.
3. Evaluate all proposals, calculate the level of service for each proposal and select the best proposal that can solve the congestion problem and provide a good performance within the design period.

Data Collection:

Traffic volume

To determine the existing traffic volumes; a digital camera is used at AL-Kafa’at signalized intersection from (7:00 a.m up to5:00 p.m) during the workday of the week from (22 February to 27 February) 2014. This survey aims to find the peak hour volume, which represent the design hourly volume.

The volume for peak hour represents the design hour volume, which will be used in the analysis of this study. Table (1) show the traffic account at nestle intersection for 15 min period from 7:00 a.m -5:00 p.m. While Table (2) shows the total volume for all approaches each 15 min.

Saturation Flow

Calculation of saturation flow rate depend on the headway data collected for queue vehicles at stop line for each approach at the time of departure on green time. Saturation flow represents one of the main parameter in which has a major effect in the capacity of intersection [4]. The existing saturation flow is calculated by using HCS Software. Table (3) shows the calculated saturation flow at the stop line for all approaches i
### Table (1): Traffic Volume At – Al-Kafa’at Intersection From 7:00 A.M To 5:00 P.M For All Approaches

| Direction | From Alhaidariya Street | From The Al-Kafa’at Street | From Baghdad Street |
|-----------|-------------------------|----------------------------|---------------------|
|           | PC | HV | PC | H V | PC | HV | PC | HV | PC | HV | PC | HV | PC | HV | PC | HV |
| Time      | LEFT | THROUGH | RIGHT | LEFT | LEFT1 | RIGHT | LEFT | THROUGH | RIGHT |
| 7:00-7:15 | 0  | 0  | 19 | 2  | 62 | 2  | 48 | 2  | 2  | 0  | 16 | 0  | 13 | 1  | 12 | 1  | 0  | 0  |
| 7:15-7:30 | 1  | 0  | 40 | 0  | 67 | 2  | 80 | 4  | 1  | 0  | 26 | 1  | 14 | 0  | 14 | 2  | 0  | 0  |
| 7:30-7:45 | 0  | 0  | 45 | 1  | 102 | 1  | 32 | 1  | 3  | 0  | 44 | 2  | 20 | 3  | 30 | 0  | 0  | 0  |
| 7:45-8:00 | 1  | 0  | 63 | 1  | 125 | 7  | 127 | 2  | 0  | 0  | 50 | 0  | 21 | 3  | 39 | 4  | 0  | 0  |
| 8:00-8:15 | 0  | 0  | 57 | 10 | 99  | 5  | 137 | 0  | 1  | 0  | 44 | 1  | 14 | 0  | 35 | 1  | 0  | 0  |
| 8:15-8:30 | 0  | 0  | 69 | 2  | 110 | 6  | 126 | 8  | 2  | 0  | 55 | 3  | 23 | 0  | 39 | 0  | 0  | 0  |
| 8:30-8:45 | 0  | 0  | 62 | 4  | 86  | 4  | 99 | 6  | 0  | 1  | 46 | 2  | 23 | 0  | 39 | 0  | 0  | 0  |
| 8:45-9:00 | 0  | 0  | 73 | 2  | 103 | 7  | 103 | 7  | 0  | 0  | 39 | 2  | 13 | 0  | 35 | 0  | 0  | 0  |
| 9:00-9:15 | 1  | 0  | 76 | 2  | 123 | 2  | 99 | 5  | 2  | 0  | 37 | 4  | 14 | 1  | 34 | 2  | 0  | 0  |
| 9:15-9:30 | 1  | 0  | 49 | 4  | 85  | 7  | 126 | 4  | 0  | 2  | 52 | 1  | 10 | 2  | 40 | 0  | 0  | 0  |
| 9:30-9:45 | 0  | 0  | 83 | 3  | 73  | 5  | 97 | 7  | 3  | 1  | 47 | 2  | 16 | 1  | 36 | 2  | 0  | 0  |
| 9:45-10:00| 0  | 0  | 64 | 2  | 94  | 4  | 107 | 9  | 1  | 0  | 51 | 1  | 28 | 0  | 42 | 2  | 0  | 0  |
|            | - 10:15 10:00 |                      | - 10:30 10:15 |            |                      | - 10:45 10:30 |            |                      | - 11:00 10:45 |                      | - 11:15 11:00 |            |                      | - 11:30 11:15 |                      | - 11:45 11:30 |            |                      | - 12:00 11:45 |                      | - 12:00-12:15 |            |                      | - 12:15-12:30 |                      | - 12:30-12:45 |            |                      | - 12:45-12:50 |                      | - 12:50-1:00 |            |                      | - 1:00-1:05 |                      | - 1:05-1:15 |            |                      | - 1:15-1:30 |                      | - 1:30-1:45 |            |                      | - 1:45-2:00 |                      | - 2:00-2:15 |            |                      | - 2:15-2:30 |                      | - 2:30-2:45 |            |                      | - 2:45-3:00 |                      | - 3:00-3:15 |            |                      | - 3:15-3:30 |                      | - 3:30-3:45 |            |                      | - 3:45-4:00 |                      | - 4:00-4:15 |            |                      | - 4:15-4:30 |                      | - 4:30-4:45 |            |                      | - 4:45-5:00 |                      |
Table (2): Traffic Volume At – Al-Kafa’at Intersection From 7:00 A.M To 5:00 P.M For All Approaches For Each (15min)

