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Geometrical Design Errors in Duhok Intersections by Driver Behavior

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Abstract

In many situations, drivers if certain of the absence traffic monitoring system tend to shorten their driving paths and travel time across intersections. This behavior will be encouraged if the geometrical design suffers from mistakes, or the geometrical design and road conditions make it harder for drivers to follow the correct routes. Sometimes the intersection arrangement is confusing for the driver to distinguish the right from the wrong track.

In this study, two sites with large number of driving mistakes were noticed. One site is a roundabout within the university of Duhok campus. The other is the intersection just outside the University of Duhok eastern main gate. At both sites, the geometry is very confusing and encourage driving mistakes.

The university roundabout which was the first site investigated, was not properly designed encouraging wrong side driving. Many traffic accidents took place at this roundabout. Wrong side driving reaches 32 % at peak hour in one approach. This was reduced to 6% when temporary divisional island was installed. The other approach has a 15% wrong side driving and no remedy could be done to it.

At the intersection near the university gate, wrong side driving reaches 56% of the traffic emerging from the main gate at peak hour. This was reduced to 14% when drivers are guided through direction sign. This percentage was reduced further to 9% with standing policeman.

Key Words: Geometrical, Design, Intersection, Roundabout, Behavior, Wrong, Driving.

الخلاصة

في حالات عديده وعندما يتأكد سائقو المركبات من عدم وجود نظام مراقبه مروري، يميل البعض الى اختصار زمن ومسافة مساراتهم عبر التقاطعات. يشجع هذا التصرف عندما يعاني التصميم الهندسي للتقاطع من الاخطاء او عندما يصعب التصميم وحاله الطريق من سلوك الاتجاه الصحيح. وقد يكون تصميم الطريق مربكا للسائق لكي يميز وجهته الصحيحة.

في هذه الدراسة تم اختيار وملاحظه موقعين يمتازان بكثره الاخطاء المرورية. أحد الموقعين هو دوره تقع ضمن الحرم الجامعي في جامعه دهوك. الأخر هو تقاطع يقع خارج البوابة الشرقية الرئيسية لجامعه دهوك. في كلا الموقعين كان التصميم الهندسي مربكا ويشجع على ارتكاب الاخطاء المرورية.

كان التقاطع الدائري في الجامعة بعيدا عن التصميم الصحيح. شجع هذا التصميم القيادة بالاتجاه الخطأ وكان سببا في وقوع بعض الحوادث المرورية. كانت نسبه القيادة بالاتجاه الخطأ في احد المقتربات تصل الى (٣٢%) في وقت الذروة. تم تقليل هذه النسبة الى (٦%) بعد نصب جزيرة تقسيم وسطيه مؤقته. كانت نسبه القيادة بالاتجاه المعاكس في المقترب الثاني (١٥%) ولم يتوفر علاجا مناسبا لهذه الحالة.

كانت نسبة القيادة بالاتحاد الخاطئ تصل الى (٥٦%) في اتجاه المرور الخارج من بوابه الجامعة باتجاه الطريق الرئيسي في وقت الذروة. تم تقليل هذه النسبة الى (١٤%) عند نصب اشاره دلاله على الاتجاه. تم تقليل هذه النسبة الى (٩%) عند الاستعانة برجل مرور يقف عند التقاطع.

الكلمات المفتاحية: التصميم الهندسي، التقاطعات، الساحات، السلوك، اخطاء السياقة.

Introduction and Scope of the Problem

Many drivers if not monitored tend to shorten their paths across intersections by selecting wrong directions. This will be more frequent if the geometry of the road allow for wrong side driving or when the correct side driving is too long or road surface condition is annoying. Sometimes clever design think in advance of the driver behavior and make measures to prevent prohibited turns. According to the AASHTO, the green book (AASHTO, 2011) "To maximize a roundabout's safe and efficient operation, entry widths should be kept to a minimum, A well-designed roundabout reduces the relative speeds between conflicting traffic streams by requiring vehicles to negotiate the roundabout along a curved path. Increasing the curvature of the vehicle path decreases the relative speed between the entering and circulating vehicles".

The smaller circumferences and curved entries at roundabouts lead to much lower operating speeds than at other circular junctions. The roundabout is generally designed for operating speeds of around 25 km/hr. (IIHS, 2000).

