Optimization of delay at intersection in anticipate stuck on the traffic by using software SIDRA intersection 8.0 (Case study : BPKP's intersection at Banda Aceh)

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Submitted : 25 May 2023
Revised : 05 August 2023
Accepted : 03 September 2023

Abstract

BPKP's Intersection at Banda Aceh is one of the signalized intersections with four approaches. So there are 16 crossings, 8 diverging, and 8 merging, between vehicles such as delay and congestion. The research uses the program SIDRA Intersection 8.0 to analyze the intersection in its current state and to remodel it. Software The user can select a preset minimum capacity for each little movement in SIDRA Intersection 8.0 (analytical model). The information was gathered from the institute utilizing a video taken using CCTV in the research area. The data from a video included vehicle volume, distances (upstream, downstream, and negotiation) and travel time. In existing condition. The total demand flow is 1060 pcu/h. Approach delay 96.8 sec and level of service is F. The redesign geometry is changed to the roundabout which is assumed as multiple unsignalized junction. The total demand flow in redesign condition at BPKP's Intersection at Banda Aceh is 1060 pcu/h. Approach delay 3.8 sec and level of service is A.

Keywords

BPKP's intersection at Banda Aceh, software SIDRA intersection 8.0, signalized intersection, roundabout, unsignalized intersection, and delay

INTRODUCTION

Any contemporary economic system would be incomplete without transportation, which also significantly affects economic growth. The expansion of the economy has had an impact on the transportation industry. In a city's road network, intersections typically act as bottlenecks for traffic [1]. Urban intersections are marked by two or more opposing traffic streams that are willing to pass through the region [2]. The inability to effectively manage traffic crossings is mostly caused by conflict [3].

The amount of vehicle growth that is not followed by the growth of the road network is due to the large traffic jams that occur regularly and continue to increase [4]. The time difference between cars not affected by the controlled intersection and those that are is known as the vehicle delay at a signalized junction [5]. Since it is directly related to the amount of time lost by a vehicle when crossing a junction, vehicle delay is the most crucial factor to consider when evaluating the level of service at signalized intersections [6]. The significance of vehicle delay in the optimization and assessment methods for this parameter [7].

Construction of Banda Aceh City's transportation system, with a focus on the districts of Jaya Baru, Lueng Bata, and Kuta Alam. The sub-districts and rural roads make up the smallest percentages of the 552,789 km of total city roadways, at 8% and 9%, respectively and 9% of the 56.65 km of village roads, respectively. Kuta Alam has the majority of the city's longest streets. In the Meuraxa sub-districts, there are 17% and 14% country roads, 16% urban roads and 14% village roads, 13.55% urban roads and 1.62% village roads in Syiah Kuala, and 14% urban roads and 1.09% village roads in Ulee Kareng [8]. As a result to the absence of integration between existing sub-districts and activity infrastructures, some sub-districts, such as Ulee Kareng, where the level of service (LOS) E-F (V/C ratio = 0.98) indicated that the current was unstable and had stopped, and Banda Raya, Jaya Baru, Baiturrahman, and Lueng Bata, where the LOS D (V/C ratio = 0,8-0.9) indicated, experienced poor road network performance and traffic jam [9].

BPKP's Intersection at Banda Aceh is one of the signalized intersections with four approaches. This intersection is crowded by local people indicated by delay 402,6 sec/veh [10]. BPKP's Intersection at Banda Aceh has four-legged, so there are 16 crossings, 8 diverging, and 8 merges, between vehicles such as delay and congestion [11].

The research uses the program SIDRA Intersection 8.0 to analyze the intersection in its current state and to remodel it. To simulate junctions, including regular intersections and roundabouts, SIDRA is specifically employed. West Wenhua Road and Changchun Road were chosen as examples to compare and contrast SIDRA. It offers suggestions for picking out traffic simulation software [12]. For this reason, in addition to the FHWA technique, the SIDRA method, which is the most popular roundabout analyzer in the U.S. and is applied by many state agencies, was employed to assess the suitable design, performance characteristics, and overall delay of roundabouts [13].

