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Evaluating the performance of Antar bin Shaddad signalized Roundabout in Baghdad city

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Abstract

In some roundabouts, the risk of blocking off or creating a long queue is likely happening when a roundabout suffers from high traffic or unbalanced flow patterns. The applying of signalization in roundabouts as treatment or replacement can be useful for such a problem, especially during peak rush hours. The purpose of this study is to examine the performance and flexibility that signalized roundabout offers in handling traffic operation in Baghdad city. Antar Bin shadad signalized roundabout are simulated using VISSIM simulation software to compare the signalized roundabout performance with other different alternative modes such a signalized roundabout with optimum cycle time, signalized intersection, metering system. The simulation results have been analyzed, compared with field collected data, and evaluated. Depending on circulating volumes and the geometric design configuration of each roundabout, it has been found out that, the best suggested scenario for the studied roundabouts (signalized roundabout, signalized intersection and meter roundabout) that could handle the current traffic volumes of all the studied roundabouts is the signalized roundabout scenario with optimum cycling time. In Antar signalized roundabout and from observed simulation results, the best location for an over pass or under pass is to separate the traffic generating from ESB from intersecting with other approaches upstream, this improvement can reduce the delay of the entire roundabout at peak hour by 26%.

Keywords: roundabout, VISSIM, Antar Bin shadad, simulation

1. Introduction

In spite of the great advantages of standard roundabouts over signal or stop intersections, roundabout's properties cannot deal with both the safety and capacity issues of each intersection. Priority roundabout can be considered as a suitable design for any intersection that has high ratio of turning vehicles, in which the roundabout could improve their safety and traffic flow. However, due to its disadvantages, for example the pedestrian's uncontrolled crossings and its insufficiency under the existence of unbalanced traffic flows, when sometimes could cause intersection redesign. In this situation, there is a good solution to integrate signal control systems with roundabout geometry in order to achieve both of the strengths signalization and roundabout geometry simultaneously. In spite of the fact that roundabouts signalization has the potential to enhance the traffic condition at plenty of the existing roundabouts, in reality, it has not been used extensively yet. In addition, among the few signalized roundabouts, the design of these roundabouts has been with little or no formal experience (Stevens, 2005).

2. Methodology and Data Collection

There are many signalized roundabouts in Baghdad city. These signalized roundabouts, diverge in shape, number of legs, dimensions, Security clearance for survey and traffic volume characteristics. These elements have influenced on the selection of study-signalized roundabouts in addition to the traffic data necessary for simulation program to function properly. As result, Antar bin Shaddad signalized roundabout locations met the desired criteria (normal operating condition). After the necessary geometric data and traffic volume are collected at selected signalized roundabouts, Geometric design properties of the signalized roundabout have been obtained in details as required by computer software simulation VISSIM (version 7.0).

2.1 Antar Bin Shaddad Signalized Roundabout

This signalized roundabout is characterized as hamburger roundabout, which means that traffic vehicle passes through connecter dividing the central islander. This signalized roundabout contains five exits but only four entrances. The location of this roundabout is in Rusafa side of Baghdad.

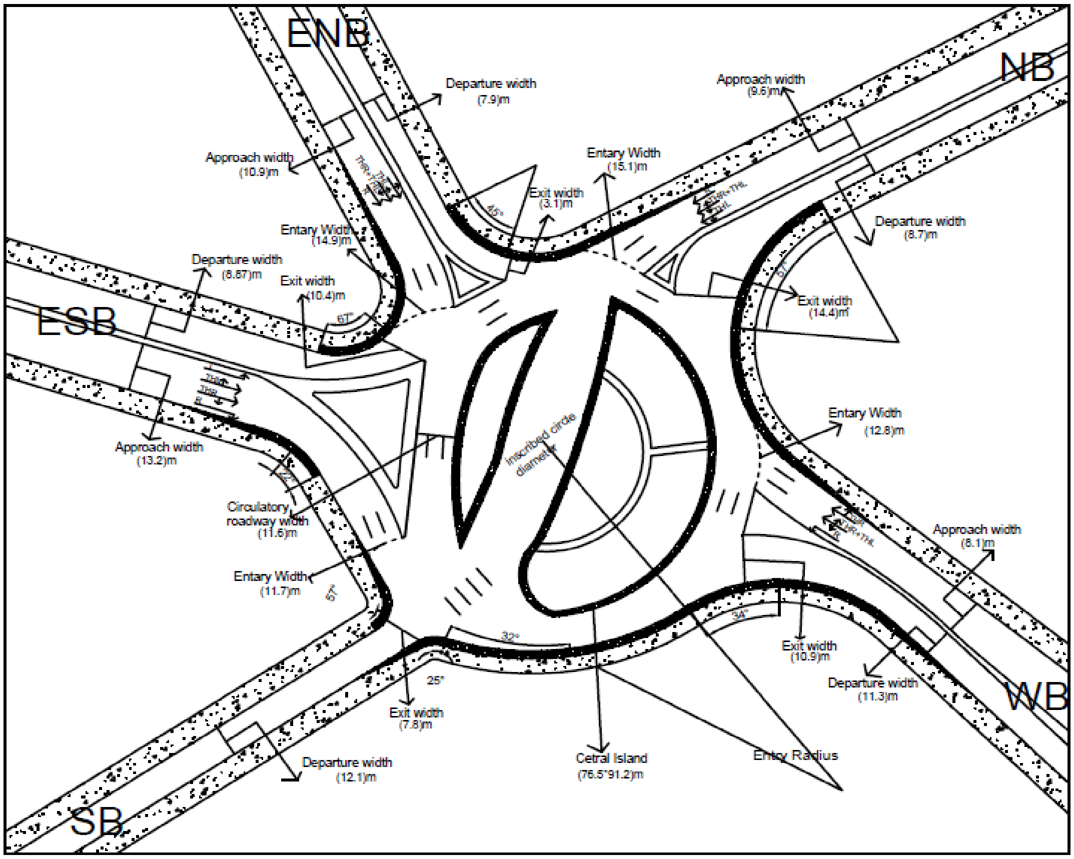

Figure 1. Antar Bin Shaddad signalized roundabout layout

2.2 Alterations

In this study, the simulates peak hour is from (7:00-9:00) and (14:00-16:00) for the Antar bin Shaddad signalized roundabouts. Four main alterations for the selected signalized roundabout are considering, for each alteration the roundabout is model and analyze separately and finally compared with each other numerically. The first alteration considered the roundabout in original existing condition and the output result analyzed as alteration No.0. The second alteration considers the roundabout in existing condition as signalized roundabout, but the cycle time optimizes to reach the pest performance, is model, and analyze as alteration No.1. In the third alteration, the replacement of roundabout with signalized intersection is proposed and named as alterations No.3. And in the last alteration, the use of roundabout with only the highest volume of vehicle is signalize and called alteration No.3. For each of the signalization technique, many different signal timings are try to achieve the best performance for all the suggestion modes. Also from the observation, the video records traffic flows and turning percentages have similar patterns and quite similar values for the two morning hours, but fundamentally different from afternoon two peak hours. All the alterations run in the VISSIM software for 15 replications. The replications average is calculated and the results are stored in the database. The comparison of all the alterations will be between their average outputs. In the following section, a calibration is conduct, where VISSIM software will be compare with software (Arcady) used before in similar studies in Iraq.

3. Data Presentation and Analysis

In This chapter, the simulation technique analysis of the selected roundabouts is applied and presented. Different alteration, which is mentioned earlier in chapter three, will be analyzed in details.

