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Traffic Flow Characteristics and Gap Analysis at Unsignalized T-intersection at Jalan Pekeliling-Jalan Perak 1 at Pasir Gudang Federal Route (FT017)

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Abstract: Unsignalized intersections are important in determining the capacity of a road network, particularly in urban and suburban regions. Many issues have arisen at the crossroads, including congestion, queues, delays, and accidents. The gap acceptance approach is used to measure capacity at unsignalized intersections and is utilised for unsignalized intersection procedures. This study was conducted at unsignalized T-intersection of Jalan Pekeliling – Jalan Perak 1 at Pasir Gudang Federal Route (FT017) to analyze and evaluate the performance of unsignalized intersection based on gap study. The first objective of this study is to analyze traffic flow parameters at the study location in terms of speed, density and flow. Second objective is to measure a critical gap. The flow and density were measured in every fifteen minutes interval using CountCam2 during morning, afternoon and evening peak hours on a weekday and a weekend, except for speed data that were calculated numerically using Greenshields' approach. Data of gaps were collected using CountCam2. Raff s method have been used in determination of critical gap. The critical gap for all peak hours were found between 9 seconds to 11 seconds.

Keywords: Unsignalized Intersection, Traffic Flow Analysis, Critical Gap, Raff's Method, Gap Acceptance

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1. Introduction

Traffic flow is often controlled at unsignalized crossings, especially in metropolitan areas. Traffic safety will be negatively impacted by a number of confrontations involving vehicle movement at crossings [1]. Introducing priority restrictions such as a give way or stop rule at an unsignalized crossroads is the most typical method of resolving such disagreements. T-intersections or 4-way junctions are where the regulations are enforced. Road accidents at T intersection are two times more often than at the cross junction [1]. Many issues have arisen at the intersection, including congestion, queues, delays, and accidents. The gap acceptance technique is used to estimate capacity at unsignalized intersections and is used for unsignalized intersection procedures [2]. The crucial gap is an important parameter to consider while evaluating an unsignalized intersection. When problems such as delays and queues emerge at unsignalized intersections, the efficiency of the performance suffers. Due to the difficulties indicated above, it is important to analyses the intersection in order to assess traffic networks and enhance the intersection's performance in order to alleviate the congestion problem at an unsignalized intersection. Using gap analysis, the performance of unsignalized intersections was investigated.

This study is conducted to analyze and evaluate the performance of unsignalized intersection based on gap study. Study location of the intersections is located at Jalan Pekeliling in Pasir Gudang which is a major road and Jalan Perak 1 as a minor road of the intersection. The unsignalized intersection was identified as T-junction where there is an intersection at which a minor roadway meets a major roadway. For a T-junction intersection, the minor roadway is almost always controlled by a stop sign, whereas the vehicles on the major roadway continue driving without having to stop. The vehicle that is planning to turn right or left onto the major roadways must come to a complete stop and look both directions before pulling out onto the 3 major roadway. The identified T-junction is located at industrial area such as CCM Chemicals Sdn. Bhd, Air Products Malaysia Sdn. Bhd and Hydro Metal (M) Sdn. Bhd. Based on the observations, the road is mostly occupied by heavy vehicles since the areas are built for industrial purposes. These frontages activities lead to busy traffic flow. Thus, this study is done to analyze traffic flow parameters at the study location in terms of speed, density and flow, and to determine critical gap at major road (Jalan Pekeliling) during peak hours using Raff's Method.

2. Unsignalized Intersection

Intersections play an important role in roads in Malaysia. The main objective of intersection design is to provide convenience, comfort, and safety to road users [3]. In addition, an intersection is two or more roads meeting and producing points of conflict between vehicles, bicycles, and pedestrians [4]. This shows that the selection of the appropriate type of intersection in a location is very important to ensure that traffic runs smoothly.

Traffic flow theory is a mathematical tool that enables transportation engineers to understand and describe the flow features of traffic. At any one moment, roadways are crowded with millions of cars. These vehicles interact with one another and have an effect on the overall flow of traffic. The fundamentals of traffic flow theory must be well understood before designing traffic controllers [5]. Traffic flow theory is mainly presented from the macroscopic perspective where aggregate traffic variables, such as traffic flow, traffic density, and average traffic speed, are considered. Traffic flow is a difficult phenomenon to describe without the use of a common set of terms.

Unsignalized intersections with two traffic flows give vehicles travelling on the major road priority; however, minor road traffic must wait until the major stream has passed through the intersection first. The critical gap is the smallest amount of major-stream headway that a typical minor-stream vehicle can make. [6]. It is an important factor in determining a minor road's capacity and delay. The crucial gap is used to determine if a vehicle from a minor stream may enter a major stream. To put it differently, the vehicle can enter the intersection when the headway of the major stream is larger than the critical gap, which is known as the accepted gap, but it cannot enter when the headway is less than the critical gap, which is known as the rejected gap. [6].