ISSN 2086 - 1206 E-ISSN 2579 - 9029

The SIDRA software package enables users to enter a thorough description of junction design, including data for individual lanes (lane disciplines, short lane lengths, shared and exclusive lanes, slip lanes, continuous lanes, lane width, lane utilisation ratio, number of buses stopping, etc.). The standard gap acceptance and queuing theory approaches are extended by the SIDRA method for roundabout capacity and performance analysis [14]. Considerations for deciding between a roundabout and a signalized intersection include traffic volume, space requirements, road environment, site topography, the presence of pedestrians, safety, operation, and economics [15].

RESEARCH SIGNIFICANCE

This study seeks to analyze the intersection in its current and improved condition following work at the BPKP's Intersection in Banda Aceh using the program SIDRA Intersection 8.0. It hoped to resolve the fundamental issue at the intersection.

METHODOLOGY

The SIDRA Intersection's (analytical model) user specifies the preset minimum capacity for each little movement. As a result, there is little capacity loss or significant movement delay. Gap acceptance is used in capacity and delay models, however, its parameters could be affected by traffic. [16].

A. COLLECTION OF TECHNIQUE DATA

Information has been collected by the institution [18] from a video using CCTV in the research area. The data from a video included vehicle volume, distances (upstream, downstream, and negotiation), and travel time. The origin to destination during a peak hour after 3x24 hours (3 days) is the basis for volume data [19] fifteen minutes apart. Based on the data MC (motorcycle), LV (light vehicle), and HV (heavy vehicle). The vehicle type and direction are used to categorize this data, starting from P. Nyak Makam's Street (PNM), Teuku Iskandar Beurawe's street (TIB), Prof. Ali Hasyimi's street (PAH), and Teuku Iskandar Tujuh's street (TIT). The data has been transformed using that comparable value from vehicle units per hour to passenger car units per hour. A motorbike is equal to a big vehicle at 0.3 and at 2. Based on the final calculation, it is also possible to show the proportion of heavy vehicle. The distance under the current circumstances and the time on the CCTV tape may be used to compute the vehicle's speed. Using a comparison of the two data, speed was determined. The study's calculation of speed takes into account each approach's negotiation, upstream, and downstream speeds. Upstream distance is the middle-block distance on an intersection leg between two junctions in the approach travel direction, the downstream distance is the distance traveled from the approach stop line to a point on the exit road according to the destination of each origin destination movement, and negotiation distance is the distance for each movement of each origin to destination movement through the intersection [16]. A length meter is used to measure distance. Based on negotiating distance, downstream distance, and upstream distance, travel time projections for one-way roads are produced in this case study. The initial trip time (t_1) and the end travel time (t_2) are calculated using videos that were recorded using CCTV taken on each leg.

B. TECHNIQUE ANALYSIS

Geometry data BPKP's Intersection at Banda Aceh is utilized to identify the geometry intersection's state depending on the movement of each leg from origin to destination. Geometry data are collected for the approach (leg name and median width) and lane arrangement (lane discipline, lane type, short lane, and lane length). There are two different forms of movement data for each lane on each leg of the road: exclusive lanes and shared lanes. Exclusive lanes are L (left), T (through), and R (right); shared lanes are LT (left through), TR (through right), LR (left right), and LTR (left through). In order to meet the needs of movement data input in Software SIDRA Intersection 8.0 plus, additional components such as a data queue space, vehicle length, and arrival type are required.