3.1 Alteration Output

3.1.1 Alteration No.0 (origin Signalized Roundabout Simulation Data*)*

Table (1) shows the output results of VISSIM simulation of Antar Bin shaddad roundabout as a signalized intersection. These results are for alteration No.1, as shown in Table (1) in Antar Bin shaddad roundabout (default conditions as signalized roundabout) when the maximum mean delay is 58.21 sec and the lowest average speed is 13.9 km/hr which is considered as acceptable for more than 6000 veh/hr entering from four approaches. As mentioned earlier in Chapter two, this roundabout has a geometric configuration as "hamburger" roundabout which means that there is a connecter shuttering the center island into two halves which has great benefit in discharging the traffic flow into 20 St. and reducing the cycling traffic which could eliminate the problem generated by the 5 the exit (20 St.), but it also creates another problem as ESB connecter intersects. This behavior is explained in Figures (2) to (5). Table (2) shows approaches queue length as outputs of alteration No.1 for Antar Bin shaddad roundabout, (HCM, 2010), (Appendix D).

Table 1. Mean delay and mean stop delay and average speeds outputs of alteration No.0 for Antar Bin shaddad roundabout.

Time from	Time to	Mean delay time (sec)	Mean stop time (sec)	Average speeds (km/h)
7:00	8:00	55.32	31.12	15.60
8:00	9:00	58.21	32.81	13.92
14:00	15:00	41.34	24.92	19.24
15:00	16:00	50.63	37.90	17.11

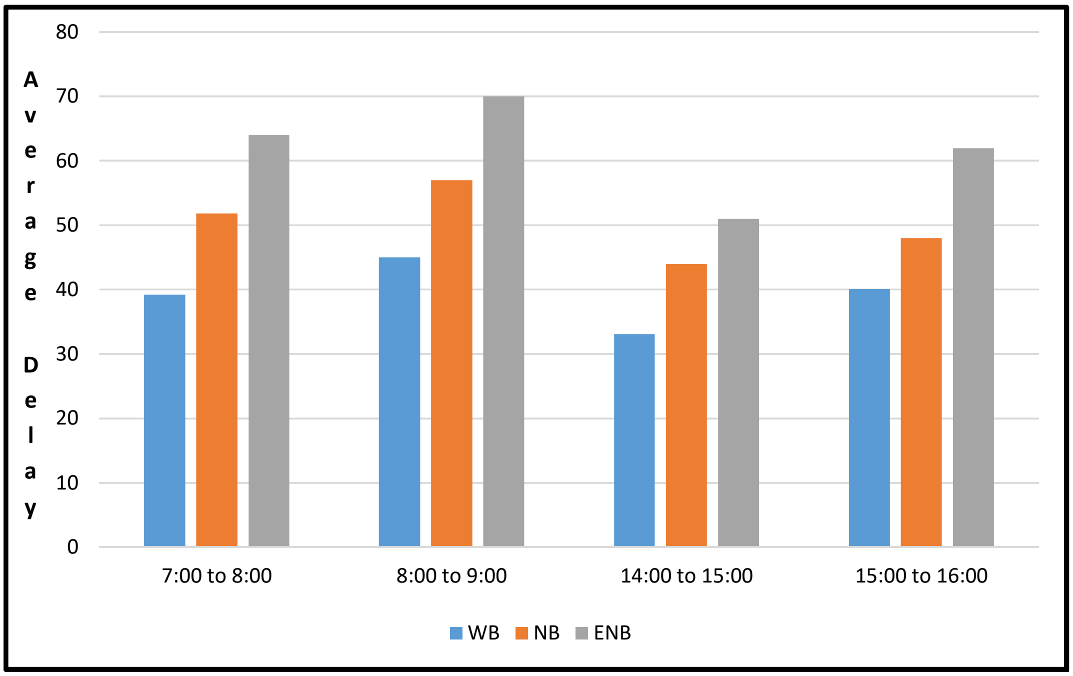

Figure 2. The Average delay of outputs of alteration No.0 Antar Bin shaddad roundabout for vehicle traveling from ESB to all approaches.

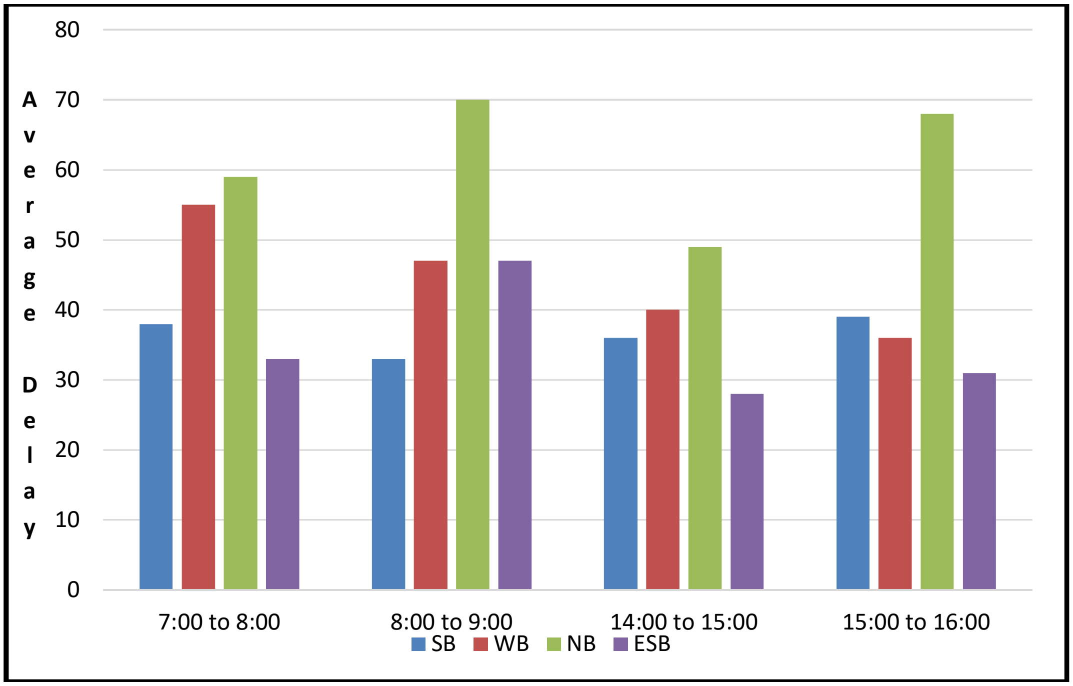

Figure 3. The average delay of outputs of alteration No.0 Antar Bin shaddad roundabout of vehicle traveling from WNB to all Approaches.

