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Performance Analysis of Roundabout Junction in Duhok with Proposed Signalized one Through VISSIM Software

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Abstract

The purpose of this research is to make the best possible decision regarding Gali roundabout, which is widely regarded as one of the most congested junctions in Duhok, as to whether the roundabout should be transformed to a signalized junction, perform some moderations regarding the geometrical properties or perform no changes at all. The analysis was carried out to obtain the results for making a decision based on the data collected such as traffic volumes by using a video camera, average speed and geometrical properties. Then the corresponding data were imported to VISSIM software for further interpretation and stimulation for the purpose of making a final decision.

Key words: Junction design, Traffic analysis, Traffic congestion, VISSIM

1. Introduction

Although roundabouts, un-signalised junctions, possess many advantages such as reducing delays and queues and being environmentally friendly, it cannot be guaranteed that they are always the best type of junction in all scenarios as they are not very suitable for above moderate (average) traffic volumes. In the last several decades, with the numbers of vehicles surging, after many studies and researches have been conducted in many countries, hundreds of roundabouts have been converted to signalized junctions. The aim of this research is similar. A decision will be made whether to convert Gali roundabout, shown in Figure 1, to a signalized junction or not. To achieve this, several data were required to be obtained such as hourly traffic volume (number of vehicles) of the roundabout, traffic flow and geometrical properties of the roundabout. All of these data are later imported to VISSIM software which helps us with the decision making process by providing unique scenarios and stimulations.

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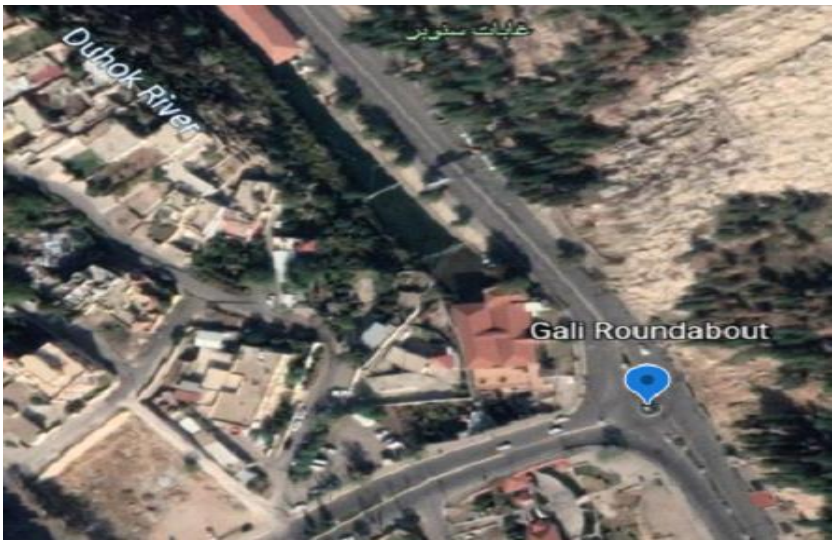


Figure 1. Gali Roundabout

2. Materials and Method

Traffic Volume Count (TVC) is simply the philosophy of counting the number of vehicles that pass through a junction in a specific interval of time and is often expressed as Passenger Car Unit (PCU) [3]. Courtesy of the Traffic Volume Count, the peak hour of a junction can be determined, as well as the Level of Service (LOS) of the junction via the V/C (Volume/Capacity) ratio.

TVC operation can be performed either *automatically or manually* with each method having their own material. Due to the lack of availability of instruments such as Pneumatic tubes, Inductive loop detectors, Video Image Detection (VID) systems, Thermal Imaging Cameras and Radar Sensors, this operation could not be operated by Automatic TVC and instead performed manual TVC method by using a video camera. Although Manual TVC may not be as accurate due to possible human error and is much more time consuming, it is nevertheless effective and therefore ideal for this research.

In manual TVC, it is essential that the surveyor, the one who collects the data, doesn't cause any distraction to the drivers by setting up the camera in a suitable location where vehicles entering and exiting all approaches are also visible. For the expense of having a better accuracy it is very ideal that at least 2 employees are involved in counting traffic.

Figure 2 illustrates the precise location of the camera when set up.