The width of the circulatory roadway, Figure (1) and the radius and width of the roundabout entry decide to large extent vehicles speed. The shape of the divisional island (Splitter Island) guide the drivers to the eight direction and prevent wrong side driving.

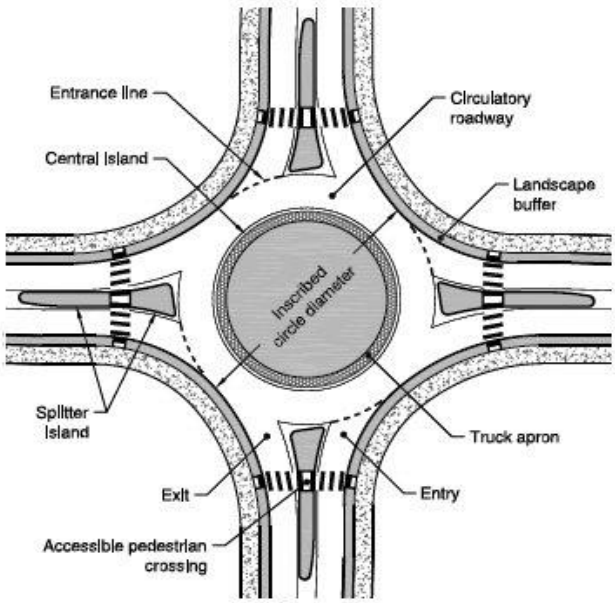

Figure (1) a layout of a typical roundabout, (ODT, 2000)

Reference (Roundabouts, 2000) lists all the specifications of the categories of roundabout including the maximum entry speed, maximum number of entering lanes

(usually 2), diameter of the inscribed circle, and shape of the splitter island. Accordingly roundabouts and intersections have local and international standards to be followed.

In this paper, two intersections within the University of Duhok have some geometrical errors have been monitored. Some temporary solutions were tried and the results shows that with these simple measures drivers can easily made to obey the correct rules.

Sites Description

In this study two sites having geometrical faults were selected. One is a roundabout within the university of Duhok campus. The other is the intersection just outside the university eastern main gate. At both sites the geometry is very confusing and encourage wrong side driving. The following is a general description of the two sites.

Site (1) The Roundabout

Figure (2) shows the location of the first site, the roundabout near the department of psychology. The roundabout have four approaches. Approaches 1 and 4 are the major roads connecting the university gate to the whole campus. Approaches 2 and 3 are the minor with the lowest in flow and density as they end at the college of medicine and the department of psychology respectively.

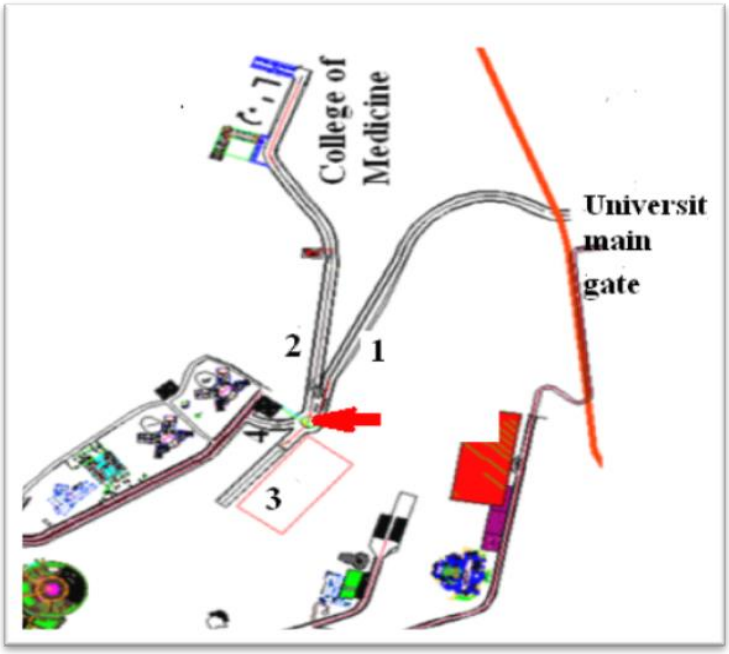

Figure (2) the location of the roundabout

Figure (3) shows the detail plan of the roundabout. The inscribed circle diameter = 46m and central island diameter = 24m. Making a clear circulatory roadway = 11.1m or three lanes of 3.7m.