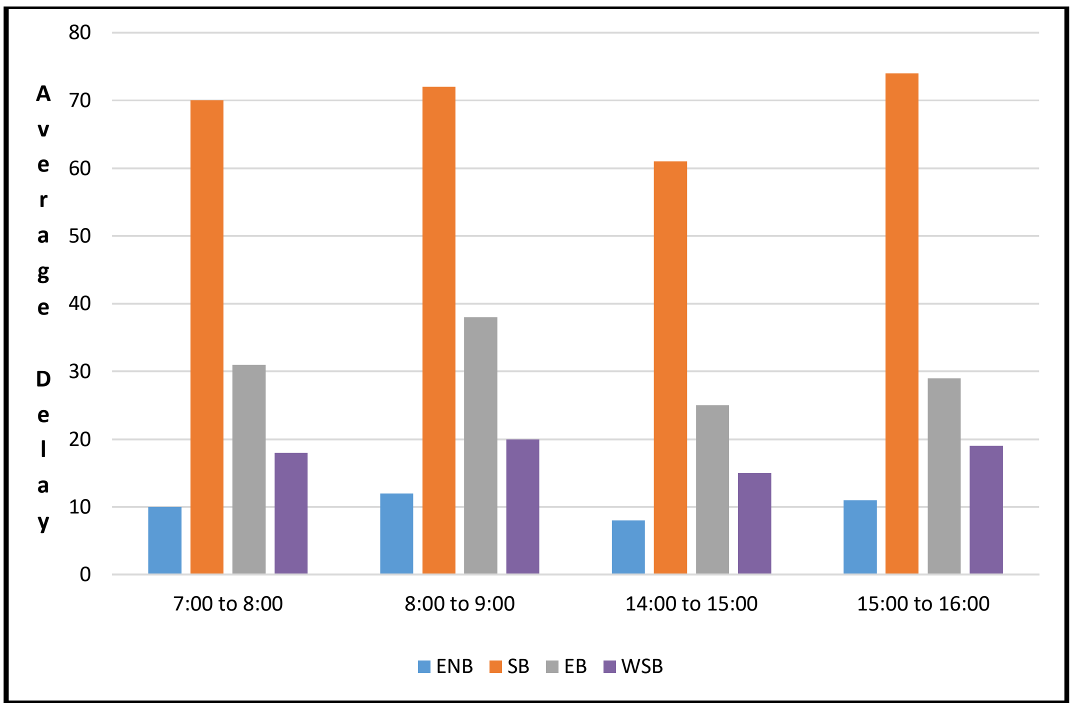

Figure 4. The average delay outputs of alteration No.0 for Antar Bin shaddad roundabout of vehicle Traveling form NB to all approaches.

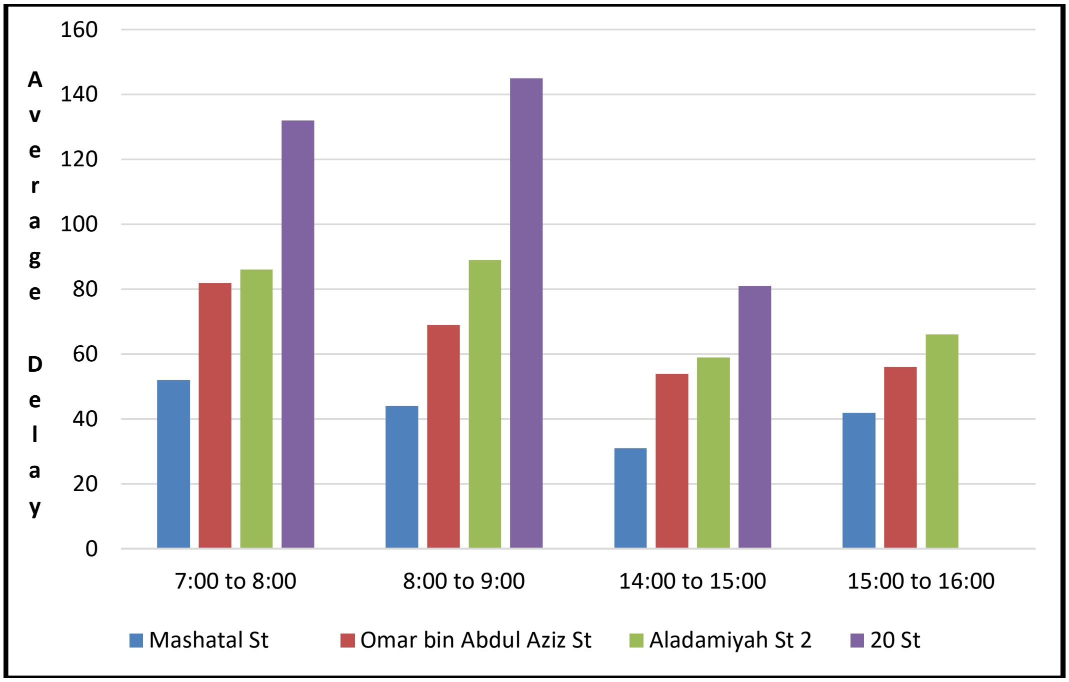

Figure 5. The average delay outputs of alteration No.0 for Antar Bin shaddad roundabout of vehicle traveling from EB to all approaches.

Table 2. Approaches queue length outputs of alteration NO.0 for Antar Bin shaddad roundabout.

Approach Name	**Mean Queue (meter)**			
	From 7:00 to 8:00	From 8:00 to 9:00	From 24:00 to 25:00	From 15:00 to 16:00
WSB	22.83	28.34	21.01	23.12
NB	-	-	-	-
EB	158.23	118.34	55.01	81.34
WNB	-	-	-	-
Major connecter	60.12	73.02	65.01	77.34
Miner connecter	-	-	-	-

From Table, (2), it is observed that most of the queuing problems take place at Al WB approach and the cause of such high queue is that there are only 2 lanes in the street which expand to 3 lanes at approach flare taking into account that there are No more than 1800 veh/hr which serve by this approach. The second queue problem takes place at peak period hour, when a high number of vehicles pass through the major connecter, which could create a queue problem.

3.1.2 Alteration No.1 (Signalized Roundabout Simulation Data)

Table (3) and Table (4) shows the output results of VISSIM simulation of Antar Bin shaddad roundabout as a signalized intersection. These results are for alteration No.1, as shown in Table (2) in Antar Bin shaddad roundabout (default conditions as signalized roundabout) when the maximum mean delay is 46.83 sec and the lowest average speed is 18.33 km/hr which is considered as acceptable for more than 6000 veh/hr entering from four approaches and the LOS is (D, D, B, D). Which is reach by trying different cycle time until delay is reduce that able the signalized roundabout operated with less average delay and queue length. Also by trying different cycle time that reduce the delay it is observed that, the average delay and queue length are decreased,the behaver of different approaches is explain in figure (6) to figure(9) (HCM, 2010), (Appendix D).

Table 3. Mean delay and mean stop delay and average speeds outputs of alteration No.1 for Antar Bin shaddad roundabout

Time from	Time to	Mean delay time (sec)	Mean stop time (sec)	Average speeds (km/h)
7:00	8:00	46.83	22.22	18.33
8:00	9:00	46.04	22.11	18.81
14:00	15:00	32.81	16.18	22.42
15:00	16:00	40.49	20.09	19.89

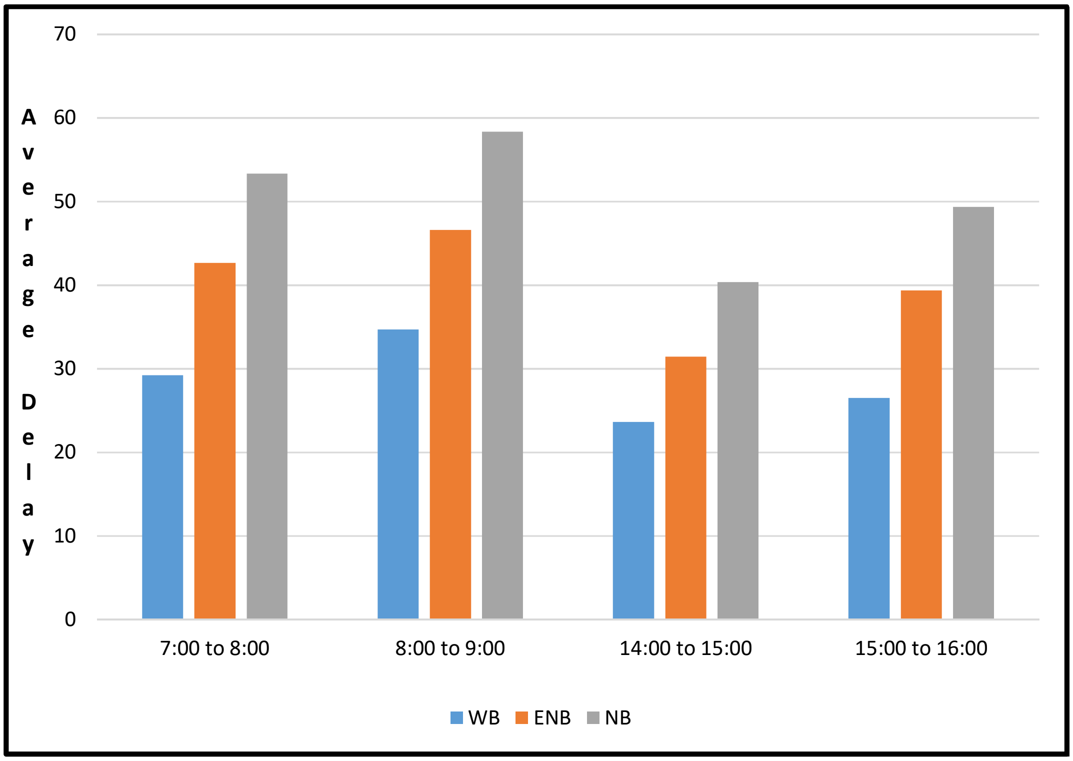

Figure 6. The Average delay of outputs of alteration No.1 Antar Bin shaddad roundabout for vehicle traveling from ESB to all approaches.