3. Methodology

The methodology of this study illustrates a brief overview of the overall process and workflow involved in the study.

3.1 Case study location

For this study, the selected intersection (Figure 1a) must accommodate a high traffic volume during peak hours since this study is focusing on the congestion issue at unsignalized intersection. Figure 1b below show the site layout. Based on the observations, the road is mostly occupied by heavy vehicles since the areas are built for industrial purposes. These frontages activities lead to busy traffic flow.

Figure 1a: Case study location

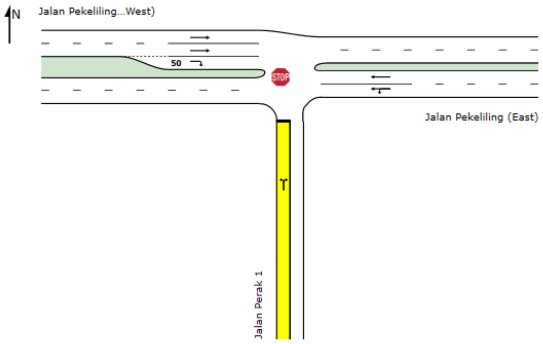

Figure 1b: Site Layout

3.2 Data collection

This process is important because it involves the data collection of field study. The data collection that needs to be obtained are traffic volume data, traffic flow parameters, accepted gaps and rejected gap. Data has been taken using a CountCam2 and the amount of traffic at each intersection and the direction of each traffic movement needs to be recorded correctly during the data collection process. Data observations have been taken for 3 peak hours, 1 hour for each peak time which are in the morning, afternoon and evening. Two days of data which were Tuesday,5th April 2022 (weekday) and Saturday, 9th April 2022 (weekend) were collected. The time in the morning starting from 8-9 a.m. The time in the afternoon starting from 12-1 p.m. and in the afternoon is at 5-6 p.m. The time interval for calculating the total traffic is 15 minutes. After volume data were achieved, flow rate of each direction was determined. Density data were calculated based on the data extracted from the video camera, in which the total vehicles divided by the distance. Speed data then were calculated numerically by using Greenshield's Method.

For the second objective, critical gap was measured by using video camera. Accepted gaps and rejected gaps for Jalan Perak 1 (minor road) merge Jalan Pekeliling (major road) were calculated on weekday and weekend. Then, the critical gaps were determined by using Raff's Method.

4. Results and Discussion

4.1 Traffic Volume

From the field observation consisting traffic volume studies that had been done for 2 days on the weekday and weekend, the data of the vehicle volume at the peak hours in the morning, noon and evening of those days are analyzed to achieve the first objective. Table 1 below shows the total traffic volume on weekday and weekend. It is found that the Weekday evening peak hour and weekend morning peak hour were had the highest traffic volume, thus chosen for further analysis in this paper. Table 2 and Table 3 show the traffic volume on weekday and weekend peak hour data respectively.

Table 1: Total Traffic volume on weekday and weekend

Day	Time	Traffic Volume (veh/hr)
Weekday	Morning peak hour	2358
	Noon peak hour	1452
	Evening peak hour	2595
Weekend	Morning peak hour	1498
	Noon peak hour	1448
	Evening peak hour	1132

Table 2: Traffic volume on weekday evening peak hour

Movement	Traffic Volume (veh/hr)	Percentage of heavy vehicles (%)
Jalan Pekeliling (West) to Jalan Pekeliling (East)	1201	10.07
Jalan Pekeliling (West) to Jalan Perak 1	32	31.25
Jalan Pekeliling (East) to Jalan Pekeliling (West)	790	21.01
Jalan Pekeliling (East) to Jalan Perak 1	452	19.25
Jalan Perak 1 to Jalan Pekeliling (West)	21	19.05
Jalan Perak 1 to Jalan Pekeliling (East)	99	22.22
Total Volume (veh/hr)	2595	

Table 3: Traffic volume on weekend morning peak hour

Movement	Traffic Volume (veh/hr)	Percentage of heavy vehicles (%)
Jalan Pekeliling (West) to Jalan Pekeliling (East)	484	11.36
Jalan Pekeliling (West) to Jalan Perak 1	16	18.75
Jalan Pekeliling (East) to Jalan Pekeliling (West)	638	22.96
Jalan Pekeliling (East) to Jalan Perak 1	270	17.55
Jalan Perak 1 to Jalan Pekeliling (West)	20	15.00
Jalan Perak 1 to Jalan Pekeliling (East)	70	17.14
Total Volume (veh/hr)	1498	

Based on Table 2, the total volume on weekday evening peak hour is 2595 veh/hr which is the highest among the others peak hour on weekday. Based on Table 3, the total volume on weekend morning peak hour is 1498 veh/hr which is the highest among the others peak hour on weekend.