Figure (3) a close look on the roundabout

Studying the geometrical and traffic conditions of this roundabout, we noticed:

1- Steep slope on approach 2:

Approach 2 from the college of medicine has a very steep slope, Figures (4) and (5). The slope towards the roundabout reaches 14%. Making it very difficult to break at the roundabout entrance. If driver inter the roundabout at a speed of 30 km/hr he needs about 40m to stop if break at the roundabout entrance. According to the AASHTO green book (AASHTO, 2011) "grades in excess of 3 percent should be avoided on the intersecting roads and where conditions make special designs too expensive, grades should not exceed about 6 percent. To reduce the speed on this approach a rubber hump was put at the entrance of this approach to the roundabout.

Figure (4) Photo of the roundabout taken from the department of psychology

2- Lack of enough stopping sight distance:

because of the high slope of approach 2 and the existing of a retaining wall, Figure (5), separating approach 1 and 2, no enough stooping sight distance is exist between vehicles approaching the roundabout from directions 1 and 2. The available stopping sight distance is about 16m, Figure (6), whereas the required stopping sight distance for a vehicle approaching from 1 at a speed of 30km/hr is 28m.

Figure (5) Retaining wall shorten the stopping site distance for vehicles at approach1

3- The lack of proper divisional islands and the small size of the central island provide a large wander space, Figure (7). This will encourage drivers to make wrong side movements.

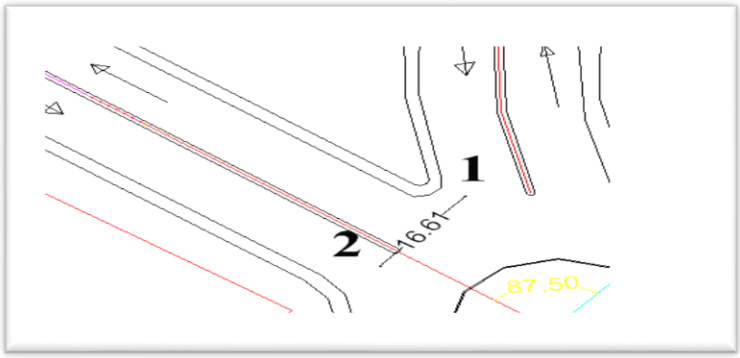

Figure (6) the available stopping sight distance for vehicle at approach 1

Figure (7) Large wander space on the roundabout

Site (2) The Intersection Just Outside the University Eastern Main Gate

This intersection, Figure (8) connect the main 4-lane divided road to the university gate. It also leads to two minor one of the university cultural center and conference hall, the other of a residential area.

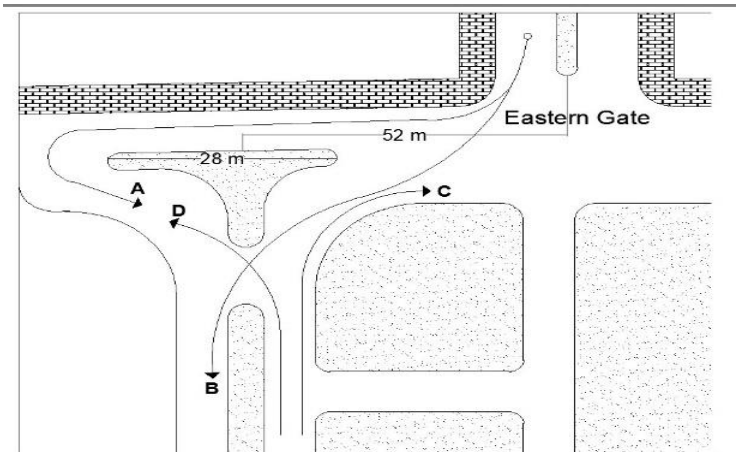

Figure (8) the intersection on the eastern gate

On diagnosing design drawback of the intersection geometry we noticed

1- A large eccentric alignment between the university main gate and the main road. The (52) m eccentricity makes the traffic flow more difficult, create some congestion on the morning peak hour, and encourage wrong side driving.
2- Drivers exiting the university main gate toward the main road have to move around (28) m divisional island, direction (A), Figure (8) before entering the main road. This encourage wrong side driving in (B) direction.
3- Drivers heading for the university cultural center from the main road should rotate around the (28) m divisional island in a sharp curve. This will encourage wrong side driving in direction (D)

On driving on path (A), vehicles faces a sever pavement corrugation, Figure (9), encouraging driving on wrong path.