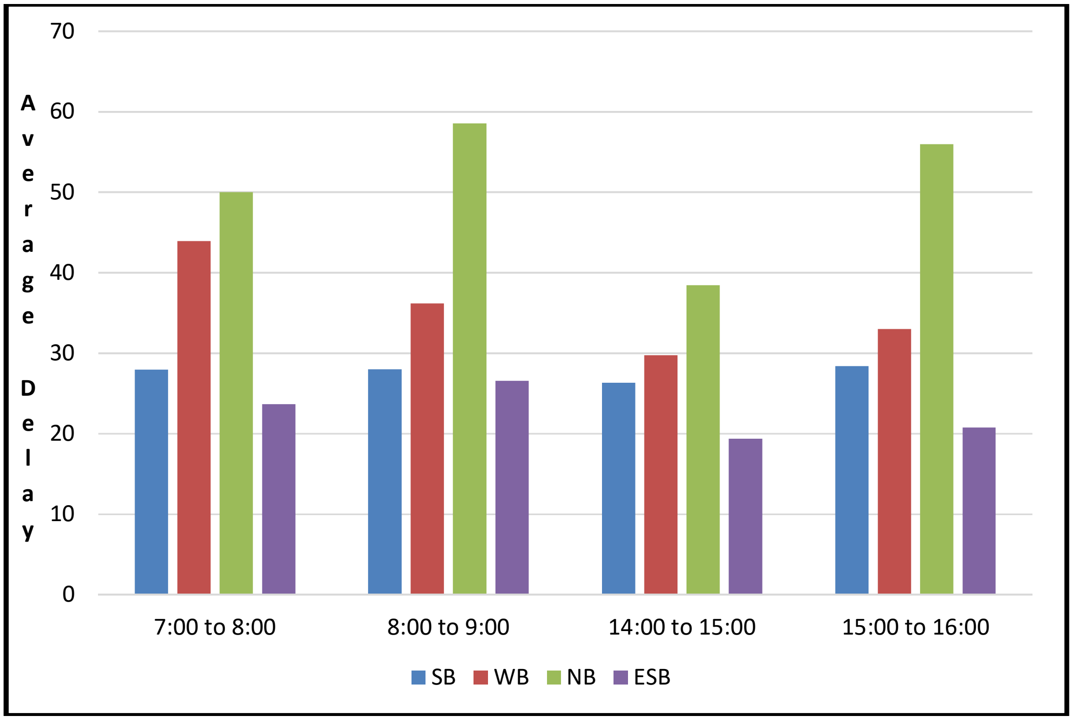

Figure 7. The average delay of outputs of alteration No.1 Antar Bin shaddad roundabout of vehicle traveling from ENB to all Approaches.

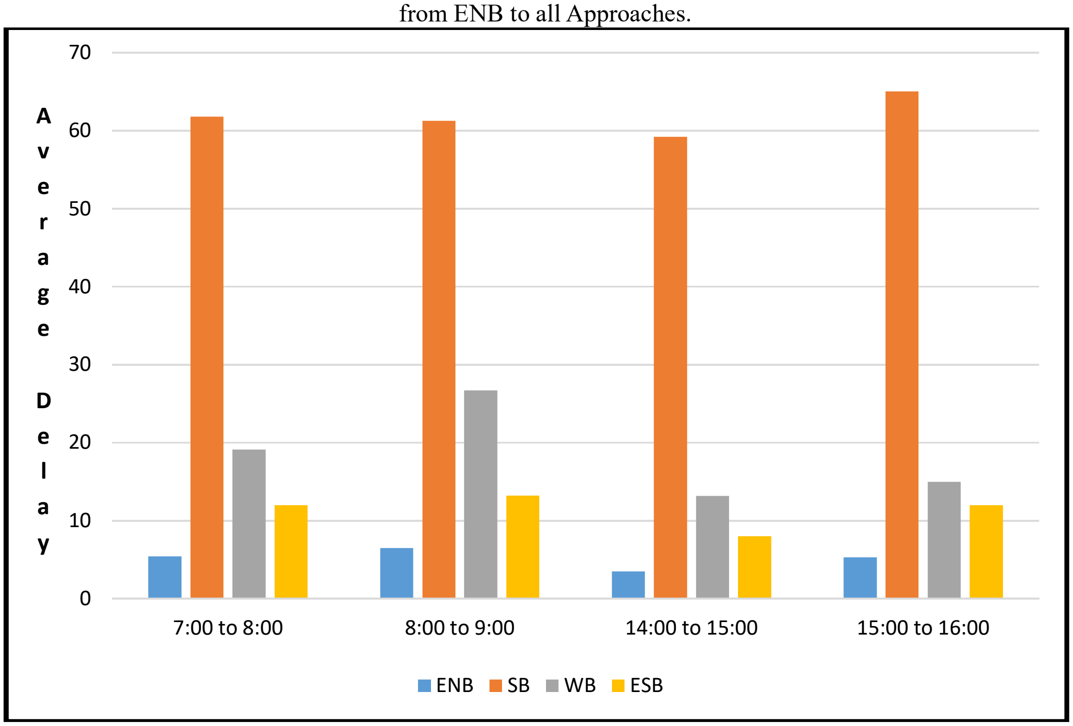

Figure 8. The average delay outputs of alteration No.1 for Antar Bin shaddad roundabout of vehicle Traveling form NB to all approaches.

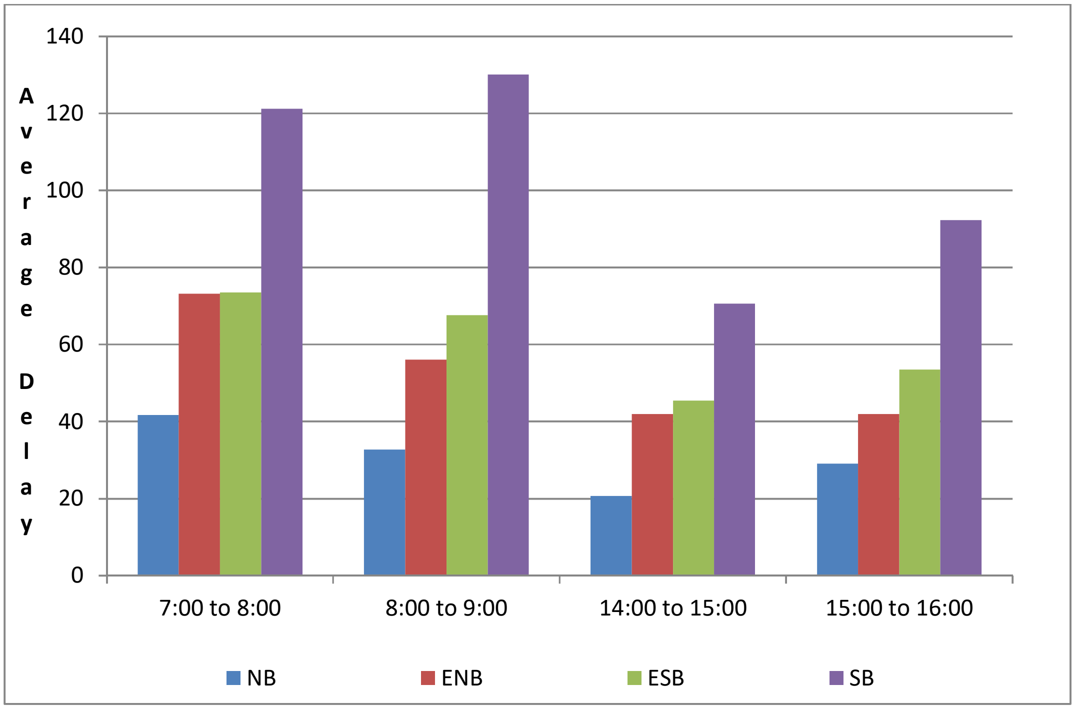

Figure 9. The average delay outputs of alteration No.1 for Antar Bin shaddad roundabout of vehicle traveling from EB to all approaches.