RESULTS AND DISCUSSIONS

Composition and traffic volume were helpful factors in measuring lane performance [17]. Performance obtained from intersection analysis using software SIDRA Intersection 8.0. By knowing the level of service (LOS) and delay (D) at the junction, this program calculates the intersection performance. Knowing the number of cars is the first step in evaluating the performance of a junction. The volume that has to be input is the volume that is distributed based on how each leg moves. Only the volume of light vehicles (LV) and heavy vehicles (HV) may be

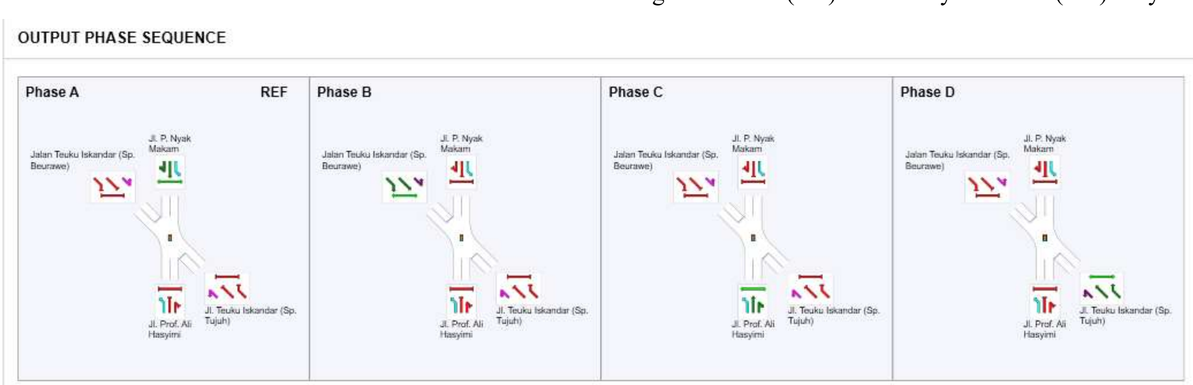

Figure 1 Output phase sequence

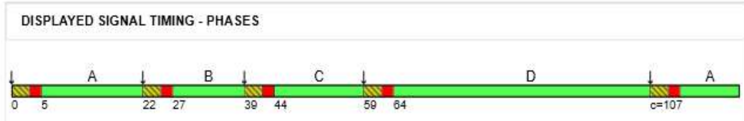

Figure 2 Displayed signal timing (Phases)

evaluated due to SIDRA's limitations on the types of vehicles that can be input as traffic volume data. The volume of motorcyclists must thus be multiplied by the comparable number of passenger automobiles at signalized junctions, which is 0.2 for protected conditions and 0.4 for opposed situations.

The intersection's geometry is currently set up as a four-legged with P. Nyak Makam's Street (PNM) and Prof. Ali Hasyimi's Street (PAH) as the main highway, Teuku Iskandar Beurawe's Street (TIB) and Teuku Iskandar Tujuh's street (TIT) is a side road. These crossroads have two types of traffic lanes: shared lanes (LT and TR) and exclusive lanes (L, T, and R).

Volume vehicle obtained from secondary data [18]. On Monday, between 16:30 and 16:45 WIB, traffic was at its busiest. This volume is formed at the junction and used as a statistic to evaluate its efficacy based on the parameters of the number of automobiles. BPKP's Intersection at Banda Aceh has four-legged which is a primary collector path of each leg [20]. To reflect the existing traffic volume, vehicle growth is rising by 4,83% annually [21]. Space Mean Speed is speed related to the average travel time over a certain distance or the average speed of vehicles in road segments for a certain period. After determining distance and trip time, speed data is acquired. Figure 1 shows the output phase sequence in the existing condition. Phase A displays green time only at PNM's leg while the other legs display red time except left turn on each leg. Phase B displays green time only at TIB's leg while the other legs display red time except left turn on each leg. Phase C displays green time only at PAH's leg while the other legs display red time except for left turn each leg. Phase D means display green time only at TIT's leg while the other legs display red time except left turn on each leg.

