THE EVALUATION ON THE PERFORMANCES OF A ROUNDABOUT AT

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ABSTRACT

At present, smooth movement on the roads is something that is needed for each user. Many roads, especially in urban areas will be upgraded because of the number of vehicles increase from time to time. So, it very important to monitor and analyze traffic congestion that can be enhanced using either the performance of traffic lights, geometry change, and others. This study is about the performance of roundabout at Jalan Tas 4, Taman Tas, Kuantan where the original type of road is unsignalized four leg intersection. In this project, Sidra Intersection 5.1 software is used to determine the effectiveness of roundabout in term of capacity of roundabout, delay and queue and level of service of roundabout. Before using Sidra Intersection 5.1, the data recorded two times on morning peak hour and evening peak hour. After the traffic flow and geometry of roundabout are taken, the data is analyzed using Sidra Intersection 5.1 and the result from the process data in term of capacity, delay, queue, and level of service for each movement on each approach are given. The output data from Sidra Intersection 5.1 is in term of graphic and text. The graphic data especially for level of service and delay is in colorful graphic to differentiate the good performance and poor performance. In this study, the recommendation for the problem at roundabout is also given. The recommendation is to increase the size of central island to 10 m since the area is limited area. By enlarging the diameter of central island, the same data is used to analyze the performance of proposed diameter by using Sidra Intersection 5.1. From the output data, there is improvement of performance of roundabout at Taman Tas, Kuantan in term of delay, queue and capacity.

ABSTRAK

Pada masa kini, pergerakan lancar di atas jalan raya adalah sesuatu yang diperlukan setiap pengguna. Banyak jalan raya terutama di kawasan bandar dinaik taraf kerana pertambahan jumlah kenderaan dari semasa ke semasa. Jadi, adalah sangat penting untuk memantau dan menganalisis kesesakan jalan raya supaya dapat dipertingkat prestasi sama ada dengan menggunakan lampu isyarat, perubahan geometri dan lain - lain. Kajian ini ialah mengenai prestasi bulatan jalan yang disediakan di Jalan Tas 4, Taman Tas, Kuantan di mana jenis asal persimpangan ini ialah 4 arah persimpangan tanpa lampu isyarat. Dalam kajian ini, "Sidra Intersection 5.1" telah digunakan untuk menganalisis prestasi bulatan jalan dari segi kapasiti bulatan jalan, kelengahan dan baris gilir dan tahap perkhidmatan bulatan jalan. Sebelum menggunakan Sidra Intersection 5.1, data telah direkodkan dua kali pada waktu kemuncak pagi dan petang. Setelah aliran trafik dan geometri bulatan jalan diambil, data akan dianalisis menggunakan Sidra Intersection 5.1 dan hasil daripada pemprosesan data dari segi kapasiti, kelengahan, baris gilir dan tahap perkhidmatan bulatan akan diberi. Hasil dari Sidra Intersection 5.1 adalah dalam bentuk gambar rajah dan jadual. Gambar rajah untuk kelengahan dan tahap perkhidmatan biasanya berwarna supaya dapat membezakan prestasi yang baik dengan prestasi yang buruk. Dalam kajian ini juga, telah dicadangkan penyelsaian masalah di bulatan jalan. Candangannya ialah dengan menambahkan saiz bulatan tengah jalah kepada 10 m kerana kawasan tersebut mempunyai luas yang terhad. Dengan pertambahan saiz bulatan, data yang sama digunakan untuk menganalisa prestasi saiz bulatan tengah yang dicadangkan dengan menggunakan Sidra Intersection 5.1. daripada hasil analisis, ada kenaikan prestasi bulatan jalan di Taman Tas, Kuantan dari segi kapasiti, kelengahan dan baris gilir.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

The traffic congestion increased day by day has cause lose billions hour and money. Therefore, roundabout has been introduced to reduce traffic congestion at intersection. Roundabout is a circular intersection that provides a circular traffic pattern with function of reducing the crossing conflict points. Roundabouts are popular. During the last 20 years, more and more intersections have been converted to roundabout. The purpose of replace intersection to roundabout is usually for traffic flow management and to improve safety.

There are two fundamental elements that can distinguish roundabout from traffic circle, which is yield at entry for entering vehicle and the deflection of approaches and exit. In Malaysia, the movement of roundabout is in clockwise circulating movement. At the entry of roundabout, signs usually direct traffic entering the circle to slow down and give the right of way to drivers already in the circle.

