CHAPTER 5

TRAFFIC CONFLICT AT BATU BERSURAT ROUNDABOUT, KUALA TERENGGANU

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5.1 INTRODUCTION

Roundabouts are a good solution for safety concerns present at the other types of intersections. However, making these roundabouts is not that easy, especially for multi-lane roundabouts to be safe for all ranges of road users, mostly for those with reduced cognitive and physical capabilities such as the older drivers. The features of roundabouts such as advance warning and signage play an important role in determining the driver's performance as they travel around the roundabout. This situation presents a significant safety concern to reduce the serious injuries from occur at or near intersections as many jurisdictions have turned to implementing roundabouts [1].

The aim of this research is to evaluate the roundabout traffic conflict exposure to identify which negotiations contribute the highest conflict exposure. The "drive-around" mode that applied at roundabout are aimed to reduce the conflicts of crossing vehicular. Not only that, but the approach to the roundabout also deflected to a certain degree able to reduce the approaching speed and facilitate weaving and merging maneuvers between

the entering and circulating vehicles as it can avoid the direct collisions. Not to mention, the purpose of roundabouts is to create a safer driving experience by the rule of yield-to-circulating at a roundabout entrance compared to the conventional intersections. The most common studies shows that roundabouts able to improve the efficiency and safety compared other type of intersections and more importantly, roundabouts can reduce conflict points at intersections and accident severity significantly [2]. However, performance of roundabouts is better than the signalized intersections only for intermediate traffic demands while for high traffic demands, signalized intersections [3].

5.2 LITERATURE VIEW

A roundabout is a circular intersection with yield control for all the entering vehicles, circulation that is clockwise or counterclockwise, and it is an appropriate geometric curvature. It is constructed in such a way that it keeps traffic moving which is purpose of reducing the rate of crashes and collisions. Roundabouts are also used to reduce delays and check the behaviors of rough drivers. The roundabout's proper geometric characteristics direct the drivers as they approach, enter, and go through the circular intersection. Sometimes it also referred as modern roundabouts to distinguish them from the older circular junction designs that had different design characteristics and operating restrictions [4].

The road is originally designed as a four-leg intersection since it has four directions that are named eastbound, westbound, northbound, and southbound. Roundabout also can be applied to a T-junction and multi-leg intersection. Since the roads at that area are connecting the business area and residential, by establishing a roundabout at the junction, it can improve the traffic flow. For a roundabout, key indicator on space requirement that is important is the inscribed circle diameter of the roundabout. To provide accommodation of entry and circulating traffic, it needs to be paid special attention when more than one lane is required. The required widening and flaring for roundabouts can be

achieved in a shorter distance better than the distance required to develop the right turn lanes and transition tapers at the conventional intersections. Thus, a larger space that required for the multilane roundabouts can be compensated for by the turning lane requirements at the alternative intersection forms. However, for the mini roundabouts, there is no additional space required compared to the conventional intersections [5].

5.3 METHODS

This study focused on the multi lane roundabout at Batu Bersurat Roundabout, Kuala Terengganu that connecting the several roads which are Jalan Sultan Ismail, Jalan Sultan Sulaiman, Jalan Sultan Mahmud, and Jalan Sultan Zainal Abidin.

5.3.1 DATA COLLECTION

The data for undesired negotiations were retrieved from recorded videos that were taken at selected location of the chosen roundabout. The system of video recording will consist of a video from a camera on 2.5m tripod. The system will be located about 40 feet from the sidewalks of a corner between two roundabout approaches for larger and more focus to a quadrant-based video review that easy to analyses the data later since it is located between two adjacent approaches. The roundabout performance will be measured two times for two days which are Wednesday and Friday. For Wednesday, the data will be taken at peak hour which is from 1.00 p.m. to 2.00 p.m. and non-peak hour which is from 9.00 a.m. to 10.00 a.m while for Friday, 2.00 p.m. to 3.00 p.m. for peak hour and 9.00 a.m to 10.00 a.m for non-peak hour.