Table 1 Phase and cycle time at BPKP's Intersection at Banda Aceh in the existing condition

Phase	SIDRA			
	Green Time (sec)	Yellow Time (sec)	All Red (sec)	Phase Time (sec)
PNM	17	3	2	22
TIT	43	3	2	48
PAH	15	3	2	20
TIB	12	3	2	17
Cycle Time				107

Figure 2 shows a phases time in existing condition. It displayed signal timing at BPKP's Intersection at Banda Aceh with yellow time and all red is 3 sec and 2 sec for each leg. PNM (A) has 22 seconds phase timing, TIT (B) has 48 sec phase timing, PAH (C) has 20 sec phase timing, and TIB (D) has 17 sec phase timing. More detail can be seen in table 1.

Table 2 Performance measure at PNM's leg in existing condition

PNM	Total Demand Flows (pcu/h)	Performance (Existing)		
		Capacity (pcu/h)	Delay (sec)	Level Of Service
Lane 1 = 3,3 m (Normal)	75	1795	8,5	A
Lane 2 = 3,3 m (Normal)	104	136	69,5	E
Lane 2 = 3,3 m (Normal)	131	157	79,3	E
Approach	310		58,9	E

Based on table 2, performance was measured by using the software SIDRA Intersection 8.0. The total demand flow at PNM's leg is 310 pcu/h. Approach delay is 58,9 sec and level of service at that approach is E. Table 3 shows the performance measure at TIT's leg. The total demand at TIT's leg is 292 pcu/h. Approach delay 230,9 sec and the level of service is F.

Table 3 Performance Measure at TIT's Leg in existing condition

TIT	Total Demand Flows (pcu/h)	Performance (Existing)		
		Capacity (pcu/h)	Delay (sec)	Level Of Service
Lane 1 = 2,5 m (*High Angle*)	175	125	226,0	F
Lane 2 = 4 m (Normal)	117	83	238,3	F
Approach	292		230,9	F

Table 4 shows performance measures by using the software SIDRA Intersection 8.0 at PAH's. The total demand flow at this leg is 239 pcu/h. Approach delay is 24,9 sec and the level of service is C. Table 5 shows performance measure at TIT's leg. The total demand flow is 220 pcu/h. Approach delay is 49,5 sec and the level of service is D. For more details, see figure 3 which shows the lane level of service BPKP's Intersection at Banda Aceh.

Table 4 Performance measure at PAH's leg in existing condition

PAH	Total Demand Flows (pcu/h)	Performance (Existing)		
		Capacity (pcu/h)	Delay (sec)	Level Of Service
Lane 1 = 3,5 m (Normal)	153	1795	5,2	A
Lane 2 = 3 m (Normal)	12	136	56,5	E
Lane 3 = 4,2 m (Normal)	74	157	60,7	E
Approach	239		24,9	C

Table 5 Performance measure at TIB's Leg in existing condition

TIB	Total *Demand Flows* (pcu/h)	Performance (Existing)		
		Capacity (pcu/h)	Delay (sec)	Level Of Service
Lane 1 = 3,2 m (*High Angle*)	103	173	36,6	D
Lane 2 = 3,2 m (Normal)	117	153	60,9	E
Approach	220		49,5	D

Table 6 Performance measure BPKP's Intersection at Banda Aceh in existing condition

BPKP's Intersection at Banda Aceh	
Performance	Existing
Demand Flows (Total)	1060 pcu/h
Intersection Capacity	754 pcu/h
Delay	96,8 sec
Intersection Level of Service	LOS F

Table 7 BPKP's Intersection data at Banda Aceh in redesign condition

Approach	Roundabout Diameter (m)	Roundabout Width (m)	Approach Radius (m)	Number of Lane on Roundabout	Number of Lane on Approach
PNM	40	6	30	2	3
TIT	40	6	30	2	2
PAH	40	6	30	2	3
TIB	40	6	30	2	2