Figure (9) Pavement corrugation around the divisional island

Observations and Data Analyses

The geometrical faults on the two investigated sites, leads to major wrong side driving. Peak time counts were conducted to observe driver's behavior and wrong side driving percentage. Some remedy measures were tried and the observations were repeated afterward.

Counting was carried out at university peak hour which is 1:30 to 2:30 pm. On sunny clear Mondays. All vehicles passing through the intersections were accounted for.

1- Observations and counts on site (1) the roundabout

As previously mentioned the geometry of the roundabout encourage wrong side movement. The large circulatory roadway and the lack of proper divisional islands increase wander space. Giving the driver a thought that it is a large open pavement area and not a roundabout. Figure (10) shows the observed wrong side movements: B, and D.

At this roundabout two approaches were observed:

The first was approach (3) from the department of psychology. This was split in two streams: the right path A around the roundabout and the wrong B towards the basic education college.

The second was approach (2) from the college of medicine. This was split in two streams: the right path C around the roundabout and the wrong D towards the main gate.

Figure (10) Observed wrong side movements, B and D

Table (1) list the count during the peak hour at the roundabout **a** total of 226 vehicles were observed on approach 2 and 171 on approach 3. As shown from table (1) and Figure (11), there is 15% and 32% wrong side driving on approaches 2 and 3 respectively.

Table (1) Traffic count at the roundabout

case1: no posts island Monday 25/4/2016 weather: sunny								
Approach 2					Approach 3			
path C		Path D			Path A		Path B	
PC	Taxi	PC	Taxi		PC	Taxi	PC	Taxi
141	52	18	15		101	16	45	9
Total = 226					Total= 171			
Percentage of wrong side driving								
15% of traffic in approach 2					32% of traffic in a approach 3			

* PC: passenger car

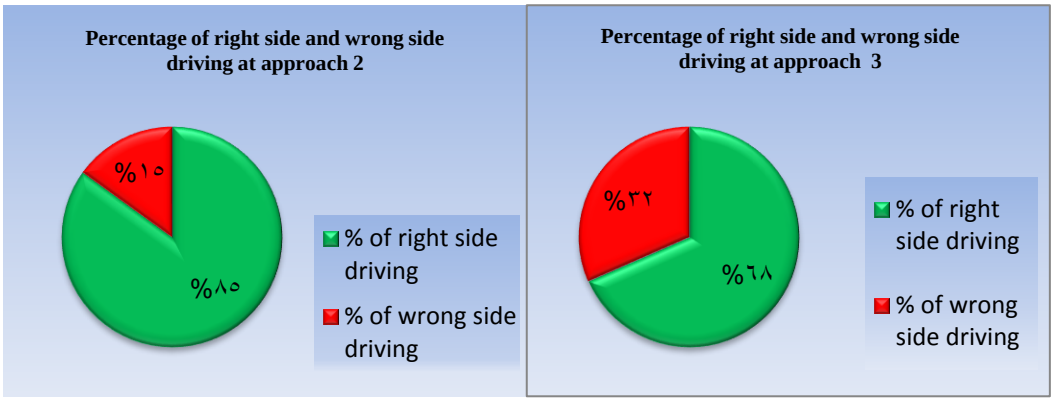

Figure (11) Percentages of right side and wrong side driving on approaches 2 and 3

Wrong side driving on path D, Figure (12), is hazardous as there is no enough stopping sight distance for vehicles entering the roundabout from approach 2 to see the wrong side moving vehicle.

Figure (12) Wrong side movement from approach2

The majority of wrong side driving took place on path B, approach 3, Figure (12). About 32% of vehicles entering the roundabout from approach 3 make wrong side turn. This can be explained on examining the roundabout geometry. The absence of divisional island on approach 3 and the large wander area, shown in Figure (6) encourage this behavior.

