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EVALUATION OF GEOMETRIC AND BEHAVIORAL FEATURES OF ROUNDABOUT BY USING SIDRA SOFTWARE

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ABSTRACT

Computer simulation can be of high importance to analysis geometry regarding the signalized roundabouts and intersections that are related to systems of urban streets. The major goal of the presented research is analyzing geometry as well as the intersection classification that is related to traffic flow, as well as enhancing the capacity related to intersections for road networks, also relieving city’s congestions. Data on number of vehicles passing through Mudaffar roundabout have been recorded through the author of the presented study from seven in the morning to three after noon for 4 days. Sidra software was adopted to analyzed the data. The results have indicated that the level of service (LOS) regarding the present conditions in the discussed roundabout has been F, and with average delay (303.6 sec/veh). There are two proposals will be used to the developing of the roundabout. The best results indicated that the LOS for present condition of Mudaffar roundabout is C with (26.4 sec/veh) of average delay.

KEYWORDS

Peak Hour Factor (PHF), Level of Service (LOS), Delay, Sidra and Roundabout.

1. INTRODUCTION

With regard to different cities, chronic traffic jams occur, also, a lot of money and time is wasted through traffic congestions, for the purpose of reducing such losses, it is very important to come up with effective approach for resolving traffic congestions and reducing delay tine (Akcelik, 1995). In heavy congestions, about thirty percent increase in the fuel consumption will occur (Greenwood and Bennett, 1996). The impact regarding these queues on the motorists will be extreme at the intersections which are controlled via roundabouts. For the purpose of directing the traffic at roundabouts in a smoother way, for giving efficient possibilities for the traffic's mass crossings, and also for having more effective control regarding queue length, it is of high importance to have traffic on these intersections organized via police (Al-Madani, 2003).

With regard to computing and assessing the performance that is related to intersection controls, some benefits are provided via SIDRA program, such benefits make it more favorable in comparison to other programs. SIDRA approach highlights consistency regarding the capacity as well as the performance analysis approaches for roundabouts, signalized, and sign-controlled intersections via using integrated modeling system. Such software offers dependable evaluations regarding the geometric delay as well as the associated slow-down impacts for different types of intersection. The main advantage of SIDRA is that it depends on Australian Road Research Board (ARRB) and US Highway Capacity Manual (HCM) research results (Akcelik and Besley, 2001). Thus, SIDRA offers the same LOS standard for roundabouts as well as traffic signals within the suggestion that the roundabout's performance will be comparable to that of traffic signals for a lot of flow conditions (Akcelik and Chung, 1994). The functionality of SIDRA has been expanded for covering range problems. Currently, it applies a major method regarding the traffic design packages (Akcelik, 2010) (Mohammed et al., 2018).

In Baghdad city, Kahtan square has been of high importance to the presented study, as the author examined the operation traffic regarding this square, the information has been manually obtained for traffic volumes regarding Kahtan square, and that is of high importance to the geometrical and traffic analysis, SIDRA has been used for processing traffic analysis. The author of this study provided 2 options for improving the traffic volume regarding Kahtan square. The first option indicated replacing the current roundabout via four legs signalized intersection for increasing the number of the lanes in each one of the directions and using the are efficiently. The other option indicated a fly over on major course regarding traffic movements (from alyarmok hospital through Kahtan square and ultimately albayaa district) the author suggested that the latter options has been more optimum (Al-Kubaisy, 2008).

By using HCS2010 software, Al-Faris Al-Arabee signalized intersection in Baghdad, was operating at LOS F with delay (393.3 and 626.0 sec/veh), respectively. Thus, enhancing the performance regarding the intersection demanded separation of traffic movements from conflicting with 3 lanes for underpass (Y-Shape) to distribute the traffic volume (through and left movement) coming from Al-Rawad Intersection. Also, Two-way two lanes flyover to transport the traffic volume in the both direction of Damascus Street. Following using the suggested geometric design, it is going to operate at LOS B and LOS D with a delay of 15.9 and 46.6 sec/veh, respectively in the design year (2039) (Mohammed, 2019).