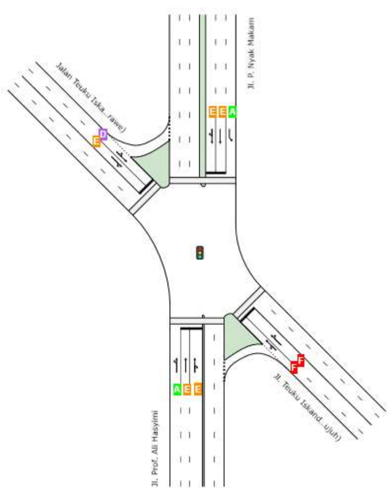

Figure 3 Level of service each lane BPKP's Intersection at Banda Aceh

Table 6 shows performance measure at BPKP's Intersection at Banda Aceh in existing condition. Total demand flow is 1060 pcu/h. Approach delay 96,8 sec and level of service is F. Level of service for primary colector path minimum should B [19], so this intersection must be redesigned to have a level of service better.

The redesign geometry is changed to the roundabout which is assumed as multiple unsignalized junctions. Roundabouts of all sizes and shapes, including double roundabouts, grade-separated roundabouts, compact roundabouts, and small roundabouts, can be classified under this category. Roundabout Informational Guide FHWA 2000 states that every roundabout has a set of essential measurements. The center island, splitter island, circulation lane, yield line, inscribed circle diameter (ICD), and apron are the needed geometric components of any roundabout. Additionally, a number of sizes, including the circulation route width, approach width, departure width, entry width, and exit width, should be determined for the roundabout design [22].

Table 7 shows roundabout data for redesign condition BPKP's Intersection at Banda Aceh. Standard roundabout performance measurements, including turning movements, approach capacity, average queue length, and delay, may be calculated using data collected [23]. Table 8 shows performance measures by using the software SIDRA Intersection 8.0 at PNM's in redesign condition. The total demand flow at this leg is 310 pcu/h. Approach delay is 3.8 sec and the level on service is A. Lane 3 is the dominant lane at the roundabout approach.

Table 8 Performance measure at PNM's Leg in redesign condition

PNM	Total Demand Flows (pcu/h)	Performance (Redesign)		
		Capacity (pcu/h)	Delay (Sec)	Level Of Service
Lane 1 = 3,3 m (Normal)	75	1054	4,0	A
Lane 2 = 3,3 m (Normal)	104	1134	4,0	A
Lane 3 = 3,3 m (Normal)	131	1332	3,5	A
Approach	310		3,8	A

Table 9 Performance measure at TIT's Leg in redesign condition

TIT	Total Demand Flows (pcu/h)	Performance (Redesign)		
		Capacity (pcu/h)	Delay (Sec)	Level Of Service
Lane 1 = 2,5 m (High Angle)	150	1029	4,8	A
Lane 2 = 4 m (Normal)	143	983	5,0	A
Approach	293		4,9	A

Table 9 shows performance measure at TIT's leg. Total demand flow is 293 pcu/h. Approach delay 4,9 sec and level of service is A. For more details can be seen figure 3 that shows lane level of service BPKP's Intersection at Banda Aceh. Lane 2 is the dominant lane at roundabout approach.

Table 10 Performance measure at PAH's Leg in redesign condition

PAH	Total Demand Flows (pcu/h)	Performance (Redesign)		
		Capacity (pcu/h)	Delay (Sec)	Level Of Service
Lane 1 = 3,5 m (Normal)	105	1822	0,0	A
Lane 2 = 3 m (Normal)	59	1034	4,0	A
Lane 3 = 4,2 m (Normal)	74	1060	4,0	A
Approach	238		2,2	A

Table 11 Performance Measure at PAH's Leg in redesign condition

TIB	Total Demand Flows (pcu/h)	Performance (Redesign)		
		Capacity (pcu/h)	Delay (Sec)	Level Of Service
Lane 1 = 3,2 m (High Angle)	103	1146	3,9	A
Lane 2 = 3,2 m (Normal)	117	1108	4,2	A
Approach	220		4	A