Figure (13) Wrong side movement from approach3

As a solution a temporary divisional island was established, Figure (14). This island should discourage driving in the wrong path B. on erecting this island, a count was made on vehicles emerging from approach 3 and the data is listed in table (2)

Figure (14) Temporary divisional island at entrance of approach 3

Table (2) Traffic count at the roundabout after installing a temporary posts island

Case 2 With posts island Monday 9/5/2016 Weather: Sunny			
Approach 3			
Path A		Path B	
PC	Taxi	PC	Taxi
137	52	9	3
Total = 201			
Percentage of wrong side driving= 6 %			

A large reduction in wrong side driving from 32% to 6% was observed. Figure (15) shows the small share of wrong side driving in approach 3

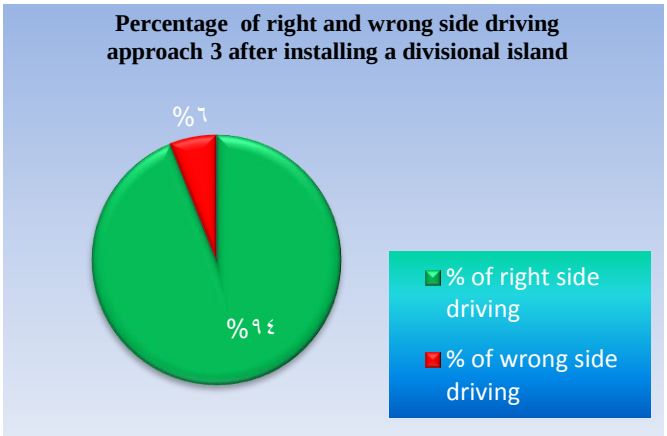

Figure (15) the obvious reduction in wrong side driving in approach 3 after erecting the divisional island

2- Observation and counts on site (2) the intersection near the eastern main gate

As mentioned earlier, the geometry of the intersection encourage wrong side driving in two paths, path D towards the university cultural center and path B from the gate towards the main road, Figure (8). Path D has minor consequence with few vehicles heading this direction in the morning peak hour. The study was focused on path B for vehicles heading toward the main road. Table (3) lists observations carried out on peak hour, 1:30 to 2:30pm.

From table (3) and Figure (16) one can notice that quite large number of vehicles drove in the wrong side path B. 56% of a total traffic of 686 vehicles drove in the wrong side. This happened despite a traffic flow of 117 vehicles coming in the opposite direction C.

Table (3) Observation at the intersection near the eastern main gate

Case 1: No Sign Monday 15/2/2016 Weather: Sunny							
Vehicles A				Vehicles B			
PC	PC:F	TAXI	BUS	PC	PC:F	TAXI	BUS
192	37	65	9	269	30	79	5
Total A= 303				Total B=383			
Total A+B= 686							
%A/(A+B) = 44%				%B/(A+B)= 56%			
% from A+B							
28%	5%	10%	1%	39%	4%	12%	1%