The aim of the presented study is studying traffic performance operation in the overcrowded signalized intersections in Baghdad city. It can be achieved through estimating existing LOS at examined zone. Then development of the intersection and evaluated of the service level (LOS) at the design period.

The presented study has been organized in the following way. Section 2 and will provide site description. Section 3 will provide traffic surveys (work methodology); Section 4 and 5 will provide analysis result discussion and design of proposals. Lastly, conclusions are provided in Section 6.

2. DESCRIPTION OF SITE

Baghdad, the capital of Iraq, this city has largest population in Iraq, because of the most important of the central business and commercial. It is believed that the quickly increases in population in Baghdad was the main reason for increasing the demand for transportation. This may create major operation problems, especially at the peak period.

Mudaffar intersection can be defined as 4 -leg roundabout intersection at Al-Rusafa side in Baghdad, the roundabout is of high importance because it connects 2 main street Al Chuader street with Al-Umal street as can be seen in the Figs. 1 and 2.

Fig. 1. Satellite image of Mudaffar intersection.

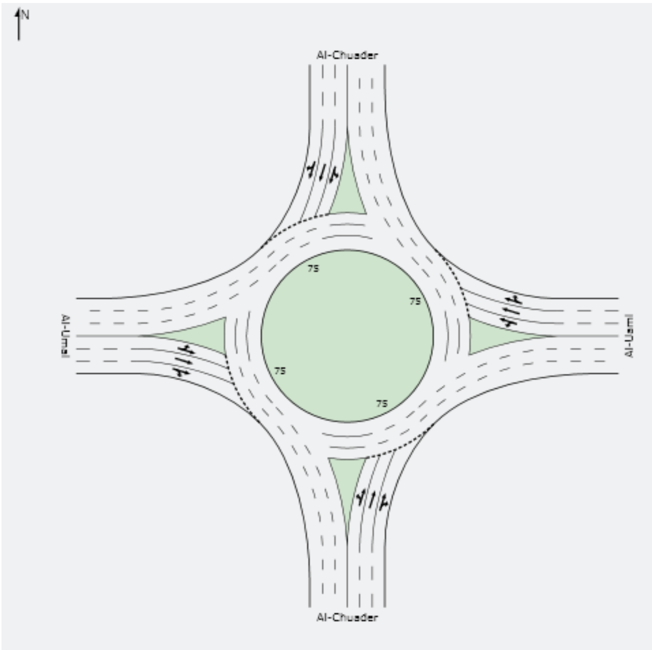

Fig. 2. Sidra layout image for Mudaffar roundabout.

3. TRAFFIC SURVEYS (DATA COLLECTION)

Video observations were carried out seeking realistic data collection of the studied intersections. Later, Sidra software was employed to evaluate and analyze the different operational performance indices.

Two data categories were required for the simulation model, roundabout geometry and traffic volumes. The roundabout geometry data considered intersections configurations, lanes alignment, lanes widths, number of lanes of both the major corridor as well as the minor intersected streets. Google maps were used to collect the required geometric data. On the other hand, as an efficient way to obtain traffic data, video observations and traffic counts for the studied intersections recorded during workdays of the week in March and April 2019 from (7:00 am to 3:00 pm) were used in this study as in Fig. 3. The ratio of total hourly volume to the maximum 15- min rate of flow within the hour which is defined as peak hour factor (PHF) (Manual, H.C., 2010), the peak hour factor was calculated in each approach of the intersection during peak period as shown in Table 1.