There are a large number of factors that should be considered in the design of the roundabout. In the preliminary study for this project, the following were identified as factors affecting the design and performance of the roundabout. Dimensional/ geometric factors affecting roundabout operations such as number of legs, roundabout diameter (D), entry radius (r), flare length (l'), entry width (e), approach width (v), entry angle (M), number of lanes and separator island and its design. These are mentioned dimensions are illustrated in Figures 1.1 and 1.2.

Traffic flow factors include entering flow (ADT or pcu/hr), circulating flow (ADT or pcu/hr), design speed, and traffic mix. Other factors which would affect the design of the roundabout include location (urban, suburban, or rural), traffic standards, traffic rules and lighting. Combinations of these factors and any other factors affect the performance of a roundabout.

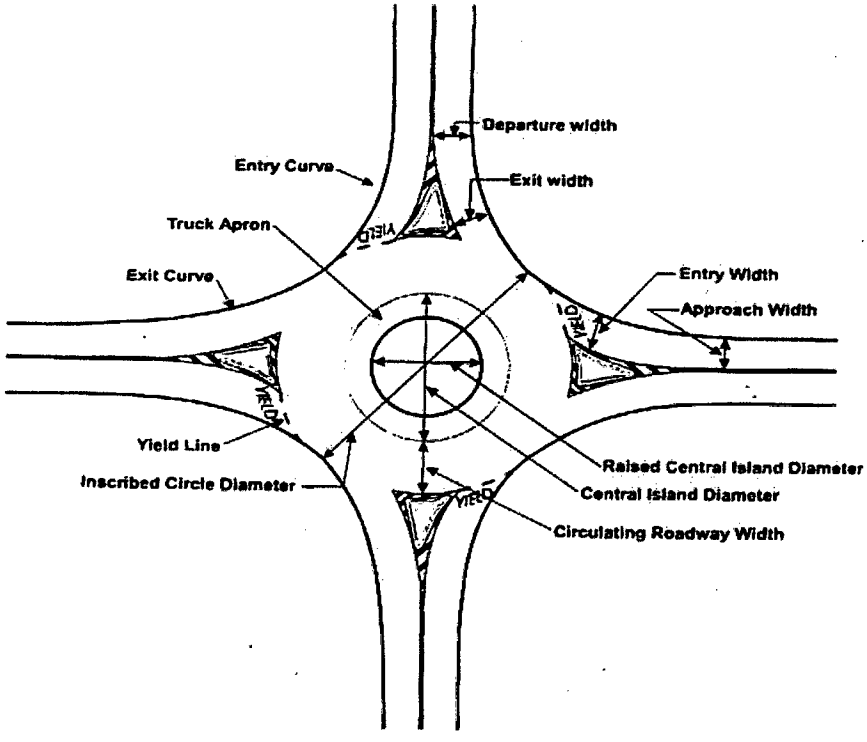

Figure 1.1: Basic Geometric Elements of Roundabout

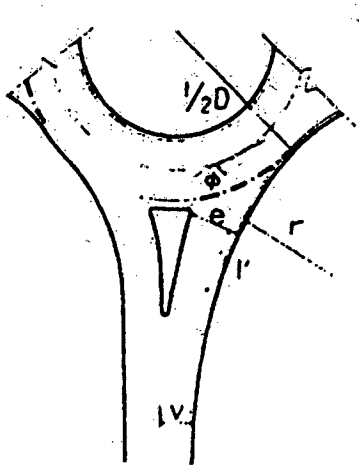

Figure 1.2: Geometric Factors of Roundabout Approach

When the roundabout is constructed with geometric and traffic condition is appropriate, roundabout can provide advantages in term of capacity, delay, queue length, emission, safety and aesthetics. Besides that, roundabout is also has been reported has low maintenance cost when compare to traffic signal since no major work is typically needed.

Since the roundabout is widely use, the performance of roundabout in term of level of service, queue, delay and capacity estimation attract traffic research interest. The performances of roundabout can be in term of level of service (LOS), capacity, delay, queue length and emission level. In this study, the performance of roundabout will be determined using Sidra software.