Table 4. Approaches queue length outputs of alteration No.1 for Antar Bin shaddad roundabout.

Approach Name	**Mean Queue (meter)**			
	From 7:00 to 8:00	From 8:00 to 9:00	From 24:00 to 25:00	From 15:00 to 16:00
ESB	16.73	22.7	14.8	14.29
NB	2.05	2.12	2.5	4.85
WB	133.73	99.18	42.99	72.7
WNB	8.97	7.02	6.68	5.96
Major connecter	3.41	2.54	3.23	3.06
Miner connecter	27.89	31.84	24.23	29.28

3.1.3 Alteration No.2 (Signalized Intersections)

Table (5) shows the output results of VISSIM simulation of Antar Bin shaddad roundabout as a signalized intersection. From Table (8), it can be concluded that, the average delay ranging from (66.58-74.00) sec is considered (E, E, E, E) LOS for the four studies hours. This behavior is explained in Figures (10) to (13). According, the high delay that, is observed in Figure (12) due to the lack of number of lanes that (EB, NB, and ENB) have, but in NB the presence of free right lane to WNB has huge benefit that helps in reducing the delay rate. ENB has low traffic volume approximately half of the traffic volume of ESB, which could have significant effect in reduction of vehicles delay. Table (6) shows approaches queue length as outputs of alteration No.2 for Antar Bin shaddad signalized intersection. Table (6) details show that, all approaches contain high queue length except ESB in spite of it has the highest volume, the queue length is small, which is due to the fact that, most of the departing traffic from this approach has two directions instead of four, (HCM,2010),.

Table 5. Mean delay and mean stop delay and average speeds outputs of alteration NO.2 for Antar Bin shaddad Roundabout.

Time from	Time to	Mean delay time (sec)	Mean stop time (sec)	Average speeds (km/h)
7:00	8:00	66.58	46.39	13.15
8:00	9:00	74.00	51.84	12.03
14:00	15:00	59.75	41.84	14.24
15:00	16:00	62.93	45.32	13.79

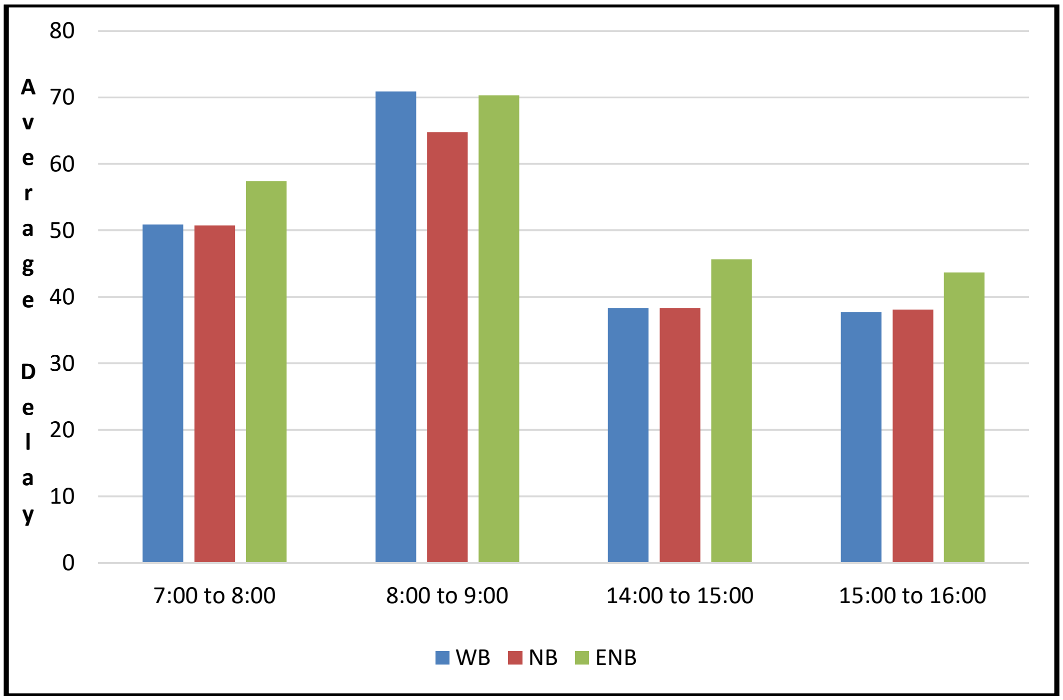

Figure 10. The average delay of vehicle Outputs of Alteration NO.2 for Antar Bin shaddad roundabout traveling from ESB to all approaches.

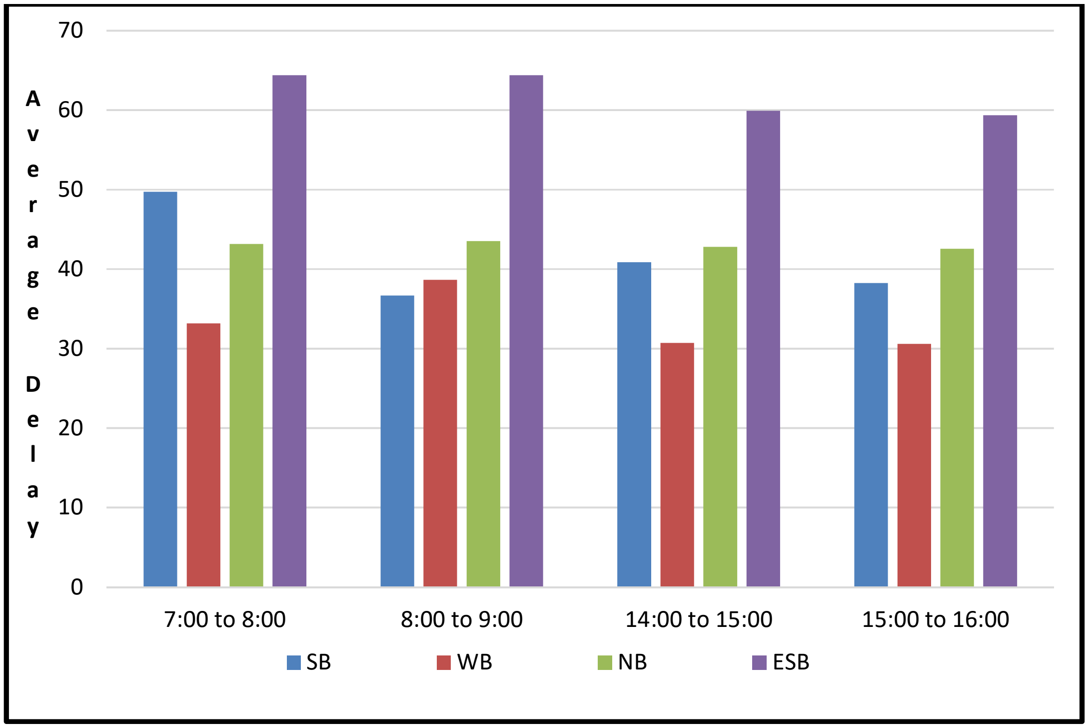

Figure 11. The average delay outputs of alteration NO.2 for Antar Bin shaddad roundabout of vehicle traveling from ENB to all Approaches