Based on table 10, performance was measured by using the software SIDRA Intersection 8.0 in redesign condition. The total demand flow at PAH's leg is 238 pcu/h. Approach delay is 2.2 sec and the level of service at that approach is A. Lane 1 is the dominant lane at the roundabout approach. Table 11 shows performance measures at TIB's leg. The total demand at TIB's leg is 220 pcu/h. The approach delay is 4 sec and the level of service is A. Lane 2 is the dominant lane at the roundabout approach. For more details, see figure 4 which shows the lane level of service at BPKP's Intersection at Banda Aceh.

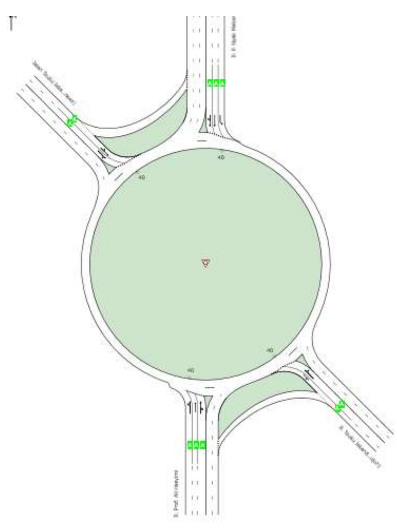

Figure 4 Movement roundabout in unsignalized intersection BPKP's Intersection at Banda Aceh

Table 12 shows performance measures at BPKP's Intersection at Banda Aceh in redesign condition. The total demand flow is 1060 pcu/h. Approach delay 3,8 sec and level of service is A. Level of service for primary collector path minimum should be B [19], so BPKP's Intersection at Banda Aceh in redesign geometry is changed to roundabout which is assumed as multiple unsignalized junction has a level of service better than existing condition.

Table 12 Performance measure BPKP's Intersection at Banda Aceh in redesign condition

BPKP's Intersection at Banda Aceh Performance	Redesign
Demand Flows (Total)	1060 pcu/h
Intersection Capacity	7289 pcu/h
Delay	3,8 sec
Intersection Level of Service	LOS A

CONCLUSIONS

1. Total demand flow BPKP's Intersection at Banda Aceh in the existing condition is 1060 pcu/h with approach delay 96,8 sec and level of service is F.
2. The redesign geometry is changed to the roundabout which is assumed as multiple unsignalized junctions.
3. Total demand flow BPKP's Intersection at Banda Aceh in redesign condition is 1060 pcu/h. Approach delay 3,8 sec and level of service is A.

ACKNOWLEDGMENTS

The authors would like to express their gratitude to Dinas Perhubungan Banda Aceh [18] for getting access them to use the data that had been collected utilizing CCTV in the research region.

REFERENCES

[1] R. Malia, N. Fadhly and S. Sugiarto, "Traffic management of intersection with more than four road segments," 4th Annual Applied Science and Engineering Conference (AASEC 2019), Journal of Physics: Conference Series vol. 1402, 2019, p. 022021.

[2] E. R. Muller, R. C. Carlson and W. K. Junior, "Intersection control for automated vehicles with MILP," IFAC-PapersOnline, vol. 49-3, pp. 37-42, 2016.

[3] X. Chen, X. Lin, M. Li, F. He and Q. Meng, "A nearly throughput-maximum knotted intersection design and control for connected and automated vehicles," Transportation Research Part B: Methodological, vol. 171, pp 44-79, 2023.

[4] Y. Fauzi and H. Widyastuti, "Analisa perubahan kinerja di Jalan Gajah Mada Medan akibat adanya jalan layang," Journal of Civil Engineering, vol 32, pp. 47-52, 2017.

[5] C. Cheng, Y. Du, L. Sun and Y. Ji, "Review on theoretical delay estimation model for signalized intersections," Transport Reviews, pp. 479-499, 2015.