4.2 Traffic Flow Parameters

Table 4 below shows the results of average flow rate, average density and average speed for each approach of the intersection on weekday peak hour while Table 5 shows the results on weekend peak hour.

Table 4: Traffic flow parameters on weekday evening peak hour

Movement	Average Flow Rate (veh/hr)	Average Density (veh/km)	Average Speed (km/hr)
Jalan Pekeliling (West) to Jalan Pekeliling (East)	1201	60	20.02
Jalan Pekeliling (West) to Jalan Perak 1	32	29.5	1.08
Jalan Pekeliling (East) to Jalan Pekeliling (West)	1604	38	42.21
Jalan Pekeliling (East) to Jalan Perak 1	452	75	19.25
Jalan Perak 1 to Jalan Pekeliling (West)	21	50	0.42
Jalan Perak 1 to Jalan Pekeliling (East)	99	53.25	1.86

Table 5: Traffic flow parameters on weekend morning peak hour

Movement	Average Flow Rate (veh/hr)	Average Density (veh/km)	Average Speed (km/hr)
Jalan Pekeliling (West) to Jalan Pekeliling (East)	270	63.25	7.65
Jalan Pekeliling (West) to Jalan Perak 1	16	29.5	0.54
Jalan Pekeliling (East) to Jalan Pekeliling (West)	638	54	11.81
Jalan Pekeliling (East) to Jalan Perak 1	270	81.25	19.25
Jalan Perak 1 to Jalan Pekeliling (West)	20	62.5	0.32
Jalan Perak 1 to Jalan Pekeliling (East)	70	53.5	1.31

4.3 Critical Gap using Raff's Method

Accepted gap and rejected both were calculated via video tape. After both accepted gap and rejected gap were tabulated, then the Critical gap were measured using Raff's Method as shown in Figure 2 and Figure 3 for weekday evening peak hour and weekend morning peak hour respectively.

