Evaluation Al-Safeena and Sayed Jawda Intersections in Kerbala City

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Abstract: Increase of traffic volumes at intersections is one of the significant reasons that cause congestion. The current study aims to analyze, assess and improve traffic performance of (Al-Safeena roundabout) and (Sayed Jawda intersection) in Kerbala city. In order to implement these goals, data of the traffic volume and geometric layout for (Al-Safeena roundabout) and (Sayed Jawda intersection) are manually collected. To achieve the traffic analysis process, (SIDRA version 7) traffic program was used. Al-Safeena intersection improved by adding a new lane for each approach, this reduce the delay times, fuel consumption, and stops. This process will reduce ratio of volume to capacity (v/c) to value 0.7 and the delay rate value to 15.3 sec and LOS to C. On other hand, traffic operation at Sayed Jawda intersection is relatively enhanced by dividing the width of approach to four lanes, however, level of service is not upgraded satisfactorily. Change Sayed Jawda intersection to roundabout reduces the value of v/c to 0.8, and the value of average delay to 24 sec and LOS C.

Keywords: Traffic congestion, Roundabout, Intersection, Peak Hour Factor, LOS.

1. Introduction
Traffic congestion is of great concern in many big cities. The intersection is characterized by slow speed, long journey times and an increase in the number of vehicles in the queue [2]. The delay is a significant problems happen in any mean of traffic, the delay can be defined “the additional travel time experienced by a driver, passenger, or pedestrian” Two factors that affect delay are lane group volume and lane group capacity [3]. A roundabout is defined as "a circular traffic intersection featuring yield control on all entering legs, one-way continuous flow within the circulatory roadway, channelization of approaches, and appropriate geometric curvature to keep circulating speeds low" [4]. When analyzing intersections, the capacity, level of service and delay are considered as fundamental factors, therefore, the capacity and level
of service should be taken fully into account when evaluating traffic performance at intersections [5]. Al-Safeena roundabout and Sayed Jawda intersection in Karbala city are an important intersection and are heavily congested as they connecting major streets. Al-Saffena and Sayed Jawda intersections have the following characteristics:
1. They have a very high traffic volume on each approaches.
2. Many activities are located around these intersections.
The SIDRA software, up on methodology extension in Australia, also employ a gap acceptance approach to model roundabout operations [1].

2. Objective of the Study:
The current traffic study aims at several basic objectives
1. Find the exist LOS at both intersections to evaluate the traffic performance.
2. Improve the current LOS for Al-Safeena and Sayed Jawda intersections.

3. Description of Site:
Al-Safeena intersection is a four-leg roundabout intersection located in Karbala city, this roundabout very important due to connection two major street Fatima Al-Zahraa street with Al-Iskan street as shown in Figure (1).
Sayed Jawda intersection is a four leg intersection located in Karbala city as shown in Figure (2).

Figure 1. Satellite Image of Al-Safeena roundabout (satellite photographs for Kerbala, 2016).
Figure 2. Satellite Image of Sayed Jawda Intersection (satellite photographs for Kerbala, 2016).

4. Methodology
The steps required to complete the analysis of intersections shown in Figure (3).

- Calculation of the traffic volume and finding the peak hour factor (PHF).
- Studing the current traffic volume condition and finding the LOS.
- Suggestion different alternatives to enhance the LOS.
- Finding LOS for intersections after the improvements.

Figure 3. Steps Required to Complete the Analysis of Intersections.

5. Data Collection
The data collection for Al-Safeena roundabout and Sayed Jawda include traffic volume and geometric data.

5.1 Traffic Volume
The calculation of traffic volume distribution by movements was done manually for each approach in four days namely (Sunday, Tuesday, Thursday and Friday) starting on (3/4/ 2018 for five hours (730-830, 830-930, 1330-1430, 1430-1530, 1530-1630) for each day, the reason for choosing these hour is the highest traffic volumes falling within those periods. For calculating PHF, traffic volumes were recorded for every 15 minutes at each approach. Tables (1) and (2) show the traffic volume at each approach across Al-Safeena roundabout and Sayed Jawda intersection.
5.2 Geometrical Data
The current geometric design that includes the number of lane and width of lane for Al-Safeena roundabout and Sayed Jawda intersection as shown in Tables (3 and 4).