Figure 5.1: Data will be recorded from 'x' location

Each lane is identified with a certain name, which are C1, C2, EN1, and EN2, to make it easier to collect the data.

Figure 5.2: Each lane identified with specified code

5.3.2 MEASURE OF THE EXPOSURE TO CONFLICTS

To achieve the objective which is to evaluate the conflict exposure at the roundabout, there are several conflict points where the accident commonly likely to happen. A conflict at the roundabout will or will not contribute to a crash but it is still considered an important to the safety of traffic. It is difficult to measure it, and there is no agreement reached about what kind of most accurate measures to identify the conflict. In this study, a simple measure of vehicle negotiation is used to identify the total value of conflict exposure rather than measure number of conflicts directly. A major reason that contributes to the cause of conflicts or crashes is due to violate the traffic control rules which the amount of the violations, or undesired negotiations, which is an indicator to the exposure to conflicts. At roundabout, “yield-to-circulating” is required as it is discouraged to changing the lane in circulating roadways. The videos that collected for this study that are taken in two different time which are at peak hour time and non-peak hour for two days which is weekday and weekend to observe which time have the possibility for the crash to be happen is higher. The following several undesired negotiations as shown below are identified to investigate the exposure to conflicts within the roundabout in this study [6].

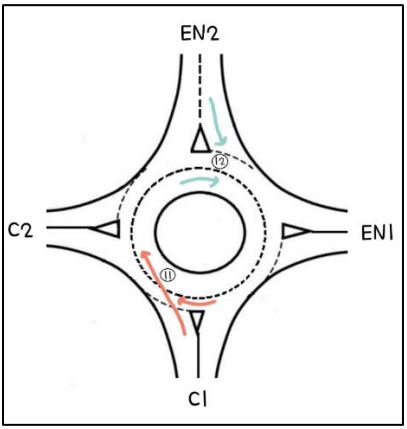

Figure 5.3: The quadrant of roundabout and undesired negotiations for FY and WY

i. C1 to C2.
ii. C1 to Ex2.
iii. C2 to C1.
iv. C2 to Ex1.
v. En1 to C2.
vi. En1 to Ex2.
vii. En2 to C1.
viii. En2 to Ex1.
ix. C2 to C2.
x. CVOL (The circulating vehicle is on lane line): A vehicle that enters the quadrant in either of the circulating lanes, travels on the lane line for a while, and then exits mostly in the right exiting lane. It is similar to C1 to Ex2.
xi. FY: A vehicle the enter the roundabout fails to yield to the upcoming circulating vehicle.
xii. WY: A vehicle circulating the roundabout that wrongly yields to the entering vehicle.

Undesired negotiations of 1 to 9 were denoted which are the left side of the arrow stands for the lane in that the vehicle enters the quadrant of roundabout and the right stands for the lane in that the vehicle will exit the quadrant of the roundabout. C1 and C2 stand for left of inner and right of outer circulating lanes while for En1 and En2 stand for left and right entering lanes, and Ex1 and Ex2 stand for left and right exiting lanes. For an example, C1→Ex2 stands for the situation when a vehicle enters the quadrant in the inner circulating lane, but it exits in the outer exiting lane. When traffic flow increases, the total of vehicles that travel to undesired negotiations will increase. To measure conflict exposure, the exposure rate to conflicts is calculated by using following formula:

$$CERx = \frac{CEx}{Volumex} \quad Eq.1$$

where,
CER*x* = the exposure rate to the conflicts of the undesired negotiation of *x*th

CE*x* = the count of the undesired negotiations of *x*th during the given period
Volume*x* = the count of vehicles that travel into the quadrant from the same lane(s) where the undesired negotiations start during the given period, which for negotiations 10–12, the count includes both lanes.

The quantitative analyses can be attempted in order to interpret the value of conflict exposure for each undesired negotiation.

5.4 RESULTS AND DISCUSSION

The data were taken in two difference period which are peak hour and non-peak hour and then, data will be compared. Thus, the result was differentiated and concluded below. The conflict exposure rates at the roundabout have been calculated by using the selected formula. From the result, the conflict exposure that contribute the highest percentage of crash patterns have been identified.