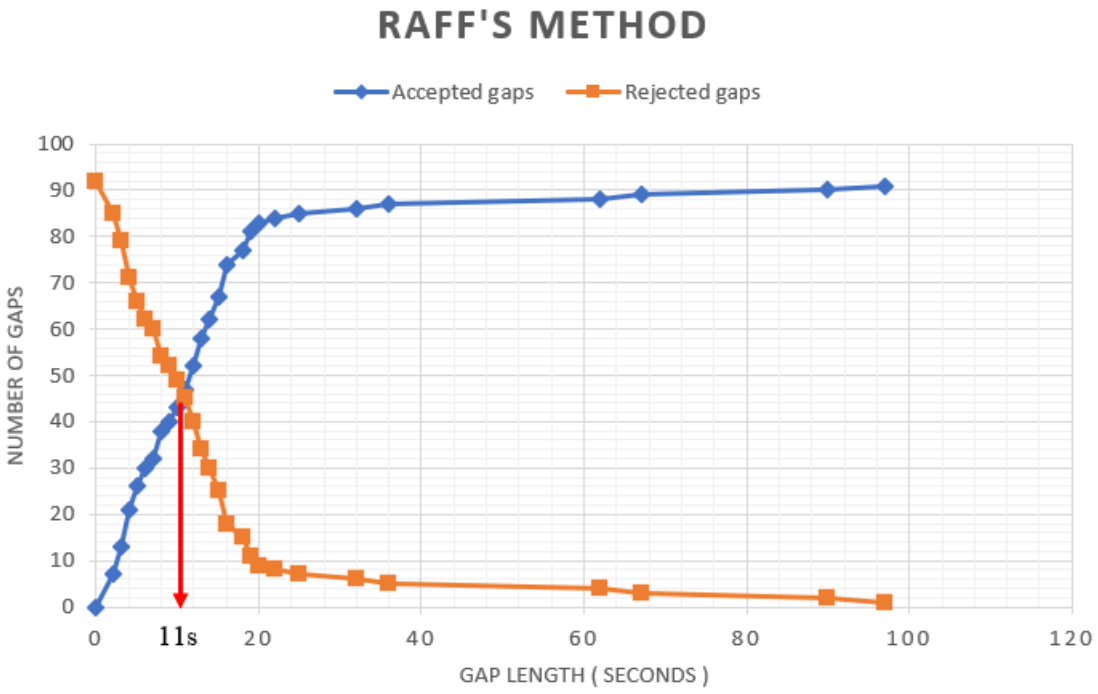

Figure 2: Critical Gaps using Raff's Method on weekday evening peak hour

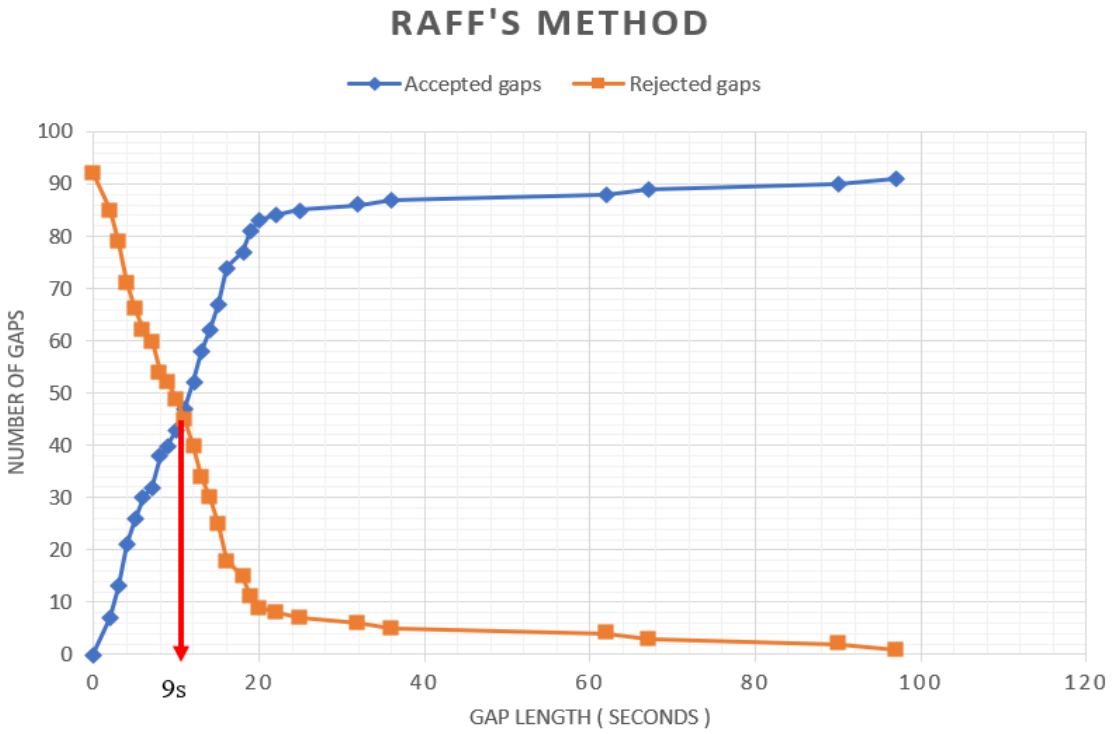

Figure 3: Critical Gaps using Raff's Method on weekend morning peak hour

Based on Figure 2, the critical gap on weekday evening peak hour was 11 seconds which is the highest critical gap compared to the morning and noon peak hour on weekday which were 9 seconds. Based on Figure 3, the critical gap on weekend morning peak hour was 9 seconds while the noon and evening peak hour on weekend were 11 seconds.

5. Conclusion

To conduct this study, traffic volume was collected for 8.00 a.m. to 9.00 a.m. in the morning, 12.00 p.m. to 1.00 p.m. in the noon and 5.00 p.m. to 6.00 p.m. in the evening peak hours during normal working day which was on Tuesday, 5th April 2022 and weekend which was on Saturday, 9th April 2022 using CountCam2 in order to record the whole movement of vehicles. From this study, it was found that the maximum traffic volume was 2595 veh/hr on weekday evening peak hour and 1498 veh/hr on weekend morning peak hour. While the minimum traffic volume was 1452 veh/hr on weekday noon peak hour and 1132 veh/hr on weekend evening peak hour. The highest density was 125 veh/km at Jalan Pekeliling (East) to Jalan Perak 1 during weekday morning peak hour. Thus, the traffic flow was high during this peak hour as many vehicles pass by the intersection The highest speed was 43.37 km/hr at Jalan Pekeliling (East) to Jalan Pekeliling (West) during weekday evening peak hour. This result showed that, during this peak hour, drivers drove with high-speed resulting a free flow at the major road but contributes to congestion and delay at a minor road in which supported with the critical gap analysis. The highest critical gap was 11 seconds which was on weekday morning and noon peak hours, and weekend noon and evening peak hours. This means that the minimum average gap length that will be accepted by drivers is 11 seconds. In other words, drivers from minor road need at least 11 seconds gap to safely merge to major road, thus may create congestion in minor road due to long critical gap duration. Based on these results of this study, it is hoped that traffic engineers and planners from authorised agencies take some actions needed to improve the traffic flow of the unsignalized intersection.

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