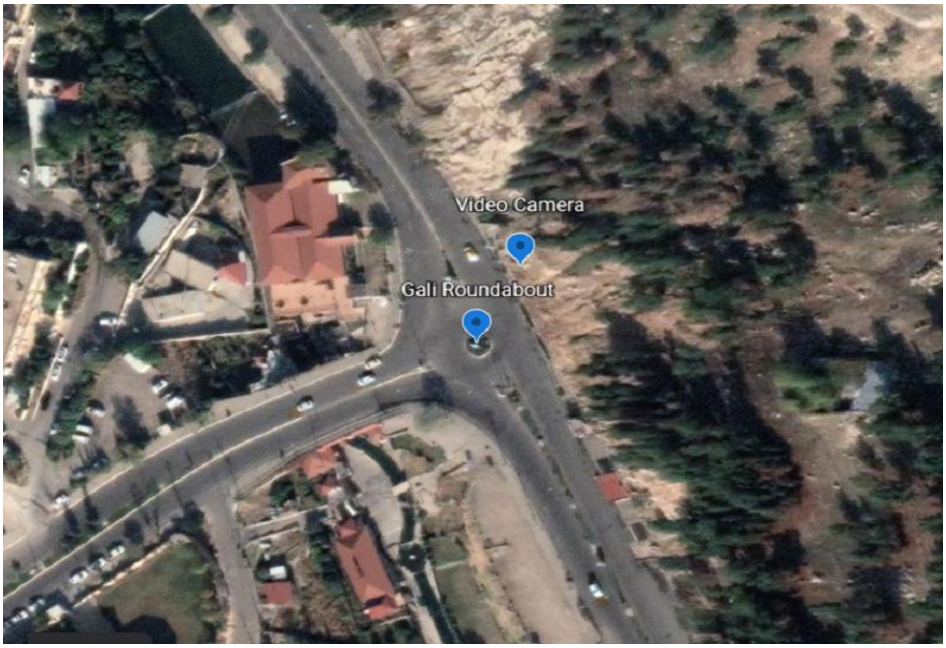


Figure 2. Location of Video Camera

2.1. Approach A

Since the roundabout serves a T-leg or three leg intersection, it consists of 3 approaches. The first approach, in this case denoted as A, provides access to Duhok Dam. On many occasions, particularly during the weekends, the Duhok traffic police block access to this approach from the other 2 approaches of this roundabout in an attempt to avoid congestion. Therefore, all of the vehicles that enter this approach during the operation are vehicles coming straight. Since, all vehicles entering this approach were straight driving vehicles, and access from left turning and U-turning Vehicles was denied, it is completely free of point of conflict and therefore not subjected to any travel time delay.

Table 1 shows the geometrical properties of this approach while Table 2 denotes the total number of vehicles that entered the approach in a 1hour period.

Table 1. Geometrical properties of Approach A

Splitter Island width (m)	Entry width (m)	Exit width (m)
5.5	9	9

Table 2. Hourly traffic volume of Approach A

Time	Straight	Left turn	U-turn
9:20-9:30	88	-	-
9:30-9:40	112	-	-
9:40-9:50	111	-	-
9:50-10:00	95	-	-
10:00-10:10	99	-	-
10:10-10:20	97	-	-
Total number of vehicles from each direction	602	-	-
Total number of vehicles	602	-	-

2.2. Approach B

The second approach is approach B. This approach provides access to the city center. This is usually the approach subjected to the most traffic congestion/highest traffic volume. As mentioned earlier, because access to Approach A from C is blocked, many right turning vehicles are forced to enter this approach in an undesirable fashion and thus usually serves as an accommodation to approach A on busy days. Tables 3 and 4 denote the geometrical properties and hourly traffic volume respectively. Since this approach had the highest traffic volume and access from both right turn and U-turn vehicles, it also had the highest travel time delay.

Table 3. Geometrical properties of Approach B

Splitter Island width (m)	Entry width (m)	Exit width (m)	Entry radius (m)
4.1	13.7	11	27.1

Table 4. Hourly traffic volume of Approach B

Time	Straight	Right turn	U-turn
9:20-9:30	36	137	11
9:30-9:40	28	160	13
9:40-9:50	36	148	11
9:50-10:00	31	131	18
10:00-10:10	35	126	12
10:10-10:20	30	140	15
Total number of vehicles from each direction	196	842	80
Total number of vehicles	1,118		

2.3. Approach C

This approach shown in Figure 3, accommodates vehicles that exit Duhok Dam or City Center. Tables 4 and 5 shows the geometrical properties and hourly traffic volume respectively.

Table 5. Geometrical properties of Approach C

Splitter Island width (m)	Entry width (m)	Exit width (m)	Entry radius (m)
3.2	13.3	12.9	18.9

Table 6. Hourly traffic volume of Approach C

Time	Left Turn	Right turn	U-turn
9:20-9:30	81	68	-
9:30-9:40	75	49	-
9:40-9:50	68	43	-
9:50-10:00	60	69	-
10:00-10:10	64	55	-
10:10-10:20	66	50	-
Total number of vehicles from each direction	414	334	-
Total number of vehicles	748		

Figure 3. Approaches of Gali Roundabout

3. Results

3.1. Volume in PCU

A total of 2,468 vehicles entered Gali Roundabout within an hour. However, this figure only represents vehicles in general without being specific by indicating the type of vehicles. Although the amount of vehicles apart from passenger vehicles and taxis entering this roundabout is very sparse, it nevertheless has an impact on the traffic flow rate, which is assessed by the PCU. Therefore, it is better to also determine the total volume of this roundabout in terms of Passenger Car Equivalent (PCE), which is calculated by multiplying the total number of vehicles entering the roundabout in 1 hour with the PCU factor [1][2], whose value varies for each type of vehicle.