Table 1. Peak hour factor (PHF) in each direction of the intersection

Direction	PHF
E	0.92
W	0.89
N	0.93
S	0.92

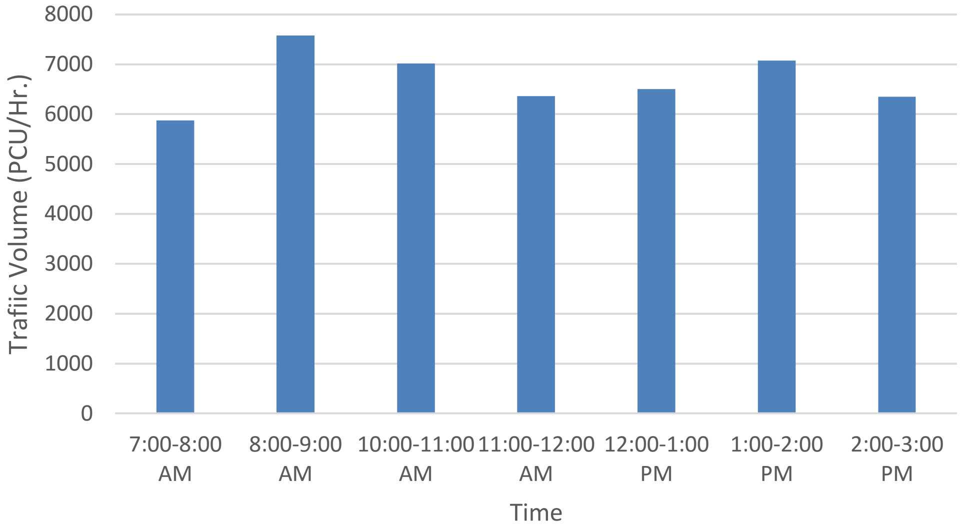

Fig. 3. Traffic volumes for all approaches at Mudaffar roundabout.

For the traffic composition aspect, it was found that the existing traffic was a heterogeneous traffic situation in both major and minor approaches. Fig. 4 illuminates the traffic volume percentages for each approach at the peak period. Traffic flow percentage has been assessed via dividing number of cars in each one of the directions on total number of cars. The existing traffic composition consisted of motorcycles, normal vehicles, minibuses and heavy vehicles (including buses, trucks and small trucks) Total traffic flow percentage can be seen in the Fig. 4.

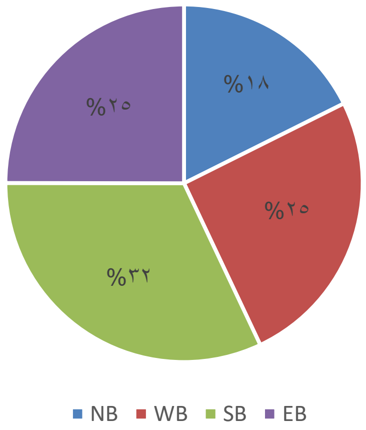

Fig. 4. Traffic volumes percentages for each approach at the peak period for studied roundabout.

4. DATA RESULTS AND DISCUSSION

4.1. Mudaffar intersection existing LOS

LOS technique is specified depending on US HCM, a particular measure utilized for relating the effectiveness regarding traffic flows. LOS is applied for dissecting the highways through sorting the traffic flows as well as doling out the movement's quality levels regarding the execution measure such as density and speed (HCM, 2010). LOS definitions according to delay HCM (for vehicles) has been displayed in the Table 2. Current LOS has been assessed in the presented study with the use of SIDRA. The results indicated Mudaffar roundabout LOS is (F) as can be seen in the Fig. 5, therefore it might be specified as un-stable flow.

Table 2. LOS definitions based for vehicles on delay HCM (HCM, 2010)

LOS	Control Delay for signalized (sec/veh.)	Control Delay for unsignalized, (sec/veh.)
A	≤ 10	≤10
B	10-20	10-15
C	20-35	15-25
D	35-55	25-35
E	55-80	35-50
F	≥ 80	≥ 50