Sidra Intersection 5.1 is a micro analytical tool that was develops by the Australian Road Research Board (ARRB), Transport Research Ltd. to aid in the design and evaluation of intersection, roundabout, two-way stop control, and yield-sign control intersection. Sidra uses more advanced models and methods, including lane-by-lane analysis, modeling of short lanes, detailed modeling of average and percentile queue lengths, stop rates, and geometric delays. The Sidra software, based on methodology developed in Australia, also uses a gap acceptance approach to model roundabout operations. Key parameters used in the Sidra methodology include:

- Critical Gap, which is essentially identical to the t_c parameter from the Highway Capacity Manual methodology.
- Follow-up Headway, which is essentially identical to the t_f parameter from the HCM methodology.
- Intra-bunch Headway, which relates to platooning in the circulating stream.
- O-D factor, which accounts for differing characteristics of circulating traffic depending on the leg of origin.

The primary focus of this study is to determine the level of performance of roundabout at Taman Tas in term of delay, capacity, queue and level of service.

1.2 Background Study

This study is being done to determine the effectiveness of applying roundabout at four leg intersection at Jalan Tas 4, Kuantan. This road is a local streets with low geometric standard and serves as main streets for Jalan Tas 4 that connect Taman Tas, Shell Oil Station, market and other business premises in that area. This roundabout has been applied at the intersection since November 2010 to reduce the conflict between vehicles at this intersection but the diameter of roundabout is much smaller than the one that stated in Highway Capacity Manual 2000.

1.2.1 Site Location

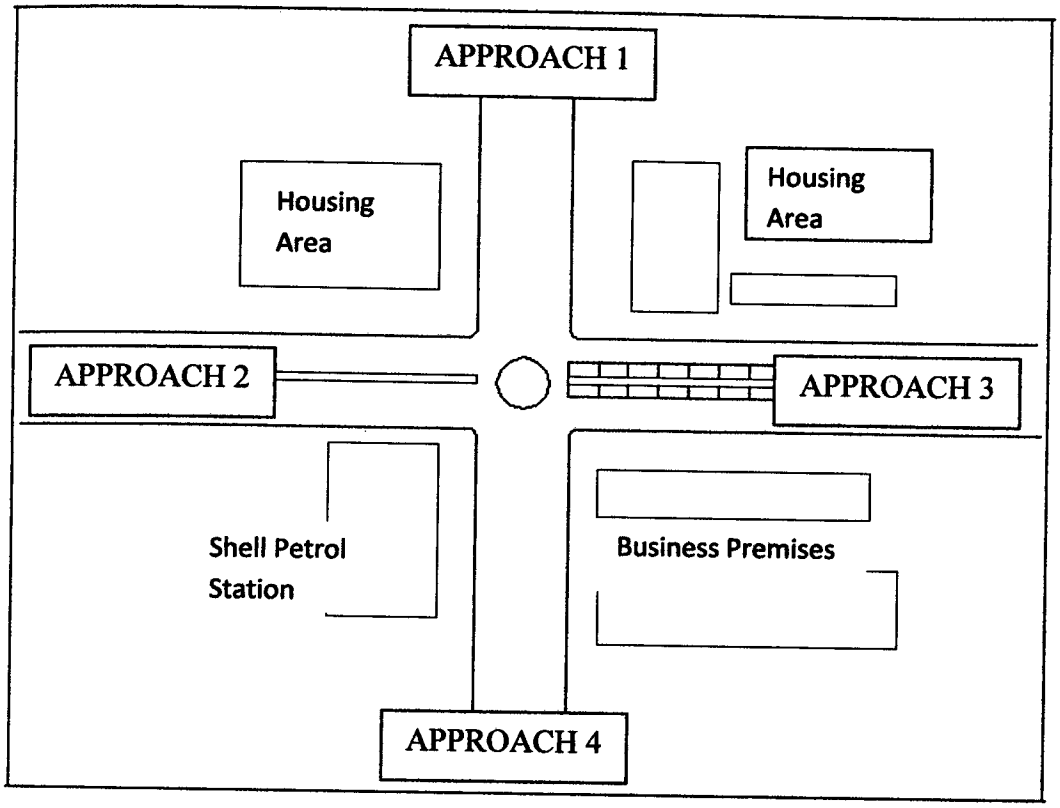

Figure 1.3: Location of Roundabout at Jalan Tas 4, Taman Tas

1.3 Problem Statement

The intersection at Jalan Tas 4 is four leg intersection types. This intersection plays important roles that connecting the Tunas Manja supermarket, residential and business premises. This intersection is usually packed tightly usually during early in the morning, lunchtime, after office hour and also on weekend.