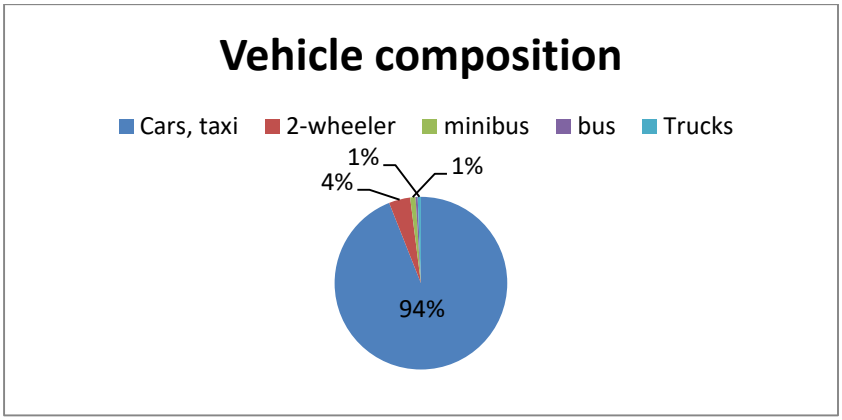
Table 7 shows the calculation of traffic volume in terms of PCU.

Table 7. Total Volume of Roundabout in PCU

Vehicle type	Approach A	Approach B	Approach C	Passenger Car Equivalent (PCE) Factor	PCU (N*PCE)
Car, taxi	581	1,055	704	1	2,340
2-wheeler	12	53	35	0.1	10
Minibus	5	6	5	1.5	24
Bus	0	1	1	3	6
Truck	4	3	3	2	18
Total Volume in PCU					2,398

According to the data, the Total Volume in PCU is about the same as the Total volume of the roundabout itself, indicating a pretty smooth traffic flow. Judging by the traffic volume, A roundabout is suitable for this junction as the volume does not exceed 3000 veh/hr. Roundabouts were originally designated for traffic volumes similar to that.

The pie chart below illustrates the vehicle composition of the roundabout. As mentioned earlier apart from cars and taxis, the amount of other types of vehicles entering this roundabout is extremely sparse as cars and taxis alone made up over 94% of the vehicles.



3.2. Delay Time of each approach

Courtesy of VISSIM software, the delay time of each approach was obtained by initially connecting links to the vehicles routes and then applying vehicle input (traffic volume). After the completion of the following steps, before performing the possible stimulation, it is extremely essential to specify the point of conflicts, by indicating which direction are its vehicles is given priority. One of the main advantages of Roundabouts over signalized junctions is their ability to reduce to the points of conflicts as the number of left turning vehicles are significantly less. With that said, the Delay time is not always greater for the approach with the most number of vehicles or highest traffic volume, it all depends on the direction of the vehicles whether left turning or right turning vehicles. Table 8 shows the Delay times (in seconds) determined through VISSIM.

Table 8. Delay time of each approach

Approach	Straight	Left Turn	Right turn	U-turn	Total Delay time of all vehicles in seconds
A	0	-	-	-	0
B	17	-	3,113	516.77	3,646.77
C	-	64.23	191	-	255.23

According to the point of conflicts given by VISSIM through the priorities given to the directions, quite clear that right turning vehicles entering approach B was subjected to the most delay and this

is not because they had the highest traffic volume out of all the connections in the roundabout but rather they were forced to give priority to vehicles from other directions the most

4. Discussion

Although the results are preliminary, based on the hypothesis proposed, it is perhaps better to continue with this roundabout at least for the present time. As mentioned earlier, since the total traffic volume per hour is less than 3,000 (2,468 to be precise) this is one of the few criteria which justify roundabout. However, with the number of vehicles increasing annually, this should also be taken into consideration. Hence why it is mentioned at the moment that the roundabout should stay as it is for the time being, perhaps in another 5 years or so, a roundabout might not be ideal. Although not many accidents have occurred in this junction since its implementation back in 2000, one of the main obstacles of the possibility of converting this to a signalized junction is its geographic location or topography as located nearby a mountain. This mountain is also an obstacle in performing any changes to the geometrical properties of the roundabout. Therefore it may not be soon possible to increase the inscribed circle diameter nor can the lanes can be widen even further. With that said, another possibility is perhaps shifting the roundabout several of meters from its original position and construct a bigger roundabout in terms of ICD.

5. Conclusions

According to the data, Approach B seems to be the main source of congestion in this roundabout as it accommodates a relatively large traffic volume out of all the connections and provides more priority to vehicles approaching from other directions than all other links combined. However, apart from that, the traffic flow of the roundabout is rather smooth, and the queue lengths are moderate and according to the archive data, this roundabout has had only 8 accidents since it's construction back in the year 2000, all of which were minor and non-fatal. The future of this roundabout ultimately remains a mystery as it will heavily depend on the magnitude or degree of the amount of vehicles increasing yearly. The roundabout will eventually be dissolved, it is only a matter of time, whether in 5 years, 10 years or so on, but it is highly unlikely to be converted because of the mountain located nearby being an obstacle for reconstruction. That`s why, the best possible remedy is to perhaps construct a larger roundabout at a distant away from its original position.

Through VISSIM, it was shown that increasing the traffic volume by another 10% from each direction, which could very well happen on a daily basis in the near future depending on how much the number of vehicles increase annually, elongated the total time delay even further.

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