Movement Performance - Vehicles											
Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Al-Chuader											
1	L	704	0.0	2.699	805.4	LOS F	172.5	1207.7	1.00	4.20	3.1
2	T	1407	0.0	2.700	799.9	LOS F	244.1	1708.8	1.00	4.66	2.7
3	R	528	0.0	2.695	797.3	LOS F	172.5	1207.7	1.00	4.20	2.6
Approach		2639	0.0	2.698	800.9	LOS F	244.1	1708.8	1.00	4.44	2.8
East: Al-Uaml											
4	L	417	0.0	1.070	79.3	LOS E	32.1	224.9	1.00	2.17	21.7
5	T	1007	0.0	1.070	71.2	LOS E	43.5	304.2	1.00	2.37	20.8
6	R	663	0.0	1.208	121.7	LOS F	51.9	363.5	1.00	2.87	13.9
Approach		2087	0.0	1.207	88.9	LOS F	51.9	363.5	1.00	2.49	18.3
North: Al-Chuader											
7	L	623	0.0	0.947	45.8	LOS D	20.8	145.3	1.00	1.62	29.6
8	T	365	0.0	0.745	17.3	LOS B	7.9	55.2	0.99	1.18	41.2
9	R	464	0.0	0.990	45.3	LOS D	18.5	129.3	1.00	1.64	26.8
Approach		1452	0.0	0.990	38.5	LOS D	20.8	145.3	1.00	1.52	30.7
West: Al-Umal											
10	L	698	0.0	1.074	74.4	LOS E	42.2	295.4	1.00	2.35	22.5
11	T	824	0.0	1.073	66.6	LOS E	42.2	295.4	1.00	2.16	21.7
12	R	524	0.0	1.074	66.9	LOS E	31.6	220.9	1.00	2.12	21.3
Approach		2046	0.0	1.073	69.3	LOS E	42.2	295.4	1.00	2.21	21.9
All Vehicles		8224	0.0	2.698	303.6	LOS F	244.1	1708.8	1.00	2.88	6.9

Fig. 5. Roundabout current LOS for each approach.

4.2. Average delay

Average delay is a factor of high importance in forecasting the travel time. Delay's results have been specified in the Fig. 6 as it show that Al-Umal and Al-Chuader streets have 2 colors (orange and red), orange indicates LOS E and red indicates LOS F. Delay has been unfavorably associated to LOS in the case when delay is minimized LOS is improved (Al-omari and Ta'amneh, 2007). At the same time, the south bound regarding Al-Chuader road has 2 colors (purple and light blue), light blue indicates LOS D, while the purple indicates LOS B that has minimum delay. Total delay for Mudaffar intersection has been recorded as 303.6 sec.

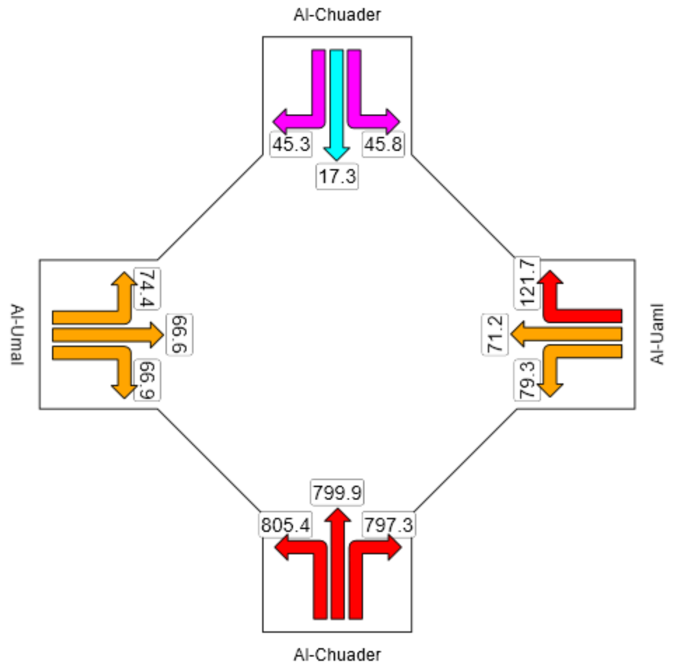

Fig. 6. Average delay for all movement at each approach.

4.3. Degree of saturation

Level of saturation (%) is considered as proportion of demand to limit on each one of the lanes for dealing with intersections, with estimation of 100% indicating that the limit and demand are comparable and no additional movements might be advancing via the intersection. Values over 85% have been generally seen as torment from the movement clogs, with vehicle's lines are shaped. Based on color code regarding degree of saturation. Each one of the degrees has certain color. The results related to the degree of saturation has been indicated in Fig. 7. Blue color indicates no more than 0.8 degree of saturation, it has been indicated that south bound related to Al-Chuader street was orange, which indicates that the degree of saturation approaches (0.9-1.0), while Al-Umal road was red, which indicates over (1.0) degree of saturation. Degree saturation regarding Mudaffar intersection has been 2.698 v/c.