5.4.1 CONFLICT EXPOSURE FOR WEDNESDAY

Based on the data in Table 5.1, the exposure rates to conflicts result data for both non-peak hour and peak hour were calculated by using equation in Equation 1 and presented in Table 5.2. The result of exposure rates to conflicts then converted in a graph for better understanding.

Table 5.1: Conflict exposure–related event counts for weekday

Traffic Count	Time	
	Non-Peak Hour (9.00 a.m. – 10.00 a.m.) (veh)	**Peak Hour (1.00 p.m. – 2.00 p.m) (veh)**
C1	1593	2056
C2	825	1277
En1	507	800
En2	560	834

Undesired Negotiations	Non-Peak Hour (9.00 a.m. – 10.00 a.m.) (veh)	Peak Hour (1.00 p.m. – 2.00 p.m) (veh)
C1 → C2	334	662
C1 → Ex2	66	208
C2 → C1	89	255
C2 → Ex1	82	283
En1 → C2	55	144
En1 → Ex2	0	0
En2 → C1	92	283
En2 → Ex1	85	266
C2 → C2	5	7
CVOL	91	222
FY	2	10
WY	0	0

Table 5.2: Exposure rates to conflicts for weekday

Undesired Negotiations	Time		Average	Percentage (%)
	Non-Peak Hour (9.00 a.m. – 10.00 a.m.)	Peak Hour (1.00 p.m. – 2.00 p.m.)		
C1 → C2	0.210	0.322	0.266	19.69
C1 → Ex2	0.041	0.101	0.071	5.26
C2 → C1	0.108	0.200	0.154	11.40
C2 → Ex1	0.099	0.222	0.161	11.92
En1 → C2	0.108	0.180	0.144	10.66
En1 → Ex2	0.000	0.000	0.000	0.00
En2 → C1	0.164	0.339	0.252	18.65
En2 → Ex1	0.152	0.319	0.236	17.47
C2 → C2	0.006	0.005	0.006	0.44
CVOL	0.038	0.067	0.053	3.92

FY	0.004	0.012	0.008	0.59
WY	0.000	0.000	0.000	0.00
			1.351	100

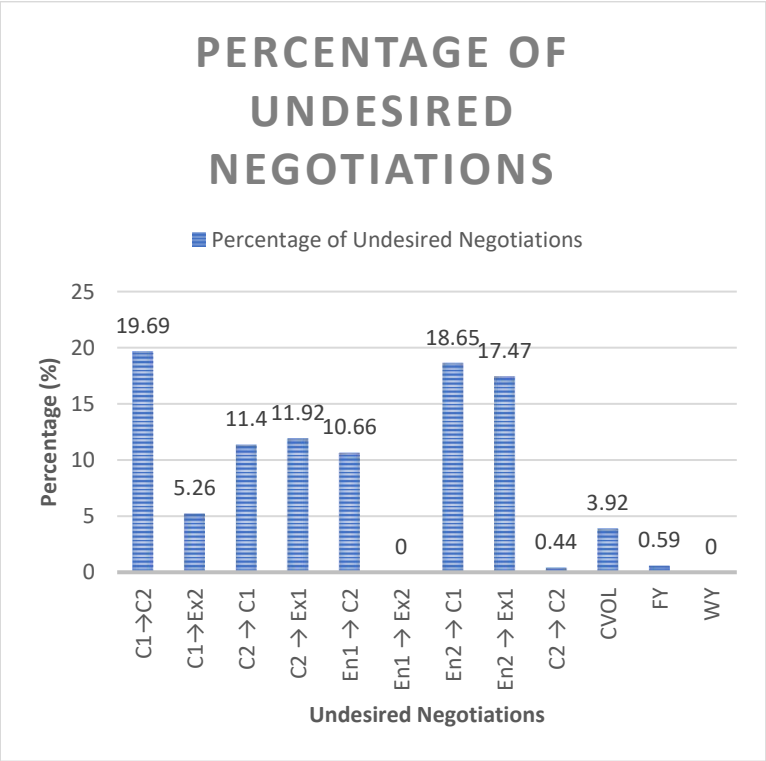

Figure 5.4: Percentage of undesired negotiations for Wednesday

Based on the data above, it shows that the highest roundabout quadrants for conflict exposure rates for Wednesday is C1→C2 with the value of 19.69%. There are many vehicles are coming from C1 entering the roundabout and exiting to C2. The vehicle creates a possible conflict if there is another vehicle travels close to it that came from the inner circulating lane, especially if the