**Table 1. Traffic Volume for Al-Safeena Roundabout.**

| Time    | W   | N   | S   |
|---------|-----|-----|-----|
| E       |     |     |     |
| R       |     |     |     |
| TH      |     |     |     |
| L       |     |     |     |
| 730-745 | 60  | 336 | 45  |
| 745-800 | 83  | 156 | 42  |
| 800-815 | 84  | 155 | 43  |
| 815-830 | 80  | 163 | 43  |
| 830-845 | 86  | 203 | 40  |
| 845-900 | 62  | 168 | 38  |
| 900-915 | 84  | 165 | 38  |
| 915-930 | 79  | 166 | 33  |
| 1330-1345 | 99 | 361 | 18  |
| 1345-1400 | 110| 199 | 27  |
| 1400-1415 | 107| 203 | 27  |
| 1415-1430 | 123| 186 | 25  |
| 1430-1445 | 117| 172 | 20  |
| 1445-1500 | 80  | 202 | 12  |
| 1500-1515 | 53  | 137 | 13  |
| 1515-1530 | 60  | 152 | 11  |
| 1530-1545 | 54  | 126 | 12  |
| 1545-1600 | 67  | 155 | 17  |
| 1600-1615 | 77  | 175 | 20  |
| 1615-1630 | 74  | 86  | 23  |
### Table 2. Traffic Volume for Al-Sayed Jawda Intersection.

| Time   | E   | W   | N   | S   |
|--------|-----|-----|-----|-----|
|        | R   | TH  | L   | R   | TH  | L   | R   | TH  | L   |
| 730-745| 88  | 293 | 74  | 55  | 110 | 33  | 211 | 116 | 43  | 46  | 224 | 118 |
| 745-800| 84  | 229 | 71  | 53  | 138 | 49  | 196 | 68  | 50  | 53  | 148 | 49  |
| 800-815| 82  | 215 | 67  | 47  | 136 | 50  | 180 | 115 | 57  | 46  | 144 | 95  |
| 815-830| 85  | 245 | 65  | 49  | 141 | 61  | 179 | 113 | 62  | 50  | 142 | 104 |
| 830-845| 99  | 140 | 29  | 39  | 96  | 41  | 134 | 98  | 275 | 41  | 212 | 140 |
| 845-900| 80  | 246 | 39  | 37  | 80  | 29  | 112 | 127 | 62  | 50  | 185 | 94  |
| 900-915| 84  | 199 | 38  | 25  | 92  | 22  | 101 | 133 | 62  | 57  | 144 | 91  |
| 915-930| 83  | 190 | 29  | 33  | 88  | 22  | 100 | 120 | 58  | 46  | 170 | 91  |
| 1330-1345| 67 | 242 | 68  | 38  | 99  | 33  | 185 | 72  | 36  | 38  | 202 | 93  |
| 1345-1400| 78 | 230 | 56  | 39  | 78  | 36  | 201 | 93  | 35  | 39  | 191 | 36  |
| 1400-1415| 69 | 243 | 69  | 41  | 78  | 47  | 183 | 81  | 47  | 44  | 192 | 66  |
| 1415-1430| 62 | 231 | 68  | 44  | 82  | 48  | 184 | 88  | 47  | 36  | 183 | 78  |
| 1430-1445| 48 | 207 | 76  | 36  | 70  | 38  | 165 | 74  | 78  | 36  | 168 | 52  |
| 1445-1500| 59 | 197 | 57  | 32  | 85  | 35  | 173 | 76  | 79  | 35  | 169 | 52  |
| 1500-1515| 60 | 193 | 64  | 31  | 79  | 31  | 167 | 68  | 69  | 34  | 170 | 57  |
| 1515-1530| 67 | 200 | 72  | 35  | 67  | 34  | 172 | 85  | 68  | 36  | 177 | 55  |
| 1530-1545| 33 | 196 | 65  | 34  | 67  | 34  | 163 | 81  | 71  | 38  | 177 | 49  |
| 1545-1600| 47 | 41  | 68  | 37  | 63  | 25  | 167 | 82  | 53  | 40  | 187 | 50  |
| 1600-1615| 41 | 53  | 75  | 46  | 70  | 47  | 174 | 72  | 63  | 44  | 195 | 59  |
| 1615-1630| 36 | 51  | 77  | 54  | 68  | 58  | 174 | 74  | 77  | 145 | 204 | 72  |

