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Evaluation of Selected Roundabout in Al-Diwaniyah City by using Vissim

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***Abstract*: Traffic simulation models considered as one of the most important tools that are widely used to analyze complicated traffic sections and suggesting alternatives solutions prior to applying in site. Traffic congestion usually starts at intersections and propagate upstream and caused longer travel time, delay at intersection (low level of service) and bad environmental areas. As in the other cities, Al-Diwaniyah city has many intersections that created such problems. This work considers traffic microsimulation (Vissim program) which is traffic simulation program to simulate traffic at selected congested intersections at Al-Diwaniyah city, Iraq. Real traffic data were collected from a selected sites representing a roundabout intersection. Manual method were used to collect data at a day Sunday at peak hour 7 am-8 am for each approach on intersection for periods reaching to a month. The first step was using the Vissim program to simulate and evaluate the level of service of selected roundabout which is eagle roundabout. The second step give solution to enhance the traffic flow and reduce the queue length on this site which is replace the roundabout by signalized intersection and use the Vissim program to simulate this condition.**

***Keywords*: Roundabout intersection, Vissim program, traffic flow, traffic simulation.**

1. Introduction

Intersection is an area consisting of two or more roads used to turn to various directions to reach to the required destinations (Garber and Hoel, 2018). Intersections represented complex sites on the highway due to all vehicles moving traffic in different directions want to occupy the same area in the same time which produce high number of conflict points. Moreover, pedestrians want the same area to cross. Drivers should make decision in part of a second and this leads to an accident if there is a small error in decision (Mathew and Rao, 2006). Road users have a bad experience at road intersections because of delay time and exposure to safety hazards (Hughes, 2010).

Most transportation engineers consider intersections to be the most dangerous place on the road network due to the conflict between flow traffic in all directions. Thus, most intersections may need traffic control and organized by stop signs, roundabout and traffic signals. The principle of the intersection controls is to solve the conflicts at the intersection to achieve the efficient movement and safety for both vehicular traffic and pedestrian's movement (Mathew and Rao, 2007).

The designs of conventional intersections cannot often relieve congestion without incurring increased conflicts and also significant improvement costs us. There is a great need for alternative intersections offering the potential to reduce delay, improve safety, improve level of service at intersection and reduce the influence on the environment with fewer effects and a lower cost than traditional solutions

Traffic simulation modeling is a strong tool that is used for analyzing a set of dynamic problems that are difficult to assess in the actual field. These models can simulate actual conditions of network and perform analysis and prediction by changing physical experiments with computer representations. Simulation models are important in applying several solutions and suggest alternative scenarios before being applying on the real site and this leads to saving time, efforts and economic losses (Detemple et al., 2007; Kolak et al., 2015).

2. Roundabouts

Roundabouts have been globally accepted and used for decades. Roundabout a subset of many types of circular intersections and that accommodates a one-way traffic flow around a central island where circulating traffic is given priority over entering traffic and where entry speeds are low relative to conventional circular intersections. Generally, roundabout handle with large-volume left-turns more efficiently and are very useful in enhancing intersection safety and capacity compared to conventional signaled intersections. However, Roundabout tends to show serious operational problems during elevated and unbalanced traffic conditions especially with left turn movements (HDM, 2012).

In general, smaller inscribed diameters are better for overall safety because they help to maintain lower speeds. Larger inscribed diameters generally lead to a decrease in vehicle approach speeds, also reduce the angle formed between entering and circulating vehicle paths, thereby reducing the relative speed between these vehicles and leading to reduced entering circulating crash rates. Therefore, roundabouts in high-speed environments may require diameters that are somewhat larger than those recommended for low-speed environments (FHWA, 2000).

3. Traffic Simulation

The traffic simulation models are playing a principal part in help traffic engineering for provides time and finance resource

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by giving the ability to evaluate the different alternative of traffic conditions and suggesting solutions without need to actually applying on sites and there is no need to wait for results and see if they are right or wrong (Hidas, 2005).

Traffic simulation models was categorized into three types such as: macroscopic, mesoscopic and microscopic (Azlan and Rohani, 2018).