The traffic volume at the roundabout approaches is about 4000 – 5000 vehicles during day from 7 a.m. to 7 p.m. with the highest volume more than 1000 vehicles per hour especially during morning peak hour (7.30 a.m. – 8.30 a.m.) and evening peak hour (5.30 p.m. – 6.30 p.m.).

Majlis Perbandaran Kuantan(MPK) has establish a small roundabout with 6m diameter at this intersection to reduce traffic congestion at this intersection but the effectiveness of the provided roundabout is not known.

1.4 Research Objectives

The objectives of this study are:

1. To analyze the performance of traffic roundabout at Taman Tas based on capacity, delay, queue and level of service using Sidra software.
2. To proposed new geometric design of roundabout based on capacity, queue, delay and level of services.

1.5 Scope of Research

In order to achieve the objectives of the study, the scopes of research were listed down as below:

1. Study the movement of traffic at Taman Tas roundabout; the number of vehicle turn left, right, go through, turning and total number of vehicle.
2. Using Sidra Intersection to calculate capacity, queue, delay and level of services of roundabout.
3. Proposed new central island diameter of roundabout and analyze the capacity, queue, delay and level of services of roundabout

1.6 Significant of the Study

This study is important because the number of vehicles used is increase day by day due to the increasing population at Taman Tas due to vary industrial growth. The effectiveness of this roundabout is issued by people who used the roundabout every day. This is because the diameter of roundabout that is too small. Besides that, the numbers of heavy vehicles use the intersection especially at peak hour increase the delay and queue at the entry section of roundabout approach.

With this study, various parties can see the level of service of roundabout and also consider the best solution for improving the service for the convenience of users.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Roundabout is a common type of intersection design in many countries these days. The number of roundabouts seems to increase steadily in countries and regions where they are already common while they are gaining popularity in regions where they were not applied in the past (Brilon and Vandehey, 1998; Brown, 1995; Pellecuer and St-Jacques, 2008; Rodegerdts et al., 2007; Thai Van and Balmefrezol, 2000; Stijn Daniels,2009).

Originally the road is design as four leg intersection. Four leg intersections is a type of intersection that has four directions usually name as east bound, west bound, north bound and south bound. Besides that, roundabout can also be applied to T-junction and multi leg intersection.

Since development in that area are increasing, the number of road users in the area began to grow. Hence, the Kuantan Municipal Council (MPK) has established a

roundabout at the junction. In this project, the effectiveness of applying roundabout at that intersection will be determined.

2.2 Types of Roundabout

Circular intersection forms have been part of the transportation system in the United States for over a century. Their widespread usage decreased after the mid-1950s, as rotary intersections began experiencing problems with congestion and safety.

Roundabouts have been classified into three basic categories according to size and number of lanes to facilitate discussion of specific performance or design issues: mini-roundabouts, single-lane roundabouts, and multilane roundabouts (Federal Highway Administration).

Based on Federal Highway Administration, mini roundabout, single lane roundabout and multi lane roundabout can be classified into 5 characteristics. The first characteristic is maximum design speed at the entry of roundabout that vehicle can applied. The second characteristic is the maximum number of vehicle entering lanes per approach; this is usually based on the number of lane at each approach. If the number of lane is one, then the number of approach is also one.

The third one is the diameter of circle. Mini roundabout usually has diameter around 13 to 27 m, single lane roundabout around 27 to 55 m, and multi lane roundabout is about 46 to 91 m. the fourth is about the central island of roundabout and the fifth is about the volume of vehicle that roundabout can approximately support. The simplified characteristic is shown in the tale below:

Design Element	**Mini Roundabout**	**Single-Lane Roundabout**	**Multi-Lane Roundabout**
Desirable maximum entry design speed	15 to 20 mph (25 to 30 km/h)	20 to 25 mph (30 to 40 km/h)	25 to 30 mph (40 to 50 km/h)
Maximum number of entering lanes per approach	1	1	2+
Typical inscribed circle diameter	45 to 90 ft (13 to 27 m)	90 to 180 ft (27 to 55 m)	150 to 300 ft (46 to 91 m)
Central island treatment	Fully traversable	Raised (may have traversable apron)	Raised (may have traversable apron)
Typical daily service volumes on 4-leg roundabout below which may be expected to operate without requiring a detailed capacity analysis (veh/day)*	Up to approximately 15,000 veh/day	Up to approximately 25,000 veh/day	Up to approximately 45,000 veh/day for two-lane roundabout
*Operational analysis needed to verify upper limit for specific applications.			