### Table 3. Geometric Characteristics for Al-Safeena Roundabout

| Approach direction | No. lane | Width of lane(m) |
|--------------------|----------|------------------|
| E                  | 3        | 4                |
| W                  | 3        | 3.5              |
| N                  | 3        | 3.5              |
| S                  | 3        | 2.9              |

### Table 4. Geometric Characteristics for Sayed Jawda intersection

| Approach direction | No. lane | Width of lane(m) |
|--------------------|----------|------------------|
| E                  | 4        | 3.2              |
| W                  | 3        | 3.5              |
| N                  | 3        | 3.5              |
| S                  | 3        | 3.5              |
6. Analysis and Results.
To evaluate and analyze the performance of intersections, the SIDRA program version 7 was used and through this program the following information was calculated:
- The degree of saturation (v/c)
- Average delay
- LOS

6.1 Determine Peak Hour Volume:
The traffic account every 15 min. is carried out from (7:30-9:30) a.m. and (13:30-16:30) p.m. for Al-Safeena roundabout and Sayed Jawda intersection. The peak hour for Al-Safeena and for Sayed Jawda located in (7:30-8:30) p.m. The PHF for Al-Safeena roundabout and Sayed Jawda intersection shown in Tables (5 and 6), where the number of vehicles accounted is equal to 5628 veh./hr for Al-Safeena roundabout. the number of vehicles for Sayed Jawda intersection is 5282 veh./hr.

6.2 Calculation of the PHF (Peak Hour Factor):
The peak hour factor defined as “the ratio of total hourly volume to the maximum 15- min rate of flow within the hour” as following equations (1) and (2) (HCM, 2000).

\[
PHF = \frac{\text{Hourly volume}}{\text{peak rate of flow (within hour)}} \quad (1)
\]

\[
PHF = \frac{\text{Hourly volume}}{4 \times V_{15 \text{min}}} \quad (2)
\]

\(V_{15}\) = The volume that is through peak 15 minutes of peak hour, on veh/15min

Variation of Traffic volume for Al-Safeena and Sayed Jawda intersections during peak period shown in Figure (4 and 5).

| Table 5. PHF for Each Direction for Al-Safeena Roundabout. |
|------------------------------------------------------------|
| Direction | PHF |
| E         | 0.93 |
| W         | 0.97 |
| N         | 0.98 |
| S         | 0.956 |

| Table 6. PHF for Each Direction for Al-Sayed Jawda Intersection. |
|---------------------------------------------------------------|
| Direction | PHF |
| E         | 0.93 |
| W         | 0.94 |
| N         | 0.932 |
| S         | 0.92 |
6.3. Existing LOS

The program SIDRA version 7 was invented to analyze the traffic conditions and to obtain the current capacity as well as to obtain the ratio of speed to volume as well as calculating the delay for each approach of each traffic movement. After setting the peak hour that represents the design hour volume, it is very important to guess the level of service in the current flow and geometric properties at Al-Safeena roundabout and Sayed Jawda intersection. When the service level is set to the current case, the delay rate must be calculated at Al-Safeena and Sayed Jawda because for LOS account, the average delay perform the major parameter. By using SIDRA 7 program, the average delay for AL-Safeena intersection at its existing geometric is (71) sec./veh. this mean, Al-Safeena will operate in LOS (F). Table (7) show the average delay
The average delay for Al-Sayed Jawda intersection at existing geometric is (123) sec/veh so Sayed Jawda intersection will operate in LOS (F). Table (8) shows the average delay and LOS for Sayed Jawda intersection for each approach that connected with this Intersection.

The Geometric layout for Al-Safeena roundabout and Sayed Jawda intersection shown in Figure (6 and 7).