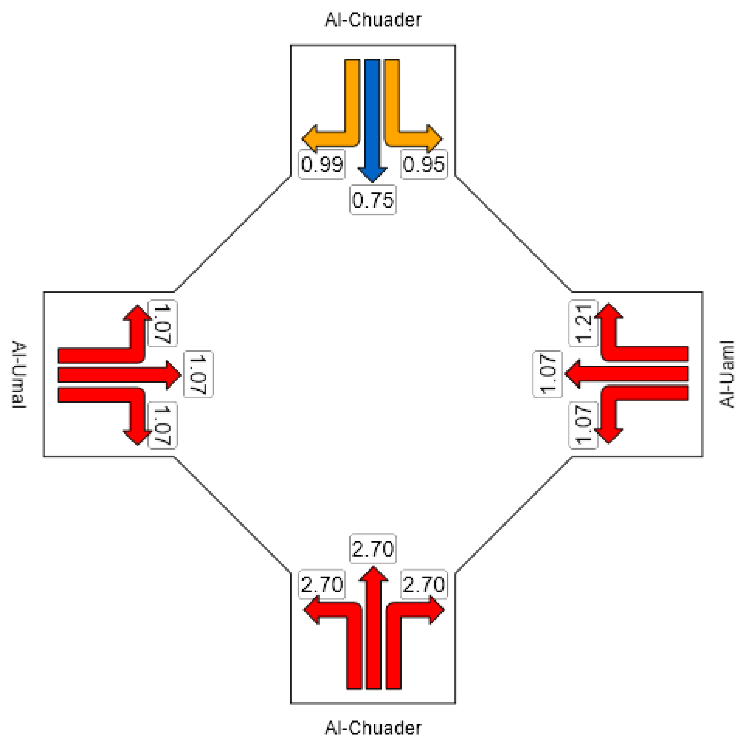

Fig. 7. Degree of saturation for all movement at each approach.

5. DESIGN OF PROPOSALS

In this paper, two proposals will be used to the developing of the roundabout delay models for as a function of traffic volumes and geometric factors.

5.1. Add lane to the existing approaches

In this proposal, it is suggested to increase the capacity for all approaches related to Mudaffar roundabout through increasing the number of lanes for both Streets (Al-Chuader and Al-Umal) by decrease width regarding middle island for south and east bounds from 7.0 to 3.5 m while the west and north bounds because of the median width from 3.5 to 0.5 m . It was found that the mentioned roundabout still remaining work in LOS (F) with an overall delay 167.4 (sec/veh). Fig. 8 illustrates the result of this proposal.

Movement Performance - Vehicles											
Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Al-Chuader											
1	L	704	0.0	1.935	465.6	LOS F	154.4	1080.6	1.00	4.37	5.2
2	T	1407	0.0	1.937	452.9	LOS F	154.4	1080.6	1.00	3.91	4.6
3	R	528	0.0	1.582	298.0	LOS F	75.1	525.8	1.00	3.31	6.6
Approach		2639	0.0	1.936	425.3	LOS F	154.4	1080.6	1.00	3.91	5.1
East: Al-Uaml											
4	L	417	0.0	1.081	91.4	LOS F	28.6	200.4	1.00	2.09	19.7
5	T	1007	0.0	1.081	83.1	LOS F	28.6	200.4	1.00	2.09	18.8
6	R	663	0.0	1.078	86.5	LOS F	39.6	277.4	1.00	2.35	17.9
Approach		2087	0.0	1.081	85.8	LOS F	39.6	277.4	1.00	2.18	18.7
North: Al-Chuader											
7	L	623	0.0	0.843	26.8	LOS C	12.4	86.6	1.00	1.31	37.4
8	T	365	0.0	0.275	6.8	LOS A	2.1	14.7	0.88	0.66	48.1
9	R	464	0.0	0.884	21.4	LOS C	10.5	73.7	0.98	1.29	37.9
Approach		1452	0.0	0.884	20.0	LOS C	12.4	86.6	0.96	1.14	39.7
West: Al-Umal											
10	L	698	0.0	0.859	29.6	LOS C	15.7	109.6	1.00	1.40	36.0
11	T	824	0.0	0.689	13.6	LOS B	7.2	50.6	0.96	1.12	44.2
12	R	524	0.0	0.903	26.9	LOS C	14.2	99.1	1.00	1.42	34.6
Approach		2046	0.0	0.903	22.5	LOS C	15.7	109.6	0.98	1.29	38.4
All Vehicles		8224	0.0	1.936	167.4	LOS F	154.4	1080.6	0.99	2.33	11.5