Table 2.1: Type of Roundabout and Its Comparison

The type of roundabout proposed at Jalan Tas 4 is mini roundabout with diameter less than 10 meter. The proposed roundabout has single lane rotary. The road

has one lane for each way from four bound. In this project, each approach will be labeled as approach 1, approach 2, approach 3 and approach 4.

2.2.1 Mini Roundabout

Mini roundabout is a small roundabout with diameter of circle is around 13m to 27m. (Federal Highway Administration). Mini roundabout usually has one lane for each way on each approach. At the project site, number of lane is one with width about 3m per lane. Therefore, only one car and motorcycle can go through entry cycle of roundabout at certain time. Besides that, mini roundabout can also support around 10 000 vehicle per day.

Mini roundabout is said to give more advantages compared to large roundabout such as, it provides traffic safety by lowering speeds of vehicle at the conflict point of intersection. When the intersection in that area are provided the point of conflict or point where there is crash occurring are large. When the roundabout is applied, the point of crash is reduced since vehicles need to enter cycle to go to the other approach. (Wisconsin Department of Transportation).

2.3 Key Features of Roundabout

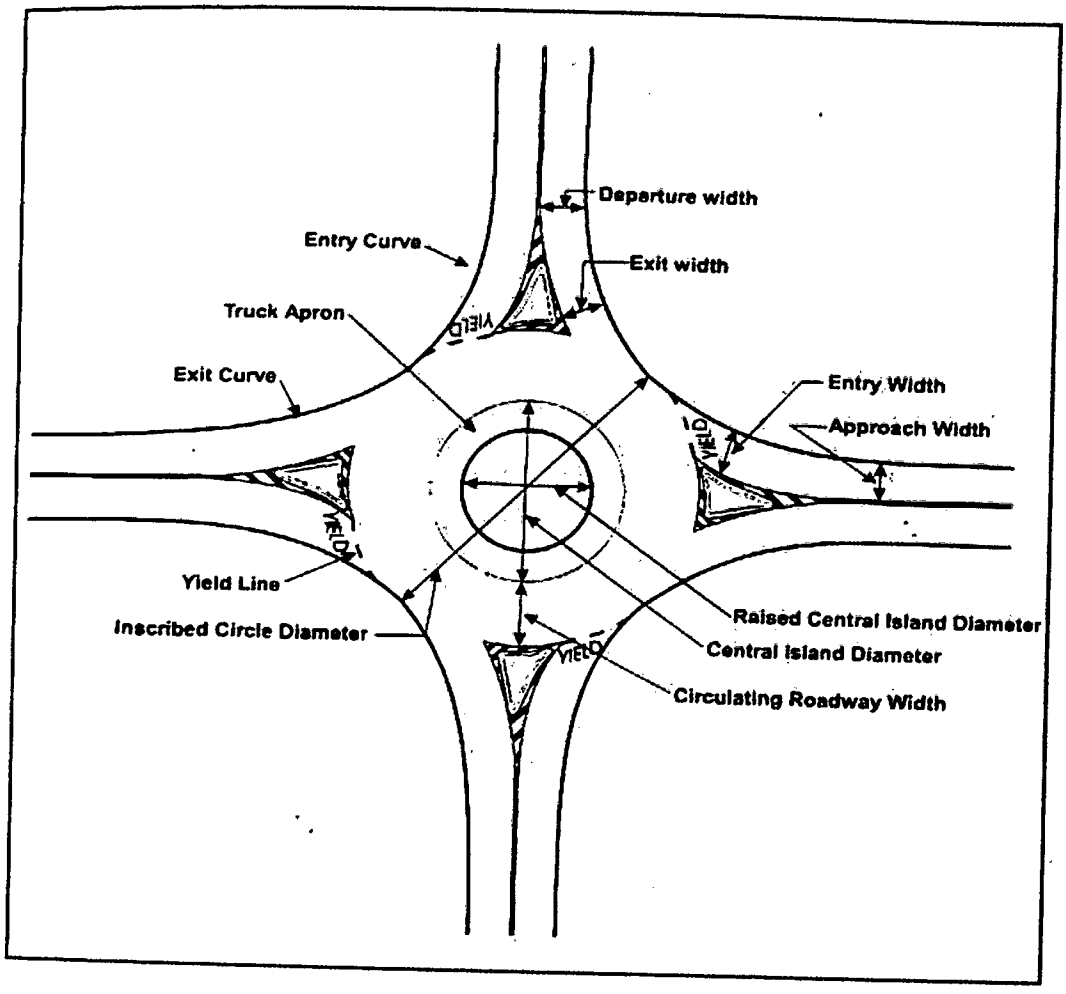

Figure 2.1: Key Feature of Roundabout

Two fundamental elements are the signal control rule for entering vehicles and the deflection of approaches and exits so as to induce lower vehicle speeds. Other characteristics of roundabouts are the clockwise movement of circulating vehicles, no parking permitted on the circulating and entry roadways, and the restriction of pedestrian movement to behind the yield sign on the legs of the roundabout.

2.3.1 Entry Section

Entry is the bottleneck of a roundabout to raise full capacity (GUO Ruijun, LIN Boliang; June 2010). Entry vehicles enter roundabouts using the chance of accepted gap. Gap acceptance is described as ability to accept a certain size given the type of maneuver desired. Therefore, the vehicle user must be alert about the gap whether he will use the gap acceptance or reject the gap.

At the entry of roundabout, the driver physical and mental condition, the perception of risk the user have towards the situation, the characteristics of acceleration and the way the vehicle is handle plays an important role at receiving or rejecting the gap acceptance. The entry capacity is suggested to be an exponential function that depends on the critical gap and the follow-up times. The critical gap is also required to determine the capacity of roundabout. (Cheng Jie, Yang Xinmiao, 2008).

2.3.2 Diameter of Central Island