Macroscopic simulation models depended on average of traffic parameters to describe traffic characteristics; these parameters such as speed, density and flow without tracking individual vehicles. The simulation takes place on a part-by-part basis.

Mesoscopic simulation models are a combined element between the macroscopic and microscopic models so the traffic flow can be resolved by the groups and individuals. In this models, movements are ruled by the average speed on the link while the unit flow of traffic is the individual vehicle.

"Microscopic simulation models simulate movements of individual vehicles at a detailed level. Microscopic models used car following CF and lane changing LG theory to represent the interactions between individual vehicles. The calibration process in this model efficient in studying hard situations and not direct as in macroscopic model (Burghout, 2005). This model can recopy queues, weaving areas, shock waves, gap acceptance, merging zones, the actuated signal and another traffic characteristic showed in real life.

A. Microsimulation Software's

In general, microsimulation software's is used in traffic modelling and is typified by software packages such as "TransModeler, PTV VISSIM, TSIS-CORSIM, Cube Dynasim, LISA+, Quadstone Paramics, SiAS Paramics, Simtraffic, Aimsun, and MATSim". Analytical modelling software such as "LINSIG, TRANSYT, TRANSYT-7F or SIDRA INTERSECTION" represent a different class of models based on mathematical algorithms representing combinations of traffic model elements

Many microscopic traffic simulation models were developed. Most popular used models like AIMSUM, CORSIM, PTV VISSIM and PARAMICS depending on many literature (Choa et al., 2002; Kaseko, 2002; Bloomberg and Dale, 2000; Sullivan et al., 2004 and Jones et al., 2004).

In case of simulation of intersections, the PARAMICS, VISSIM, SIDRA, CORSIM and SIMTRAFFIC are commonly used. While, in case of roundabout intersection, not all simulators models allow the user to accurately model roundabouts. There are two classes of simulation software used in roundabouts intersections: deterministic and stochastic simulation models. A summary of the principal roundabout software packages is shown in Table 2-1. Deterministic models analyze the performance of a roundabouts with a series of equations, linking attributes like delay, queues, and capacity to a set of variables. The stochastic models use time-interval simulation to describe the traffic processes (Vaiana et al., 2007; Espada et al., 2010; Praticò et al., 2010).

Table 1
Summary of the principal software's for roundabouts simulation

COUNTRY	NAME	MODEL
U.K.	RODEL	Deterministic Empirical
U.K.	ARCADY	Deterministic Empirical
U.K.	PARAMICS	Stochastic Simulation
Australia	SIDRA	Deterministic Empirical
Germany	KREISEL	Deterministic Empirical
Germany	VISSIM	Stochastic Simulation
U.S.A.	HCS/SYNCHRO	Deterministic Empirical
U.S.A.	CORSIM	Stochastic Simulation
U.S.A.	INTEGRATION	Stochastic Simulation
U.S.A.	SIMTRAFFIC	Stochastic Simulation
France	GIRABASE	Deterministic Empirical
Spain	GETRAM	Stochastic Simulation

4. Previous Studies using Traffic Simulation

There are many global studies research in simulation models at intersections and roundabouts such as:

Sisiopiku and Heung-Un Oh (2001) used SIDRA simulation model to compare the performance of roundabout intersections with that of signalized intersections. They concluded that roundabouts can be considered as design alternatives for improving capacity.

Lu et al. (2001) used CORSIM for evaluation of ten sites in Florida. The results showed that replacing the DLT maneuver with the RTUT maneuver significantly reduced the total travel time and overall delay.

Mandavilli et al. (2008) the Sidra simulation model was used to analyze the environmental impact of the roundabout. They concluded that the performance of the roundabout was better than that of the controlled intersection.

Pirdavani et al. (2009) used S-Paramics to investigate the effect of changing the speed limit under different traffic volumes on traffic safety. The results indicated that increasing the speed limits on both roads would lead to a deterioration in the safety

Gavulová and Drličiak (2012) use PTV Vissim to assess the capacity of three roundabouts in the city of Žilina, Slovakia. Selected roundabouts suffer from long queues at their entrances and waiting time high than the standard values. They use new geometry changes (by-passes) by making right turns moved through the by-pass lane and straight and left turns moved through the roundabouts. They concluded that the use of by-pass lanes increased the performance of the roundabouts.