Vehicles C		
PC	TAXI	BUS
52	47	18
Total C= 117		

* PC: passenger car
* PC:F passenger car drive by female

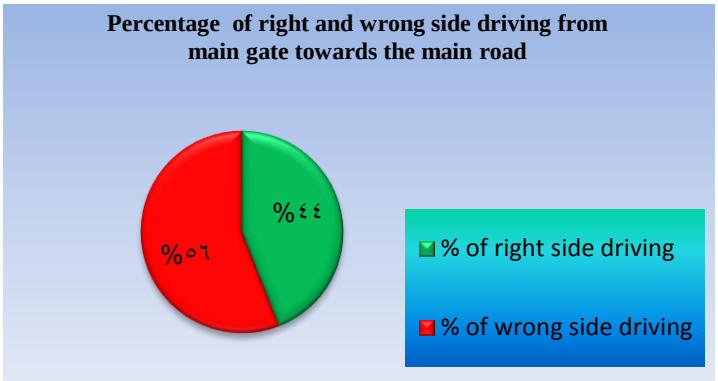

Figure (16) Percentage of right and wrong side traffic from the main gate

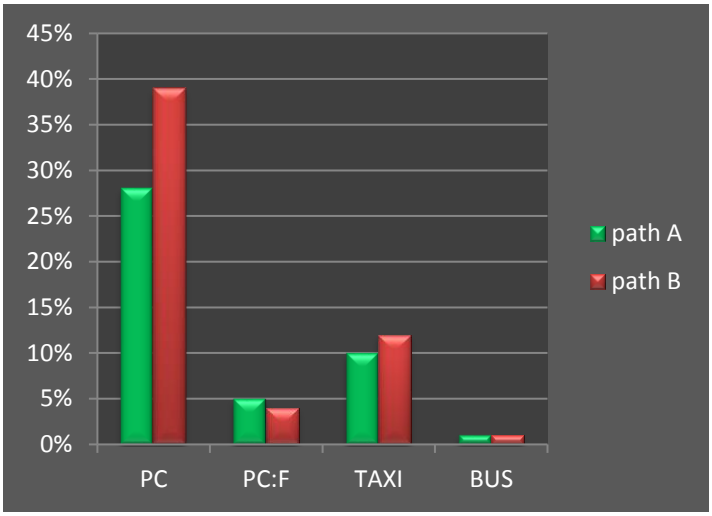

Figure (17) Vehicle categories in right and wrong paths

Figure (17) shows that there is no significant difference in road user's categories in the right and wrong paths except for the passenger cars. 28% of the total vehicles emerging from the main gate go in direction A, whereas 39% go in the wrong direction.

As a control measure, a direction sign, Figure (18), was fixed to guide drivers for the right direction A.

Figure (18) the direction guide sign

A new count was made to see the effect of drivers' behavior on seeing the direction sign. Data is listed in table (4). From table (4) and Figure (19) one can notice

the large reduction in wrong side driving as an effect of using the direction sign. A drop from 56% to 14% was achieved. Figure (20) shows that there is significant reduction in wrong side driving among all categories.

Table (4) Observation at the intersection near the eastern main gate after installing direction sign

Case 2 With direction sign Monday 11/4/2016 Weather: Sunny							
Vehicles A				Vehicles B			
PC	PC:F	TAXI	BUS	PC	PC:F	TAXI	BUS
424	41	122	11	66	11	20	1
Total A=598				Total B= 98			
Total A+B= 696							
%A/(A+B) = 86%				%B/(A+B)= 14%			
% from A+B							
61%	6%	17%	2%	9%	2%	3%	0%

Vehicles C		
PC	TAXI	BUS
19	13	12
Total C=44		

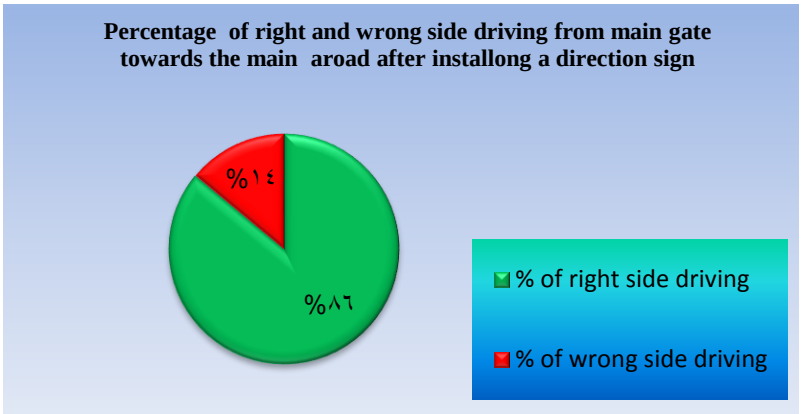

Figure (19) Percentage of right and wrong side driving after installing the direction sign

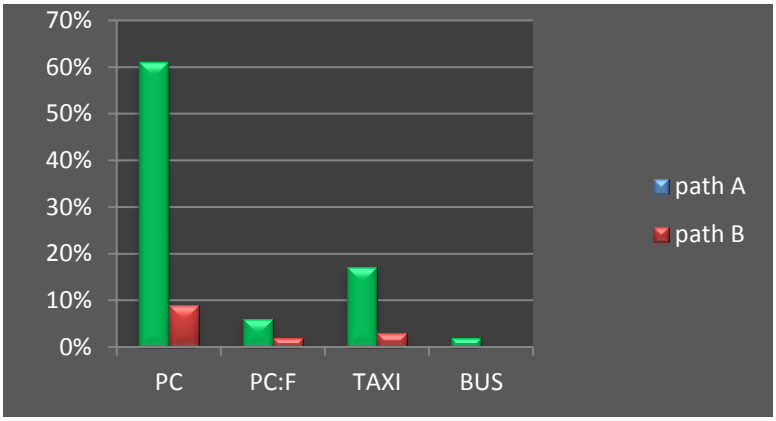

Figure (20) Vehicle categories in right and wrong paths after installing the direction sign