[6] P. P, A. Varghese and A. R, "Modelling delay at signalized intersections under heterogeneous traffic

conditions," Transportation Research Procedia, vol. 17, pp. 529-538, 2016.

[7] F. Dion, H. Rakha and Y. S. Kang, "Comparison of delay estimates at under-saturated and over-saturated pre-timed signalized intersection," Transportation Research Part B, vol. 38, pp. 99-122, 2004.

[8] N. Fadhly, R. Matondang, Sirojuzilam and S. M. Saleh, "Regression analysis of transportation infrastructure development using transit oriented development concept," Revista De Ciencias y Sociales, pp. 1575-1607, 2018.

[9] N. Fadhly and R. Matondang, "Implementation of transit oriented development in handling congestion effect on urban sprawl phenomenon and traffic growth in Banda Aceh," in 4th Annual Applied Science and Engineering Conference (AASEC 2018), Journal of Physics: Conference Series, vol. 434, 2018, p. 012200.

[10] S. M. Saleh, N. Fadhly and R. Faisal, "Analysis signalized intersection and four road segments (case study Simpang BPKP, Banda Aceh)," Jurnal Teknik Sipil, vol. 1, no. 3, 2012.

[11] D. J. B. Marga, Manual kapasitas jalan Indonesia (MKJI) (Jakarta: Direktorat Bina Jalan Kota (BINKOT)). 1997 (Draft)

[12] C. Tianzi, J. Shaochen and Y. Hongxu, "Comparative study of VISSIM and SIDRA on signalized intersection," 3th COTA International Conference of Transportation Professionals (CICTP 2013) Procedia – Social and Behavioral Sciences, vol. 96, 2013, 2004 – 2010.

[13] X. Yang and M. J. Magalotti, "A service life analysis of roundabout retrofits for signalized intersection," Procedia Engineering, vol. 145, pp. 452-459, 2016.

[14] R. Akcelik, "Lane-by-lane modelling of unequal lane use and flares at roundabouts and signalised intersection: the SIDRA solution," Traffic Engineering + Control, vol. 38 (7/8), pp 388-399. 1997.

[15] M. O. P. Works, Design manual for roads and bridges edition 2 part 1 and 15. Kuwait. 2012.

[16] R. Akcelik, SIDRA Intersection 8.0 User Guide, (Melbourne: Akcelik & Associates PTY LTD), 2016.

[17] P. J. Romadhona and T. N. Ikhsan, "The effect of on-street parking on u-turn area towards urban road performance (study case: Affandi Street, Yogyakarta)," Journal of Civil Engineering, Vol. 36, pp. 14-22, 2021.

[18] D. Perhubungan, Volume lalu lintas, Jakarta, 2022 (Draft).

[19] P. M. P. R. Indonesia, pedoman pelaksanaan kegiatan manajemen dan rekayasa lalu lintas (nomor PM 96 tahun 2015) (Jakarta: Menteri Perhubungan republik Indonesia). 2015 (Draft).

[20] C. Mutiawati and H. Suprayitno, "Tinjauan awal struktur jaringan jalan di Kota Banda Aceh," Jurnal Manajemen Aset Infrastruktur & Fasilitas, ISSN: 2615-1847, pp. 39-52, 2018.

[21] K. P. U. D. P. Rakyat, Manual desain perkerasan jalan (nomor 02/M/BM/2017) (Jakarta: Direktorat Jenderal Bina Marga). 2017 (Draft)

[22] S. Alkheder, F. Al-rukaibi and A. Al-faresi, "Driver behavior at Kuwait roundabouts and irs performance evaluation," IATSS Research vol. 44, pp. 272-284, 2020.

[23] X. Chen and M. S. Lee, "A case study on multi-lane roundabouts under congestion: Comparing software capacity and delay estimates with field data," Journal of Traffic and Transportation Engineering, vol. 3, no. 2, pp. 154-165, 2016.