Taha (2015) used VISSIM to evaluate the performance of several types of U-turn such as right turn followed by U-turn (RTUT) and U-turn followed by right turn (UTRT). It was concluded that the unconventional left-turn control types have lower delay and travel time compared to the DLT.

Zhou et al. (2016) they used AIMSUN micro-simulation for several roundabouts in Changchun. They used V/C ratio and delay to evaluate roundabout performance. They concluded that using addition of lane is much more appropriate in weaving sections is much more appropriate than apply signal control.

5. Data collection

Data collection is the process of collecting and measuring information on objected variables in a system that gives the ability to reply relevant questions and evaluate results. The

system of data collection is based on the study type being making. Depending on the research plan and design, there are various methods of data collection starting from manual methods to more modern automatic counts methods. In this research we depending on manual method to collect the traffic data based on traditional rule for volume, density and speed.

A. Criteria in sites selection

There are such criteria that must be taken in selecting sites such as:

1. The site must contain important problems and study them in order to find appropriate solutions.
2. The traffic volumes should be of different size ranging from normal to congestion traffic.
3. The data collection process should be at times when the visibility is appropriate.
4. Considerable the costs used to collect the data, they should be as minimal as possible.
5. The data collection process should not cause traffic problems, for example, causing road blocking, delays, or less from driver's attention.
6. Permission from local authorities should be given to collect the data.

B. Field Parameters

Eagle roundabout is located in Military district, Al-Diwaniyah, Iraq. This is a four leg with two lanes at each approach and contained roundabout with two lanes. The width of approach is (3.5 m) with median width of (1.5m). Central island has an elliptical shape with main and secondary diagonal (25m-14m) respectively. The intersection is containing high percentage of heavy vehicles because of its location at the city entrance. Also, sometimes a police man control traffic in order to improve movements.

According to the nature of current study, one sites of intersection have been selected in Al-Diwaniyah city, Iraq which is Eagle intersection (Roundabout intersection). The parameters are collected from the manual method in peak hour include:

1. Through volumes
2. Right volumes
3. Left volumes
4. Queue length
5. Traffic compositions
6. Speed of every approach

1) Traffic data results

The data were recorded in the selected roundabout for the peak hour periods from 7AM - 8AM during the day Monday for one month and take the average value of the data.

Traffic flow rates and queue length:

Fig. 1. Traffic flow and queue length at Eagle roundabout

Table 2
Traffic flow (veh) for west approach at Eagle roundabout

15min interval	Right lane	Through lane	Left lane	Total volume	Queue length
1	70	89	75	234	18
2	75	97	88	260	25
3	72	92	86	250	22
4	72	91	86	249	22

Table 3
Traffic flow (veh) for east approach at Eagle roundabout

15min interval	Right lane	Through lane	Left lane	Total volume	Queue length
1	65	72	60	197	16
2	71	80	62	213	22
3	60	74	67	201	14
4	58	69	60	187	14

Table 4
Traffic flow (veh) for north approach at Eagle roundabout

15min interval	Right lane	Through lane	Left lane	Total volume	Queue length
1	62	74	63	199	15
2	70	82	60	212	17
3	62	77	61	200	12
4	60	68	50	178	11

Table 5
Traffic flow (veh) for south approach at Eagle roundabout

15min interval	Right lane	Through lane	Left lane	Total volume	Queue length
1	58	65	50	173	15
2	66	70	54	190	15
3	55	62	42	159	11
4	55	60	33	148	11

The data was analyzed with respect to directions (Through, Right, Left) and taking into the consideration the vehicles type (passenger car 'PC' and Bus). The analyses duration was divided for each 15 minutes. Fig. 1 show the traffic flow and queue length at Eagle roundabout.

Table 2 to 5 show the traffic flow rates (derived from 15 minutes' volumes) and queue length. In general, there is a linear relationship between flow rates and queue lengths.

Speed measurement:

The speed at each approach of at Eagle intersection were measured by using traditional method according to estimate the travel time of each vehicle that pass a selected distance. The mean speed used to represent the true speed for the vehicle's drivers on the road. Table 6 shows the mean speed, standard deviation, minimum speed and maximum speed at each approach. The mean speed that used was (35 km/hr) for North-South approach and (30 km/hr) for East-West approach. For circulating movements, the average circulating speed was (10 km/hr).