![Figure 6. Geometric Layout of Al-Safeena Roundabout.](image)

![Figure 7. Geometric Layout of Sayed Jawda Intersection.](image)
Table 7. LOS at Al-Safeena Roundabout.

| Direction     | Approach Delay (sec) | LOS | Intersection Delay (sec) | LOS |
|---------------|----------------------|-----|--------------------------|-----|
| Northbound    | 178                  | F   | 71                       | F   |
| Eastbound     | 78                   | F   |                          |     |
| Southbound    | 154                  | F   |                          |     |
| Westbound     | 60                   | F   |                          |     |

Table 8. LOS at Sayed Jawda Intersection.

| Direction     | Approach Delay (sec) | LOS | Intersection Delay (sec) | LOS |
|---------------|----------------------|-----|--------------------------|-----|
| Northbound    | 110                  | F   | 123.5                    | F   |
| Eastbound     | 147                  | F   |                          |     |
| Southbound    | 92                   | F   | 123.5                    | F   |
| Westbound     | 147                  | F   |                          |     |

7. Design of Proposals

7.1 Design of proposal for Al-Safeena roundabout.

The level of service of Al Safeena intersection improve by decrease the width of middle island for east approach from 9.8 to 4.5 so this increase the no of lane for the east approach (when the no of lane increase the approach capacity increase so the LOS enhanced). The no of lanes for the north and west approach increase in same method for east approach as shown in Figure (8). The north approach increase through the increase of entry radius this lead to increase flare length and entry width and consequently the capacity of approach increase. The improvement of Al Safeena shown in Figure (8). In these improvement v/c reduce to 0.7 and the LOS for this intersection enhanced to (C), as shown in Table (9) and Figure (9).
Figure 8. Improvement Proposal for Al-Safeena Intersection.

Figure 9. Shown the Movement Intersection for Al-Safeena Roundabout after the Improvement.

Table 9. LOS at Al-Safeena Roundabout by SIDRA 7.

| Direction | Approach | Intersection |
|-----------|----------|--------------|
|           | Delay (sec) | LOS | Delay (sec) | LOS |
| Northbound | 17 | C | 15.4 | C |
| Eastbound  | 13.3 | B | 15.1 | C |
| Southbound | 15.5 | C | | |
| Westbound  | | | | |

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7.2 Design of Proposals for Sayed Jawda

The LOS at Sayed Jawda Intersection was enhanced by remarking approaches pavement into four lanes instead of three. The traffic lanes that have low traffic volume are assigned to be shared. In this proposal the LOS enhanced to E, which is not enhanced to accepted level as shown in Figure (10), the LOS and delay for this intersection are shown in Table (10).

| Direction | Approach | Delay (sec) | LOS | Delay(sec) | LOS |
|-----------|----------|-------------|-----|------------|-----|
| Northbound | U        | 65          | E   |            |     |
|           | L2       | 78          |     |            |     |
|           | T1       | 84          | F   | 78         | E   |
| Westbound | U        | 77          | E   |            |     |

Figure 10. The Intersection Movements and LOS for Sayed Jawda Intersection after Pavement Remarkering.

Table 10. LOS for Sayed Jawda intersection after Pavement Remarkering by SIDRA 7
Changing Sayed Jawda intersection to roundabout reduced the v/c to 0.8 and LOS to C as shown in Figure 11 and Table 11. This roundabout with circulatory width 14m and island diameter of 30m, the improvement for Sayed Jawda is shown in Figure 12.