| TIME   | PC  | HV | Total= (PC+2*HV) | TIME   | PC  | HV | Total= (PC+2*HV) |
|--------|-----|----|------------------|--------|-----|----|------------------|
| 7:00-7:15 | 172 | 8  | 188             | -12:15 | 431 | 21 | 473              |
| 7:15-7:30 | 244 | 9  | 262             | 12:00  |     |    |                  |
| 7:30-7:45 | 276 | 8  | 292             | -12:15 | 399 | 23 | 445              |
| 7:45-8:00 | 342 | 17 | 376             | 12:30  | 378 | 18 | 414              |
| 8:00-8:15 | 387 | 17 | 421             | 1:00-1:15 | 322 | 17 | 356              |
| 8:15-8:30 | 424 | 19 | 462             | 1:15-1:30 | 373 | 17 | 407              |
| 8:30-8:45 | 355 | 17 | 389             | 1:30-1:45 | 299 | 20 | 339              |
| 8:45-9:00 | 366 | 18 | 402             | 1:45-2:00 | 299 | 19 | 337              |
| 9:00-9:15 | 386 | 16 | 418             | 2:00-2:15 | 349 | 13 | 375              |
| 9:15-9:30 | 363 | 20 | 403             | 2:15-2:30 | 322 | 13 | 348              |
| 9:30-9:45 | 355 | 21 | 397             | 2:30-2:45 | 299 | 15 | 329              |
| 9:45-10:00 | 387 | 18 | 423             | 2:45-3:00 | 343 | 11 | 365              |
| -10:15  | 422 | 19 | 460             | 3:00-3:15 | 336 | 9  | 354              |
| -10:30  | 397 | 12 | 421             | 3:15-3:30 | 315 | 12 | 339              |
| -10:45  | 338 | 23 | 384             | 3:30-3:45 | 356 | 17 | 390              |
| -11:00  | 372 | 17 | 406             | 3:45-4:00 | 322 | 7  | 336              |
| -11:15  | 389 | 20 | 429             | 4:00-4:15 | 372 | 9  | 390              |
| -11:30  | 392 | 12 | 416             | 4:15-4:30 | 335 | 6  | 347              |
| -11:45  | 347 | 20 | 387             | 4:30-4:45 | 383 | 12 | 407              |
| -12:00  | 373 | 22 | 417             | 4:45-5:00 | 383 | 7  | 397              |

Table (3): Calculated Saturation Flow At AL-Kafa’at Signalized Intersection

| Approach          | Movement | Saturation flow pc/h |
|-------------------|----------|----------------------|
| Baghdad Street    | Th       | 1574                 |
|                   | L        | 1510                 |
| AL-Kafa’at Street | R        | 2355                 |
|                   | L        | 3878                 |
| Alhaidariya Street| Th       | 1610                 |
|                   | R        | 1554                 |
Existing Geometric Design

To evaluate the level of service at nestle intersection it is very important to specify the number of lanes for each approach. The existing geometric layout for AL-Kafa’at intersection and its approach is shown in Figure (2).