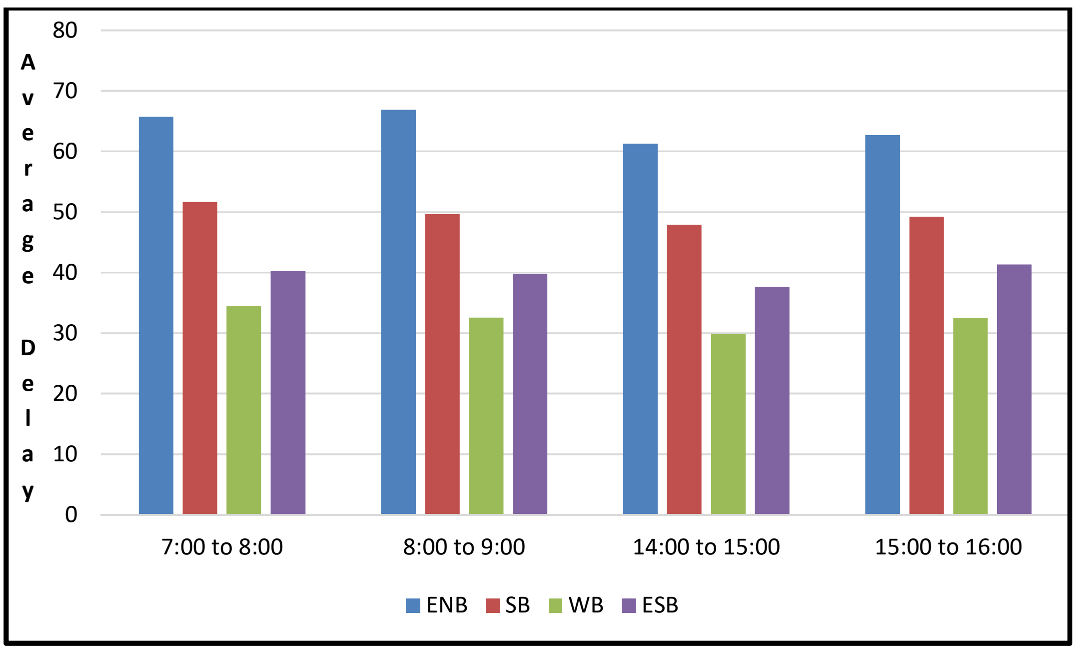

Figure 12. The average delay outputs of alteration NO.2 for Antar Bin shaddad roundabout of vehicle traveling form NB to all approaches.

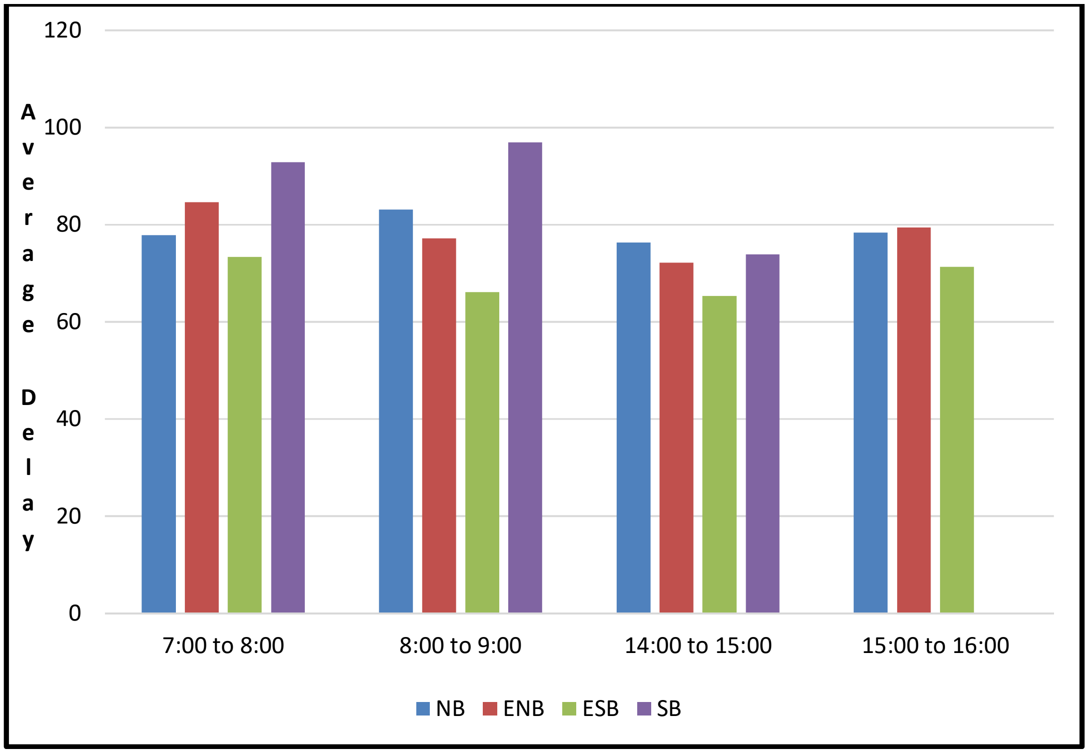

Figure 13. The average delay outputs of alteration No.2 for Antar Bin shaddad roundabout of vehicle traveling from EB to all approaches.

Table 6. Approaches queue length outputs of alteration NO.2 for Antar Bin shaddad roundabout.

Approach Name	**Mean Queue (meter)**			
	From 7:00 to 8:00	From 8:00 to 9:00	From 24:00 to 25:00	From 15:00 to 16:00
ESB	22.28	21.22	20.89	18.19
NB	124.04	126.26	106.72	119.31
WB	91.19	91.19	86.79	87.84
ENB	63.35	100.75	39.83	41.50

3.1.4 Alteration No.3 (Meter Control*)*

Table (7) shows the output results of VISSIM simulation of Antar Bin shaddad roundabout as a meter controlled roundabout. As shown in Table (7) the roundabout in the meter control has average delay ranging from (36.95-51.66) sec which is considered as acceptable for more than 6000 veh/hr entering from four approaches. This behavior is explained in Figures (14) to (17). Installing a traffic signal on the heaviest approach (ESB) could create more gaps for cycling traffic and reduces the average delay in all directions but, as it can be observed from these figures that, (ESB and ENB) approaches perform better than the others although they have higher traffic volume and this is due to the signal control location. Table (8) shows approaches queue length as outputs of alteration No.3 for Antar Bin shaddad roundabout as a meter controlled roundabout. As it is detailed in Table (8), there are two approaches that contain high queue length (NB and EB) and both of them have the same two reasons of such high queue length which are: first the lack of gaps to enter the cycling lanes and the second is the lack of lanes in their geometric design, (HCM, 2010), (Appendix D).

Table 7. Mean delay and mean stop delay and average speeds outputs of alteration No.3 for Antar Bin shaddad roundabout.