Table 6
The mean speed, standard deviation, minimum speed and maximum speed at each lane for Eagle intersection

Approaches	North	south	East	West	Circulating
Mean (Km/hr)	28	29	29	30	15
Std. deviation (Km/hr)	3.8	4.2	3.5	3.5	4.1
Min. speed (Km/hr)	18	16	16	16	8
Max. speed (Km/hr)	39	40	38	42	17

6. Simulation Works

A. *Vissim Model Building*

In order to build model by vissim microscopic simulation model, there are a steps should be followed.

1) Route selection

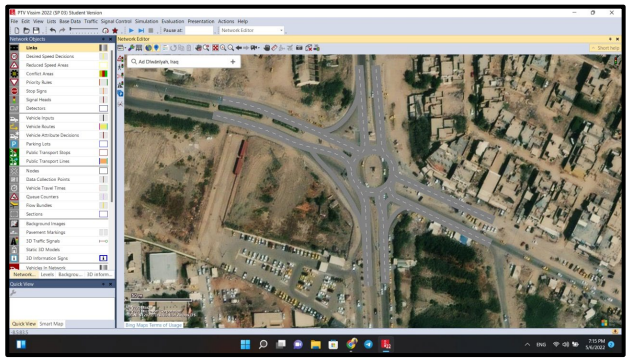


Fig. 2. The selection of route location of roundabout

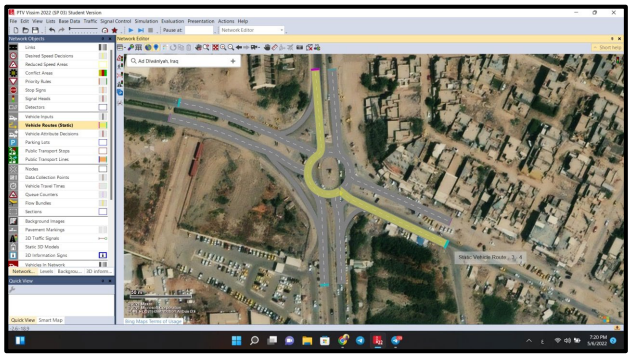


Fig. 3. Connection the node by link

The road geometry is built up by using nodes and links. Nodes are represented as a point in the network that branches off from it a group of links, Fig. 2 and 3 show the first step in simulation which the selection of route location.

2) Traffic volume

The second step in simulation is addition of traffic volume which is important Parameters to evaluate the roundabout, high traffic volume means larger numbers of delays and lead to low level of service. Fig. 4 shows the addition of traffic volume.

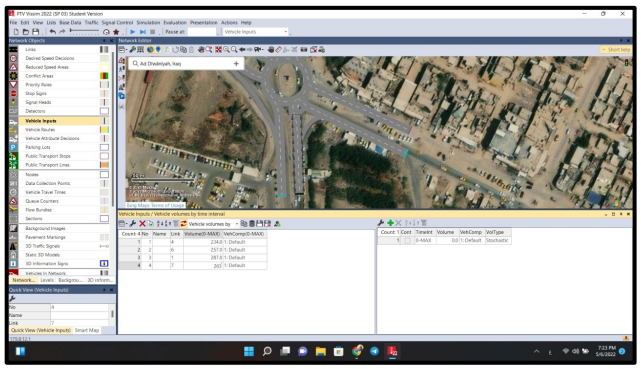


Fig. 4. Addition of traffic volume

3) Speed at intersection

Improving any road or intersection especially in topic traffic safety need to collecting data of speed of the study area and statically analysis to obtained the mean value of speed. Fig. 5, show the step of speed addition before and after entrance to the roundabout.