vehicles are being drove in high speed. The reason why there are many vehicles from C1 entering the roundabout and exiting the roundabout at C2 is because C1 is the federal road and C2 are the main road that connected to the several schools and residential areas. The time period that contributes to the traffic volume data is during peak hour with value of 662 vehicles as people take their lunch hour from office to go to home or to take their children at school before going back to the office later before the office hour for evening session start. Meanwhile, the lowest percentage of undesired negotiations are En1→En2 and WY with both got 0%.

5.4.2 CONFLICT EXPOSURE FOR FRIDAY

Table 5.3: Conflict exposure–related event counts for weekend

Traffic Count	**Time**	
	Non-Peak Hour (9.00 a.m. – 10.00 a.m.) (veh)	**Peak Hour (2.00 p.m. – 3.00 p.m) (veh)**
C1	2842	4101
C2	2635	3988
En1	1967	4405
En2	2055	3304
Undesired Negotiations	**Non-Peak Hour (9.00 a.m. – 10.00 a.m.) (veh)**	**Peak Hour (2.00 p.m. – 3.00 p.m) (veh)**
C1 → C2	233	308
C1 → Ex2	462	300
C2 → C1	102	338
C2 → Ex1	291	684
En1 → C2	220	632
En1 → Ex2	0	18
En2 → C1	209	502
En2 → Ex1	239	487
C2 → C2	0	15
CVOL	331	204
FY	0	3
WY	0	0

Based on the data in the table above, the exposure rates to conflicts result data for both non-peak hour and peak hour were calculated by using Equation 1 and presented in Table 5.4. The result of exposure rates to conflicts then converted in a graph for better understanding.

Table 5.4: Exposure rates to conflicts for weekend

Undesired Negotiations	**Time**		**Average**	**Percentage (%)**
	Non-Peak Hour (9.00 a.m. – 10.00 a.m.)	**Peak Hour (2.00 p.m. – 3.00 p.m.)**		
C1 → C2	0.082	0.075	0.079	9.46
C1 → Ex2	0.163	0.073	0.118	14.13
C2 → C1	0.039	0.085	0.062	7.43
C2 → Ex1	0.110	0.172	0.141	16.89
En1 → C2	0.112	0.143	0.128	15.33
En1 → Ex2	0.000	0.004	0.002	0.24
En2 → C1	0.102	0.152	0.127	15.21
En2 → Ex1	0.116	0.147	0.132	15.81
C2 → C2	0.000	0.004	0.002	0.24
CVOL	0.060	0.025	0.043	5.15
FY	0.000	0.001	0.001	0.12
WY	0.000	0.000	0.000	0.00
			0.835	100