Time from	Time to	Mean delay time (sec)	Mean stop time (sec)	Average speeds (km/h)
7:00	8:00	49.05	15.86	17.78
8:00	9:00	51.66	19.5	17.36
14:00	15:00	36.95	12.89	21.20
15:00	16:00	39.72	16.72	20.13

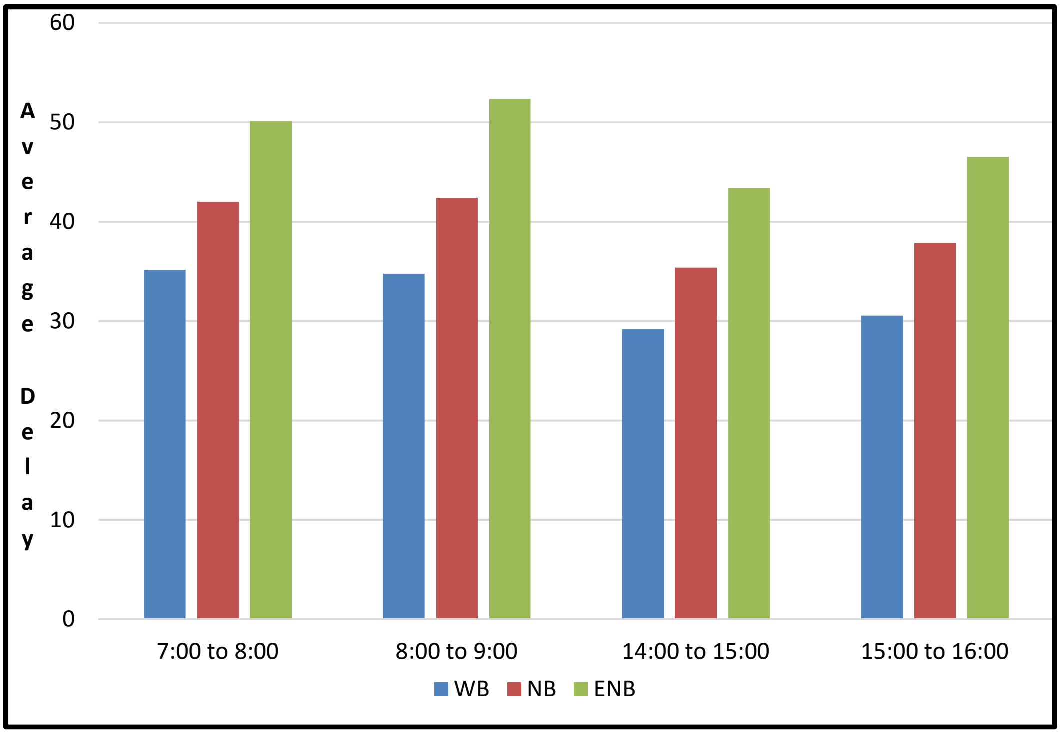

Figure 14. The average delay of vehicle Outputs of Alteration No.3 for Antar Bin shaddad roundabout traveling from ESB to all approaches.

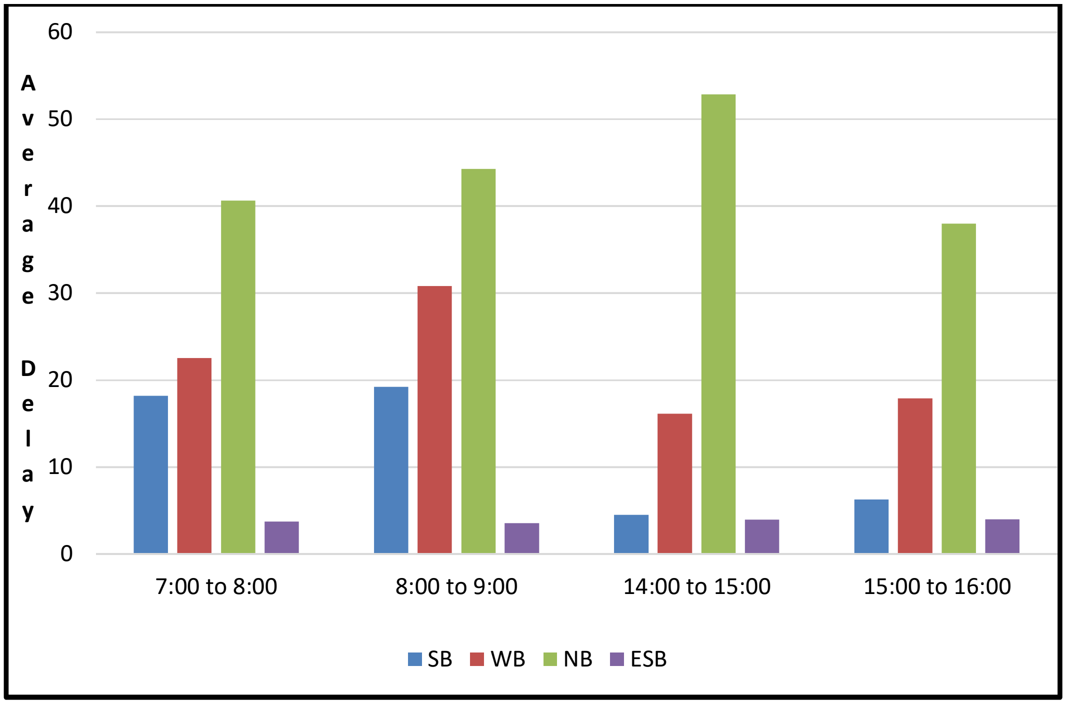

Figure 15. The average delay outputs Alteration No.3 for Antar Bin shaddad roundabout of vehicle traveling from WNB to all approaches.

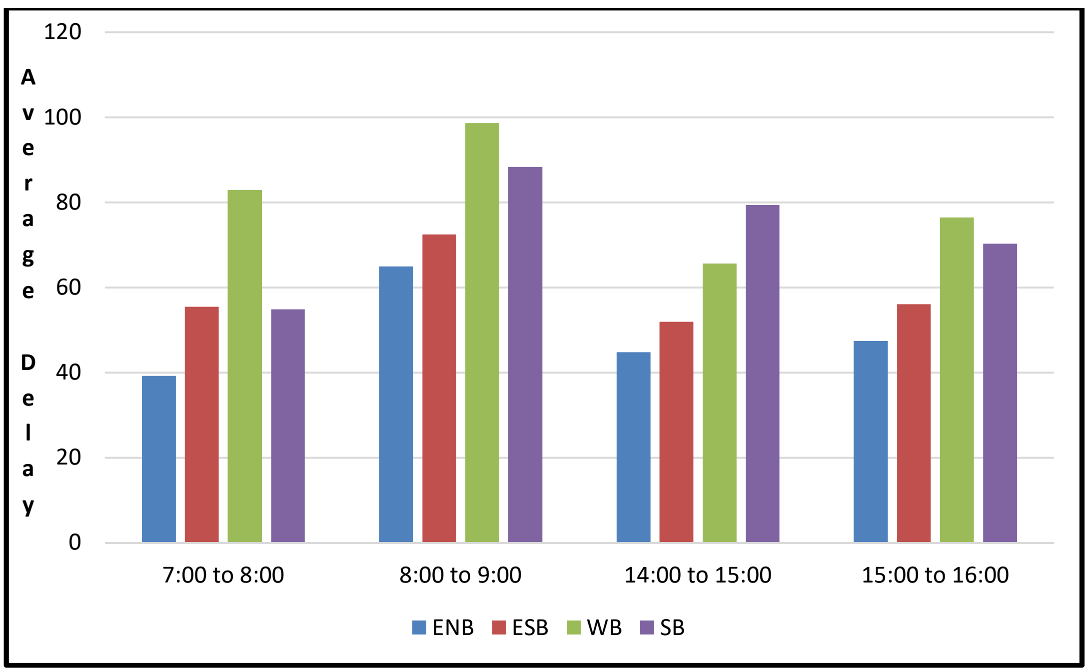

Figure 16. The average delay outputs Alteration No.3 for Antar Bin shaddad roundabout of vehicle traveling form NB to all approaches.