Analysis and Results:

Peak Hour Volume

By using Excel program, the traffic account shown in Table (1) was analyzed to specify the peak hour. From site investigation and traffic account, the following conclusions were observed:

a. It was found that the peak hour is limited between 12:00 P.M and 1:00 P.M. The total volume during this hour is (1691) pc/h.

b. The maximum traffic volume is concentrated in the approach coming from the Alhaidariya Street. This volume is (751) pc/h, while the lowest volume is (345) pc/h comes from Baghdad Street.

c. The percentage of heavy vehicles for all approaches in AL-Kafa’at signalized intersection is shown in Table (4).

d. The variation of traffic volume for each approach is shown in Figure (3) for 15 min interval while Figure (4) shows the total volume at the intersection for each (15) min.

| Approach        | % of heavy vehicles |
|-----------------|---------------------|
| Baghdad Street  | 9                   |
| AL-Kafa’at Street | 13                 |
| Alhaidariya Street | 11                 |

Table (4): Percentage of Heavy Vehicles for All Approaches At AL-Kafa’at Signalized Intersection

Figure (2): Existing Geometric Design for All Approaches in AL-Kafa’at Signalized Intersection
Figure (2): Total Traffic Volume At AL-Kafa’at Signalized Intersection for Each (15) Min

Figure (3): Variation of Traffic Volume for All Approaches at AL-Kafa’at Signalized Intersection

Peak Hour Factor:
The peak factor is defined as the ratio of total hourly volume to the maximum 15 – min rate of flow within the hour.

\[
\text{PHF} = \frac{\text{Hourly volume}}{\text{(higher traffic volum for 15 min) } \times 4}
\]

The peak hour factor is calculated for each direction in AL-Kafa’at intersection using the data mentioned in Table (1). Results of PHF is shown in Table (5) below.

Table (5): PHF for All Approach At AL-Kafa’at Signalized Intersection

| Approach             | PHF  |
|----------------------|------|
| Baghdad Street      | 0.96 |
| AL-Kafa’at Street   | 0.80 |
| Alhaidariya Street  | 0.96 |
Existing Los at AL-Kafa’at Signalized Intersection

The operational of the existing geometrical features and traffic volumes of AL-Kafa’at intersection is performed using HCS 2000. Table (6) illustrates the result of analysis. The result indicate that the intersection LOS is (F) with an average intersection delay of 105.1 sec/vehicle. Therefore, the enhancements are required to reduce the intersection delay and change the LOS.

Table (6): Existing Level Of Service At AL-Kafa’at Signalized Intersection

| Approach                  | Average delay sec/veh | Level of service (LOS) |
|---------------------------|-----------------------|------------------------|
| Baghdad Street            | 40.90                 | D                      |
| AL-Kafa’at Street         | 23.90                 | C                      |
| Alhaidariya Street        | 206.90                | F                      |
| Average Intersection delay| 105.1                 | F                      |

Proposal Enhancement of Traffic Performance:

In order to improve the traffic performance in the study area, improvement proposals will be explained in the following section.

Proposal NO 1: Increasing number of lanes in one direction:

In this proposal, changing of geometric design for the intersection by increasing number of lanes in one approach for Alhaidariya is suggested to right turn. It was found that the LOS of the intersection became D with an overall delay of (38.1) sec/veh. Table (7) shows the result this proposal No.1

Table (7): Expected Level of Service at AL-Kafa’at Signalized Intersection with Adopting Proposal (1)

| Approach                | Average delay sec/veh | Level of service (LOS) |
|-------------------------|-----------------------|------------------------|
| Baghdad Street          | 41.90                 | D                      |
| AL-Kafa’at Street       | 24.40                 | C                      |
| Alhaidariya Street      | 49.50                 | D                      |
| Average Intersection delay| 38.1                 | D                      |

Proposal NO 2: changing the cycle length for the intersection

In this proposal, several cycle lengths are examined using HCS program. From the result, it is noticed that the (LOS) for the intersection is (E) therefore, the proposal is not good enough for the intersection. Table (8) shows the results for this proposal for the cycle time 98.1 sec. as example. The results are based on existing traffic volume observed at the selected signalized intersection.
Table (8): Expected Level of Service at AL-Kafa’at Signalized Intersection with Adopting Proposal (2)

| Approach            | Average delay sec/veh | Level of service (LOS) |
|---------------------|------------------------|------------------------|
| Baghdad Street      | 230.60                 | F                      |
| AL-Kafa’at Street   | 38.40                  | D                      |
| Alhaidariya Street  | 24.50                  | C                      |
| **Average Intersection delay** | **68.9**          | **E**                  |

CONCLUSIONS

AL-Kafa’at signalized intersection is one of the most important intersections in AL-kut city, and serves of about 8000000 passages of vehicles yearly. The operational analysis of the existing conditions of this intersection by the Highway Capacity Software (HCS2000) indicates that the LOS equal to (F) with an intersection delay value of 102.8 sec./vehicle. Therefore, and because of the reasons above, two enhancement proposals were suggested. The study showed that increasing number of lane to right turn for Alhaidariya approach is the best solution to enhance the intersection performance.

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