A new count was made to see the effect of having a watching traffic policeman, Figure (21), beside the direction sign. Data is listed in table (5)

Table (5) Observation at the intersection near the eastern main gate after installing direction sign and watching policeman

Case 3 with direction Sign & Policeman Monday 18/4/2016 Weather: Sunny							
Vehicles A				Vehicles B			
PC	PC:F	TAXI	BUS	PC	PC:F	TAXI	BUS
380	36	31	7	30	9	4	0
Total A= 454				Total B=43			
Total A+B= 497							
%A/(A+B) = 91%				%B/(A+B)= 9%			
% from A+ B							
77%	7%	6%	1%	6%	2%	1%	0%

Vehicles C		
PC	TAXI	BUS
7	2	3
Total C= 12		

Having law enforcement mean and a control sign reduced the wrong side driving to 9%, table (5) and Figure (21)

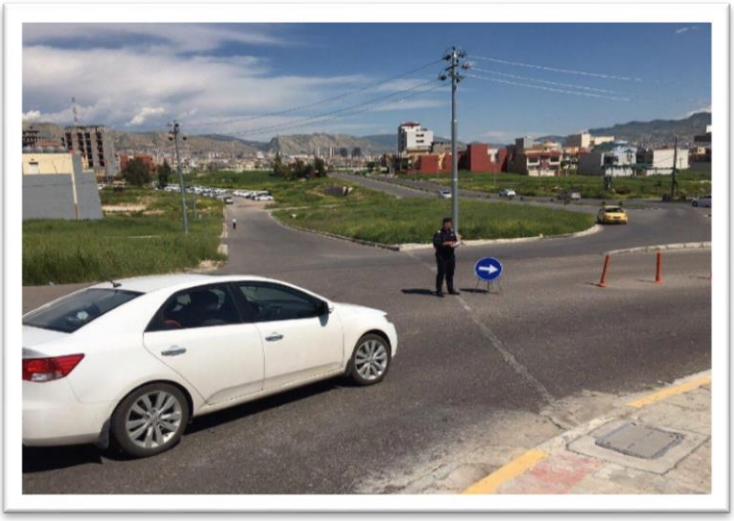

Figure (21) a standing policeman beside the direction sign

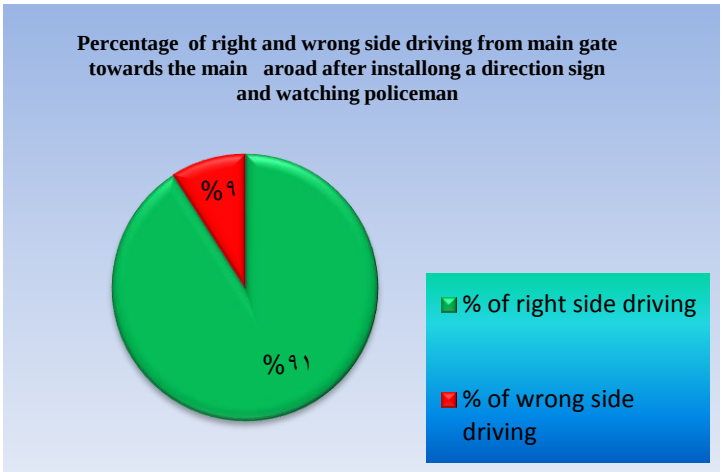

Figure (22) a large reduction in wrong side driving was achieved as a result of having direction sign and standing policeman

Figure (23) shows the greater reduction in wrong side driving among all categories with the presence of control sign and standing policeman.

Figure (24) shows car number in different cases. Among all the cases we can notice the obedience of taxi drivers in the eastern gate to the direction sign. After installing the direction sign only, among 142 taxi car only 20 made wrong side movement.