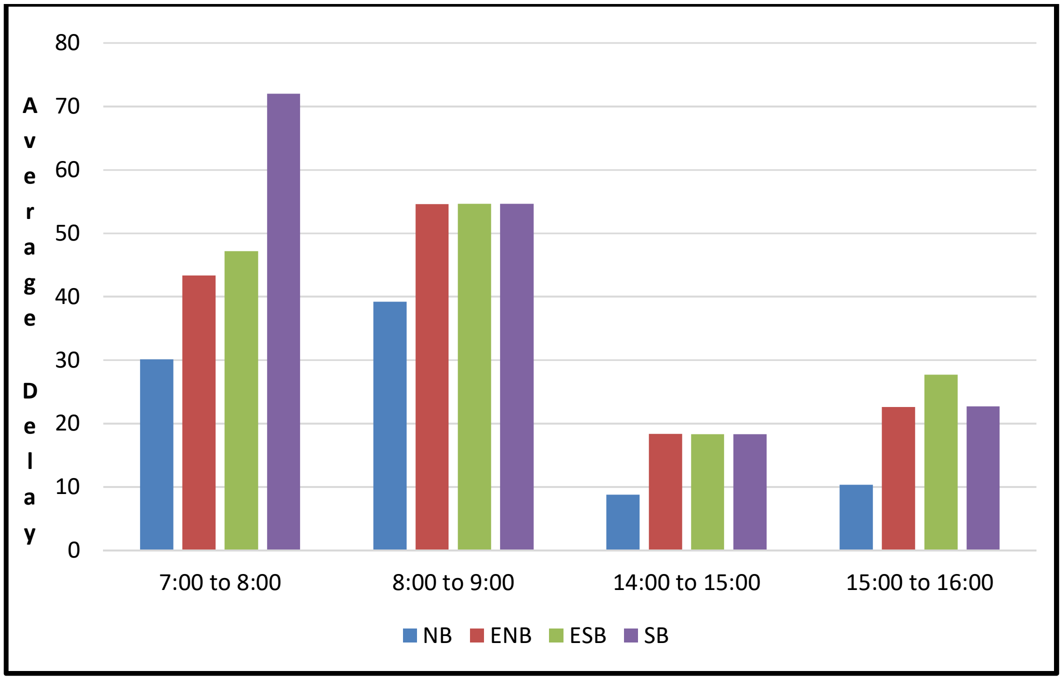

Figure 17. The average delay outputs Alteration No.3 for Antar Bin shaddad roundabout of vehicle traveling from EB to all approaches.

Table 8. Approaches queue length outputs of alteration NO.1 for Antar Bin shaddad roundabout.

Approach Name	Mean Queue (meter)			
	From 7:00 to 8:00	From 8:00 to 9:00	From 24:00 to 25:00	From 15:00 to 16:00
ESB	33.16	37.59	27.93	28.65
NB	101.11	112.06	96.22	97.43
WB	100.64	82.65	7.17	13.97
ENB	1.55	1.77	1.21	1.45

4. Comparison

In this section, a numerical comparison will be conducted on the results of simulation of all alteration and the original condition of the Antar Bin shaddad roundabouts.

In the following figures, numerical comparison between the delays of the original alteration with the delay of each alternative alteration will be carried out. The purpose is to provide a clear numerical view of output changes using different alterations. As there are many traffic factors in VISSIM outputs, it is not practical to present all of them for all the studied alteration in figures. On the other hand, it is still quite easy to have a good overview of output differences in the following tables, thus comparing the alteration can be carried out easily. In these figures, Alteration No.1, No.2 and No.3 are shown by blue, red, green color respectively as a symbol for unacceptability of the output values.

In Antar Bin shaddad roundabout and as shown in Figure (18), the alteration No.1 and alteration No.3 are performing better than the other alterations. The configuration of burger in alteration No.1 has huge benefit in reducing cycling movement and maneuvers and as a result: to overcome the negative effects of the unbalanced flows in Antar Bin shaddad roundabout, it is recommended to implement alteration No.1 for this roundabout in case of the fix signal.

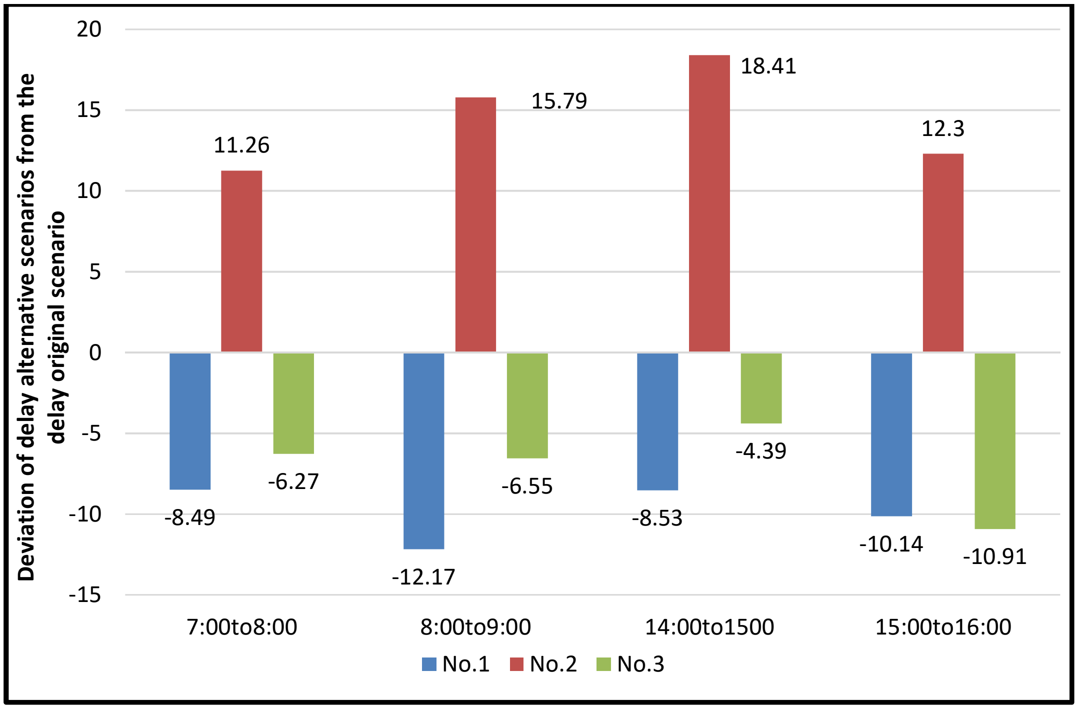

Figure 18. Comparison between original alteration delay and alternative alteration delay for Antar Bin shaddad roundabout.

5. Conclusions

1. Micro-simulation software VISSIM has the most powerful capability in modeling congested traffic networks in comparison with other simulation techniques. It has the capacity to simulate traffic queuing conditions; therefore, it is more realistic and close to actual traffic conditions.

2. It has been found out that, the best suggested scenario for the studied roundabouts (signalized roundabout, unsignalized roundabout, signalized intersection and meter roundabout) that could handle the current traffic volumes of all the studied roundabouts is the signalized roundabout scenario with optimum cycling time.

3. It can be concluded that, if the heaviest approach volume has more than 40% of the total roundabout volume: the meter roundabout scenario (signalize the heaviest volume approach only) could be the best control mode that provides the best performance.

4. Since that traffic volumes and movements are different from hour to hour, it is necessary to use queue detectors or advance traffic control signals that have different cycling timings for each 24 hours.

5. The use of suitable configuration that could reduce the circulating flow is very important to enhance the performance and reduce the delay.

7. In Antar signalized roundabout and from observed simulation results, the best location for an over pass or under pass is to separate the traffic generating from ESB from intersecting with other approaches upstream, this improvement can reduce the delay of the entire roundabout at peak hour by 26%.

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