**Figure 11.** LOS at Sayed Jawda Intersection after Pavement Remarking and Changing to Roundabout.

**Table 11.** LOS for Sayed Jawda after Pavement Remarking and Changing to Roundabout by SIDRA.

| Movement | Performance | Vehicles |
|----------|-------------|----------|
|          | Max Delay  | Avg Delay | Min Delay |
|          | (sec)      | (sec)     | (sec)     |
| South Roadname |                |          |          |
| 3a | 35 | 0.0 | 0.000 | 22.2 | LOS C | 4.4 | 33.1 | 0.80 | 1.02 | 47.1 |
| 5 | 12 | 0.0 | 0.000 | 16.2 | LOS C | 4.4 | 33.1 | 0.80 | 1.02 | 46.1 |
| 10 | 12 | 0.0 | 0.000 | 7.7 | LOS D | 4.2 | 32.0 | 0.85 | 1.11 | 40.6 |
| Approach | 1722 | 0.0 | 0.000 | 15.1 | LOS C | 4.4 | 33.1 | 0.81 | 1.01 | 46.9 |
| East Roadname |                |          |          |
| 3a | 35 | 0.0 | 0.000 | 32.2 | LOS D | 2.6 | 19.5 | 0.88 | 1.04 | 42.7 |
| 5 | 12 | 0.0 | 0.000 | 23.0 | LOS C | 2.6 | 19.5 | 0.88 | 1.04 | 41.8 |
| 10 | 12 | 0.0 | 0.000 | 26.2 | LOS D | 5.1 | 30.5 | 0.96 | 1.20 | 43.6 |
| Approach | 1429 | 0.0 | 0.000 | 31.2 | LOS D | 6.2 | 47.0 | 0.91 | 1.21 | 46.6 |
| North Roadname |                |          |          |
| 3a | 39 | 0.0 | 0.000 | 29.2 | LOS D | 2.4 | 18.2 | 0.84 | 0.98 | 44.9 |
| 5 | 12 | 0.0 | 0.000 | 19.3 | LOS C | 2.4 | 18.2 | 0.84 | 0.98 | 43.7 |
| 10 | 12 | 0.0 | 0.000 | 26.4 | LOS C | 4.0 | 30.7 | 0.86 | 1.11 | 46.7 |
| Approach | 1550 | 0.0 | 0.000 | 33.5 | LOS D | 7.0 | 52.9 | 0.94 | 1.37 | 35.5 |
| West Roadname |                |          |          |
| 3a | 36 | 0.0 | 0.000 | 24.4 | LOS C | 3.2 | 24.4 | 0.83 | 1.01 | 40.9 |
| 5 | 12 | 0.0 | 0.000 | 19.2 | LOS C | 3.5 | 26.4 | 0.82 | 1.00 | 40.2 |
| 10 | 12 | 0.0 | 0.000 | 15.7 | LOS C | 3.6 | 27.2 | 0.88 | 0.97 | 40.1 |
| Approach | 1475 | 0.0 | 0.000 | 22.8 | LOS C | 6.1 | 46.4 | 0.84 | 1.08 | 44.3 |
| All Vehicles | 6216 | 0.0 | 0.000 | 24.1 | LOS C | 7.0 | 52.8 | 0.85 | 1.11 | 43.7 |
8. Conclusions

The results indicated that the LOS for Al-Safeena roundabout was unacceptable. The level of service of al Safeena intersection was improved by decreasing the width of the middle island for east approach from 9.8m to 4.5m which increases the no of lane for the east approach (When the no of lanes increases, the approach capacity also increases and the LOS enhanced). The no of lanes for the south and west approach increases in the same manner as of the east approach. The north approach width increases through the increase of entry radius this lead to increase flare length, and entry width and consequently the capacity of approach capacity increases. Following these improvements, the LOS for this intersection enhanced to (C). Also the unacceptable LOS for Sayed Jawda was enhanced by dividing the width of the approaches to four lanes so each movement in each lane is isolated and the low traffic lanes are shared, the level of service of Sayed Jawda intersection was not enhanced and still work in LOS E. Changing Sayed Jawda intersection to roundabout will enhance the LOS to (C).
References

[1] Akcelik R 1986 SIDRA version 2.2 input and output (Austrian road research board) Technical manual, ATM No. 19.

[2] Federal Highway Administration 1995 Improving Traffic Signal Operations (U.S. Department of Transportation), p 1.

[3] Khisty C J and Lall B k 1998 Transportation Engineering Handbook Second edition (Prentice – hall International) Inc.

[4] Kittelson & Associates Inc Roundabouts an Informational Guide Report FHWSRD-00-067 FHWA, U.S. Department of Transportation, 2000. I am at, Federal Highway Administration, Publication No. FHWA-RD-00-067, June 2000.

[5] Zegeer D.C 1986 Field Validation of Intersection Capacity Factors (Transportation Research record 1091, Transportation research Board Washington, DC).