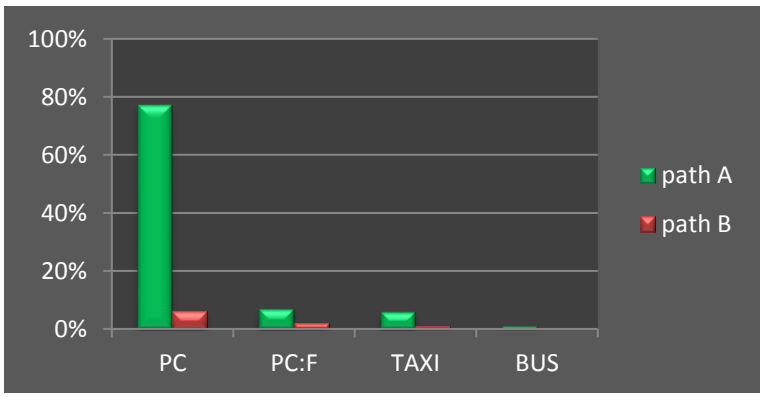

Figure (23) the great reduction in wrong side driving after installing a direction sign and standing policeman

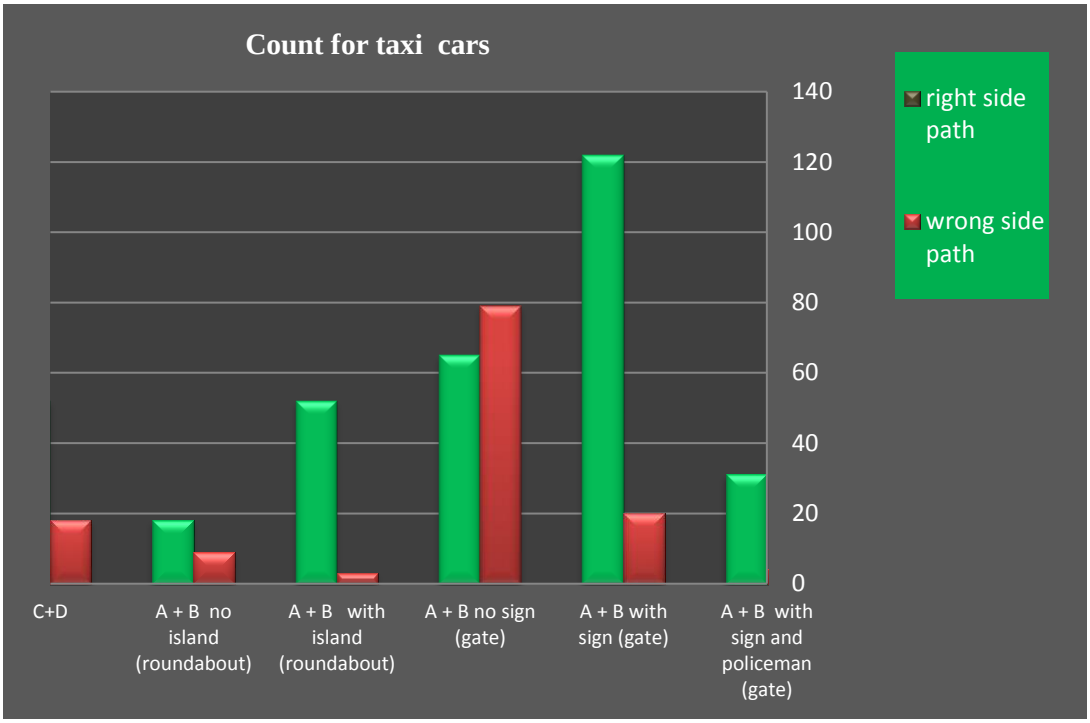

Figure (24) Count for right and wrong side taxi vehicles in different cases

Conclusion and Discussion

1- Roundabout and intersections should be properly designed with the assigned circulatory roadway dimensions and proper diameter Central Island plus curbed or marked divisional islands.
2- The roundabout has clear circulatory roadway of three lanes. According to the size of traffic, this is far from the need. Two lanes is quite enough.
3- The roundabout is located at the end of steep slope of approach 2. Approach 2 has a 14% slope making it hard to stop at the required distance.
4- In the intersection near the eastern gate, drivers have to drive along distance around inappropriate badly designed divisional island. The island has a sharp small radius curve. Near the tip of this curve, the asphalt pavement is badly corrugated. These factors encourage drivers for wrong side move.
5- On simple measures, which we tried, a substantial reduction in wrong side driving was made. In the roundabout and after installing a divisional island the wrong side move fell from 32% to 6%. After installing a direction sign in the eastern gates, the percentage of wrong side moves dropped from 56% to 14%. This percentage was reduced even farther, (9%) with the presence of policeman.
6- In the eastern gate and before installing the direction sign, male drove cars, taxi cars, buses made more wrong side movement more than the right side. Only female drove cars made more right side move than the wrong.

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