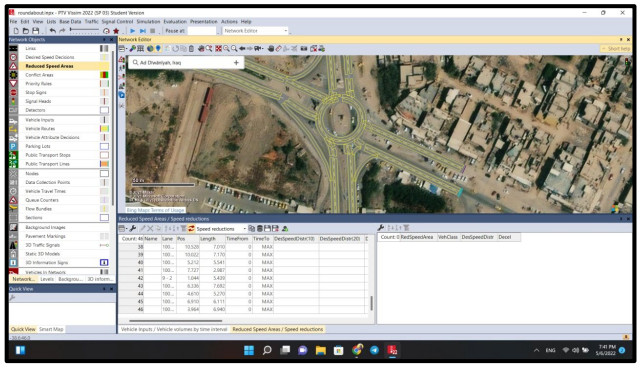


Fig. 5. Speed addition before and after entrance to the roundabout

4) Conflicts point

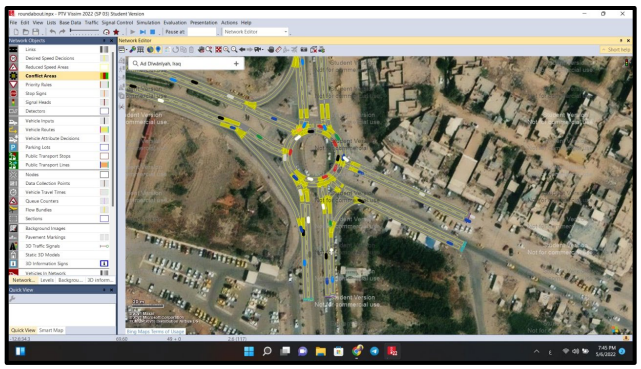


Fig. 6. The conflict point at roundabout

Conflicts occur when traffic streams moving in different directions interfere with each other. The three types of conflicts are merging, diverging, and crossing. The number of possible conflict points at any intersection depends on the number of approaches, the turning movements, and the type of traffic control at the intersection. The primary objective in the design of a traffic-control system at an intersection is to reduce the number of significant conflict points. Fig. 6 show the conflict point at roundabout.

5) Traffic movement

Traffic Movement is an important part of the simulation at each intersection or junction to show a legal representation of the road network movement. Every movement has a lane range correlating with it and this representing in a minimum lane number and a maximum lane number. All these lanes range can be used by vehicles to make the turning movement. Fig. 7 show the simulation of traffic movement.

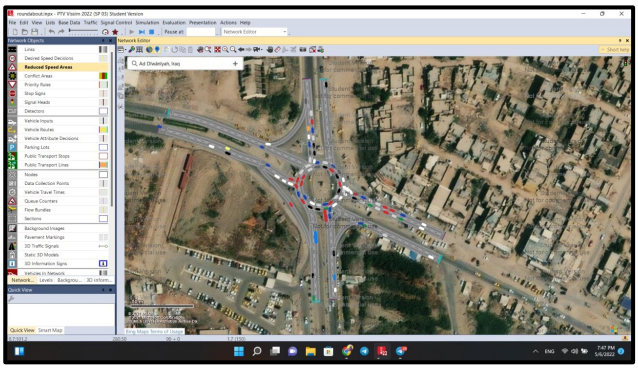


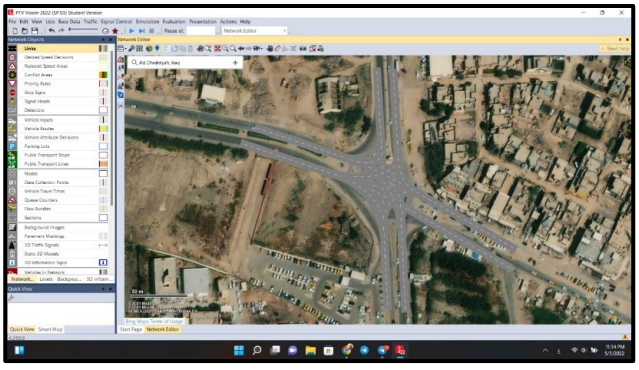
Fig. 7. The simulation of traffic movement