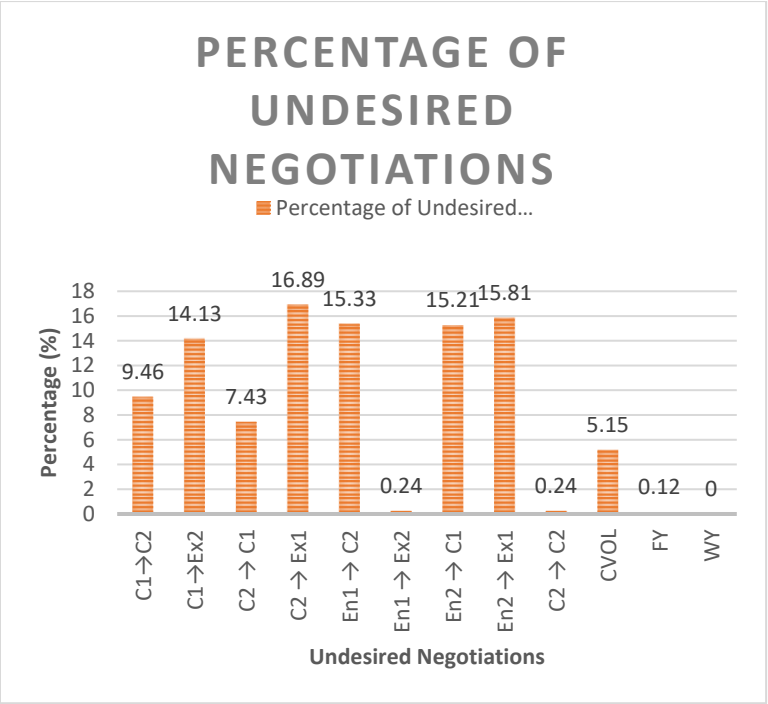

Figure 5.5: Percentage of undesired negotiations for Friday

Based on the data above, it shows that the highest roundabout quadrants for conflict exposure rates for Friday is C2→Ex1 with the value of 16.89%. There are many vehicles are coming from C2 entering the roundabout and exiting to Ex1. The vehicle creates a possible conflict if there is another vehicle travels close to it that came from the inner circulating lane, especially when the vehicles are being drove in high speed. The reason why there are many vehicles from C2 entering the roundabout and exiting the roundabout at Ex1 is because Ex1 the main road to go to shopping complexes and also the federal road while C2 are connected to the residential areas. The time period that contributes to the traffic volume data is during peak hour with value of 684 vehicles. Since it is weekend, people tend to go to the shopping complexes to something or to relax with families and

friends. Not to mentioned that the road connected to the drawbridge which one of the tourism attractions. Meanwhile, the lowest percentage of undesired negotiations is WY with the value 0% while for lowest percentage of undesired negotiations for lane are En1→Ex2 and C2→C2.

5.5 CONCLUSION

The data were taken in two difference periods which are non-peak hour and peak hour for two days which are weekday and weekend. The result was differentiated for each undesired negotiations and concluded that the highest value for conflict exposure is during weekday at the peak hour for undesired negotiation C1→C2 which from Jalan Sultan Mahmud exiting to Jalan Sultan Ismail. Meanwhile for weekend, the highest value for conflict exposure for undesired negotiations is C2→Ex1 which from Jalan Sultan Ismail exiting to Jalan Sultan Zainal Abidin during the peak hour. The exposure rate to the conflict points at the roundabout increased at the certain undesired negotiations as it is related to their surrounding and time factors such as negotiation to Ex1 which Jalan Sultan Zainal Abidin during weekend due to the location of shopping complexes connected to that lane and negotiation to C2 which Jalan Sultan Ismail during weekday because of lunch hour for back home for rest for a while or pickup child at school. During the high traffic, the road users can avoid the risk for crashes by practice the safety measurement such as make sure be at the right lane when travels the roundabout and remember to light the signal to make the other road users know which lane you will be exiting later. For the upcoming research that related to the conflict exposure, the method to collect the data can be improved by using specified tools that can automatically get the data in order to avoid the human error.

There are many improvements that can be implemented that related to the conflict exposure study. The future study or recommendations that can be done are adding the crash patterns together with conflict exposure as the researcher can be able to identify the value of the crashes happened for every type of crashes and identify the highest type of crash that happened at

roundabout. This study can be implemented by using 2022 accident data statistic.

Other than that, another improvement that can be implemented for study that related to conflict exposure or recommendation is make a comparison between conflict exposure at single lane roundabout and multi lane roundabout. It is because the lanes in single lane roundabout is not same quantity as multi lane which it has lower undesired negotiations at the roundabout. It also recommended to improve the study finding by analysis another roundabout at Kuala Terengganu which is at Batu Enam Roundabout and compare the data to know which roundabout has the highest exposure point.

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