Fig. 8. Mudaffar roundabout LOS for the first proposal.

5.2. New geometrical proposal

This proposal includes construct flyover along Al-Chuader street due to the highest traffic volumes and available spacing in this street, it will change the traffic of all approaches of the mention intersection. The level of service of Mudaffar roundabout improves by using the width of middle island along Al-Chuader street, so the exiting no of lane for Al-Chuader street will serve two movement for north and south approaches (when the no of lane increases approach capacity will increase, thus LOS will be improved). This proposal makes the at grade intersection work in LOS (C) with an average delay 26.4 (sec/veh) as shown in Fig. 9 below. In such improvements v/c decrease to 1.034 and LOS for the intersection improved to (C), as can be seen in the below figure:

Movement Performance - Vehicles											
Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: 1											
3L	L	704	0.0	0.875	26.8	LOS C	8.8	66.9	0.96	1.43	27.9
8R	R	528	0.0	0.924	26.6	LOS C	13.6	103.2	0.99	1.69	26.0
Approach		1233	0.0	0.924	26.7	LOS C	13.6	103.2	0.98	1.54	27.1
East: 2											
1L	L	417	0.0	0.975	47.0	LOS D	19.0	144.8	1.00	1.99	22.7
6T	T	1007	0.0	0.974	44.1	LOS D	19.0	144.8	1.00	1.99	21.8
6R	R	663	0.0	1.033	55.5	LOS E	30.6	232.2	1.00	2.54	18.8
Approach		2087	0.0	1.034	48.3	LOS E	30.6	232.2	1.00	2.17	21.0
North: 3											
7L	L	623	0.0	0.740	15.8	LOS B	5.6	42.8	0.92	1.17	31.8
4R	R	464	0.0	0.774	11.8	LOS B	7.5	57.1	0.94	1.22	32.3
Approach		1087	0.0	0.773	14.1	LOS B	7.5	57.1	0.93	1.19	32.0
West: 4											
5L	L	698	0.0	0.830	13.6	LOS B	11.5	87.1	0.96	1.33	32.7
2T	T	824	0.0	0.635	7.4	LOS A	5.6	42.4	0.85	1.00	35.1
2R	R	524	0.0	0.784	10.8	LOS B	8.8	66.6	0.92	1.20	32.8
Approach		2046	0.0	0.830	10.4	LOS B	11.5	87.1	0.90	1.16	33.6
All Vehicles		6452	0.0	1.034	26.4	LOS C	30.6	232.2	0.95	1.56	27.0

Fig. 9. Average delay and LOS for Mudaffar roundabout.

6. CONCLUSIONS

The results indicated that LOS for Mudaffar roundabout was unacceptable due to high traffic volumes. LOS of the mentioned intersection has been enhanced via developing the width of middle island for all approaches that increase the no of lanes for approaches, that means approach capacity increase and LOS enhanced. It was found that the mentioned roundabout still remaining work in LOS (F) with an overall delay 167.4 (sec/veh). Following these improvements and constructed of the flyover along Al-Chuader street will transport the through traffic volume in both direction of the mentioned road, so this intersection will serve at LOS (C) with an average delay 26.4 (sec/veh).

It has been indicated that the mentioned roundabout requires more improvements such as the use of intelligent transportation system application (ITS) for regulating the traffic signals, thus reducing traffic jams, applying closed circuit TV (CCTV) which might allow traffic office to identify jam points, and thus reducing traffic jams.

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