7. Simulation of the Signalized Intersection

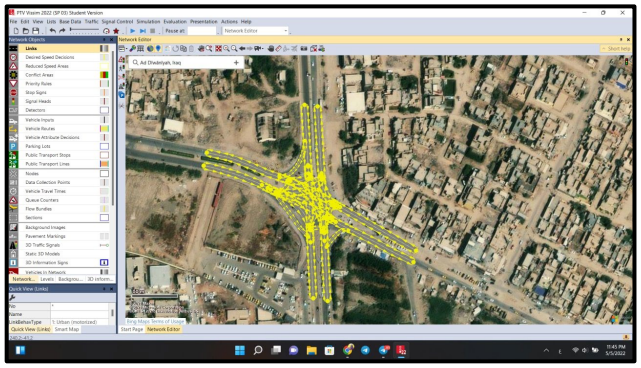
The steps of simulation the signalized intersection summarized as below:

1) Route location
2) Linking the all the selected road
3) Turning movement of vehicle and conflict point
4) Traffic signals (4 phase) with cycle length 110 sec
5) 5-traffic volume

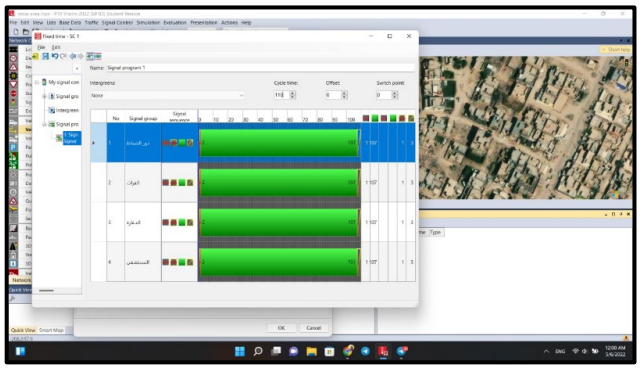
Fig. 8 show the simulation steps to proposal signalized intersection by using Vissim program for selected roundabout.



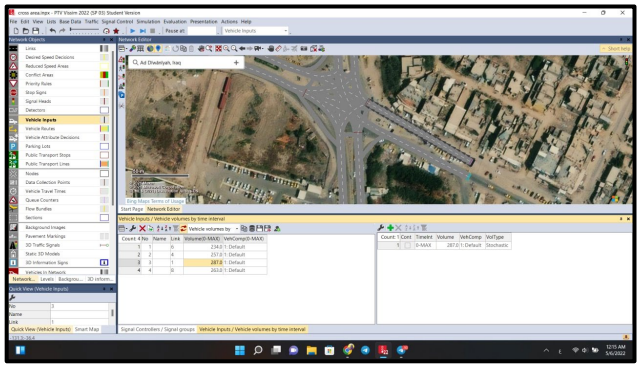
Step 1: Route location and linking selected road



Step 2: Movement and conflict point



Step-3: Addition traffic signals (4 phase) with cycle length



Step-4: Addition traffic volume

Fig. 8. The simulation steps to proposal signalized intersection

8. Level of Service of Roundabout

Level of service (LOS) is a term used to qualitatively describe the operating conditions of a roadway based on factors such as speed, travel time, maneuverability, delay, and safety. After simulation the eagle roundabout we obtained the level of service which is type E, type E refer to low level of service. The proposal solution for this problem is to change the roundabout to the signalized intersection. After done the simulation of the traffic flow on signalized intersection the results of level of service is type C which is high grade of level of service E in roundabout.

9. Conclusions Obtained from Traffic Data and Simulation

1) The selected sites having daily congestion which lead to high delays, unsafe area with high pollution and requires some attention to enhance the traffic condition.
2) The Queue length at intersection with roundabout increase

due to circulating movements.

3) The simulation results give low level of service of roundabout this mean high delay, high density and high traffic volume in this site.
4) The simulation results give accepted level of service of proposal signalized intersection, this means less delay at this site.
5) Due to low level of service the speed of cars very low in case of roundabout and accepted in case of signalized inter section

10. Recommendation and Further Research

1) Providing data collection equipment such as: special cameras or loop detectors or other tools used to collect data that would help the researchers in focusing on traffic problems in efficient way.
2) Further studies are needed to extend the model applications and testing other scenarios for other intersections.
3) Making regular road maintenance to provide smooth movement because when found any bad road areas effect on the driver's behavior.
4) Collecting data for periods of up to a year in order to obtain very accurate data and solve problems very easily.

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