The diameter of the central island is derived from the diameter of the inscribed circle less the width of the circulating roadway. Typically, central islands consist of a core area not intended to be traversed by motor vehicles and bicycles, bordered by a truck apron of a slightly raised pavement not intended to be used by vehicles smaller than a school bus, but available for the inner rear wheel track of larger motor vehicles.(Highway Capacity Manual,2000).

In this project, there is no island provided but the cone marking has been placed at site location to made central island.

2.3.3 Exit Width

Exit curves join tangentially to the inner and outer diameters of the roundabout in the same manner as the entry curve. The outside exit curve joins smoothly and tangentially to the outside edge of the circulating roadway, while the inside curve, if continued, would join tangentially to the central island.(Highway Capacity Manual,2000). Frequently, exit curves have larger radii than entry curves, to reduce the possibility of congestion at the exit points.

Entry or exit crossings that involve more than one lane of traffic create a situation of increased uncertainty for the pedestrian with visual impairments. The yielded vehicle in the curb lane can make it difficult for the pedestrians to see vehicles approaching in the inside lane, which can be problematic for both sighted and low vision pedestrians. (Robert Wall, 2005).

2.3.4 Approach Width

This approach width refers to the half of the roadway that is approaching the roundabout (Highway Capacity Manual, 2000).

2.3.5 Entry Angle

To provide the optimum deflection for entering vehicles, the angle of entry should be approximately 30 degrees. Smaller angles reduce visibility to the driver's left, while larger angles cause excessive braking on entry and a resulting decrease in capacity(Highway Capacity Manual,2000).

2.4 Types of Roundabout Control

There are usually two types of roundabout control. The first one is yield control and the other one is stop control.

When there is yield sign, all drivers on approach are required to slow down and yield the right of way to all conflicting vehicles in the cycle. Stopping at yield sign is not mandatory, but drivers are required to stop when necessary to avoid interfering with a traffic stream that has the right of way. Yield sign is placed at left side of lane on each approach. The symbol of yield sign is triangular.

A stop sign is used where an approaching vehicle is required to stop before entering the intersection. Most Malaysian intersection and roundabout use stop sign. Stop sign is in hexagon shape with red, blue as the background color and white for the writing. Stop sign usually used at unsignalized intersection where the combination of high speed, restricted view, and serious crashes indicates the necessity for such a control.

In this project, where the actual road type is intersection, the stop signs were placed in each of the four corners of the intersection.