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Performance Analysis of 3 Arms Without Signal Access (Case Study Jl. Raya Bogor-Sukabumi, Jl. Siliwangi-Cibolang, Jl. Perintis Kemerdekan)

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ABSTRACT

One of the types of intersections is the type of unsignalized intersection, the unsignalized intersection which is on Jl. Raya Bogor-Sukabumi, Jl. Siliwangi- cibolang, Jl. Independence pioneer. is the intersection of three arms. This study aims to determine the value of cur/hour and the performance of unsignalized intersections

at the intersection. This research method is a field survey, which is carried out by researching directly in the field to obtain the required data. calculation of unsignalized intersection performance data using the 1997 Indonesian Highway Capacity manual method. Results

the analysis obtained, the value of capacity from seven days of observation obtained a value of....cur/hour, the value of the degree of saturation DJ=....., too high occurred on the day... at WIB and the value of the delay is

obtained by.... sec/cur. The queue probability value ranges from....% -....%

KEYWORDS
Unsignal Intersection
Degrees of Saturation
Delays and Chance of Queues

1. Introduction

1.1 Background

The increasing number of people every year will result in an increase in the need for transportation facilities and infrastructure [1] [2]. The increasing population is getting taller to carry out dense and diverse activities so that it will cause increasingly dense traffic which is often found in various places at certain times[3]. In urban and rural areas, land transportation is a problem that must be solved and the most influential when compared to other transportation, because it has a very high number of conditions [4] [5]. This indicates trying to fulfill the transportation facilities and infrastructure that meet.

An intersection is something of a road segment where currents from different directions meet each other [6] [7] [8]. As a result, the intersection often causes problems between currents from opposite directions that intersect each other, resulting in traffic congestion along the intersection arm road [9] [10]. To overcome this problem, it is necessary to study or estimate the effect on the capacity of the intersection. The research and assessment is certainly used to obtain an accurate work ability regarding the intersection. If the performance of the intersection does not meet the provisions in the Indonesian Road Capacity Manual (MKJI 1997), it is necessary to have a service improvement process, so that it is hoped that the service improvement can provide comfort and safety for road users [11].

The intersection of Jl. Raya Bogor – Sukabumi, Jl. Siliwangi – Cibolang, Jl. Perintis Kemerdekaan, is a national road with roads leading to various centers of the City Government or Sukabumi Regency so that on holidays at certain hours the traffic flow is quite busy. Based on these circumstances, the intersection of Jl. Raya Bogor - Sukabumi, Jl. Siliwangi - Cibolang, Jl. Perintis Kemerdekaan needs to get sufficient attention so that the traffic flow can be served properly and of

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International Journal of Engineering and Applied Technology (IJEAT)
Vol. 4., No. 1, Mei 2021, pp. 40-51

course minimizes the occurrence of delays and conflicts in vehicles passing at the intersection so that users do not feel the loss of time and travel costs.

A. Intersection Capacity

The capacity of the intersection is calculated for the total current that enters from all the intersections and is defined as the product of the basic capacity (C0) which is the capacity under ideal conditions, with correction factors that take into account differences in environmental conditions against ideal conditions [12] [13]. The equation is:

$$C = C_O \times F_{LP} \times F_M \times F_{UK} \times F_{HS} \times FB_{Ki} \times FB_{Ka} \times FR_{mi} \quad (1)$$

Where:

C: capacity of the intersection, cur/hour

CO: base capacity of the intersection, cur/hour

FLP: approximation average width correction factor

FM: median type correction factor

FUK: city size correction factor

FHS: side resistance correction factor

FBKi: left-turn current correction factor

FBKa: right turn current correction factor

It is causing side barriers and the lack of effective width of the road so that it will result in congestion which affects the performance of the intersection, at certain hours the flow of vehicles is quite high, causing queues at the intersection. Based on these problems, the authors are interested in conducting research to analyze the performance of the intersections in the Majene Market and provide alternative solutions to the problems encountered so that road users can feel smooth and comfortable.

B. Number of Lanes

The number of lanes used for calculation purposes is determined from the average width of the minor road approach and the main road that it is shown on Table 1. [14] [15].

Table 1. Number of Lanes

Average Width of Minor and Major Approximations W_{AC}, W_{BD}	Average Width of the Approach	Number of Lanes (Total for Both Directions)
$W_{BD} = (b + \frac{d}{2})/2$	< 5,5	2
	≥ 5,5	2
$W_{AC} = (a + \frac{c}{2})/2$	< 5,5	2
	≥ 5,5	2

Source: MKJI, 1997

C. Intersection Type

The type of intersection determines the number of intersection arms and the number of lanes on the main road and minor road at the intersection with a three-digit code where it can see on Table 2 [16].

Table 2. Intersection Type

IT Code	Number of Intersection Arm	Number of Minor Roads	Number of Mayor Roads
322	3	2	2
324	3	2	4
342	3	4	2
422	4	2	2
424	4	2	4

Source: MKJI, 1997

D. Study of Unsignalized Intersection

Intersection performance is a condition at the intersection to determine the level of achievement of the intersection. Parameters used:

F_{Rmi}: current ratio correction factor of minor road

D1. Intersection Base Capacity (Co)

For intersection base capacity, the table 3 provide the information of intersection base capacity.

Table 3. Intersection Base Capacity

IT Code	Base Capacity
322	2700
342	2900
324 or 344	3200
422	2900
424 or 444	3400

Source: MKJI, 1997

D2. Approximate width adjustment factor (Fw)

The approximation width adjustment factor (Fw) is obtained based on equation. The input variable is the average width of all approaches W1 and the type of intersection (IT).

IT 422

$$Fw = 0{,}70 + 0{,}0866 \times \text{W1} \quad (2)$$

IT 424 or 444

$$Fw = 0{,}61 + 0{,}0740 \times \text{W1} \quad (3)$$

IT 322

$$Fw = 0{,}73 + 0{,}0760 \times \text{W1} \quad (4)$$

IT 324 or 344

$$Fw = 0{,}62 + 0{,}0646 \times \text{W1} \quad (5)$$

International Journal of Engineering and Applied Technology (IJEAT)
Vol. 4., No. 1, Mei 2021, pp. 40-51

IT 342

$$Fw = 0{,}67 + 0{,}0698 \times \mathrm{W1} \tag{6}$$

D3. Main road median adjustment factor (FM)

Traffic engineering considerations are needed to determine the median factor. The median is called wide if standard light vehicles can take cover in the median area without disturbing the departing flow on the main road [17]. This may occur if the median width is 3 m or more. Main road median adjustment factor (FM) shows on Table 4.

Table 4. Main Road Median Adjustment Factor (FM)

Description	Median Type	Median Adjustment Factor
No main road median	None	1,00
Main road median, wide < 3 meters	Wide	1,05
Main road median, wide ≥ 3 meters	Narrow	1,20

Source: MKJI, 1997

D4. City size adjustment factor (FCS) Adjustment factors for the type of road environment, side barriers and non-motorised vehicles (FRSU)

The city size adjustment factor can be determined by the number of residents that it can see on Table 5.

Table 5. City Size Adjustment Factor (FCS)

City Size (CS)	Population (millions)	Adjustment Factor
Very Small	< 0,1	0,82
Small	0,1-0,5	0,88
Medium	0,5-1,0	0,94
Large	1,0-3,0	1,00
Very Large	>3,0	1,05

Source: MKJI, 1997

D5. Adjustment factors for the type of road environment, side barriers and non-motorised vehicles (FRSU)

The input variables to obtain the FRSU value are the type of road environment (RE), to the side barriers (SF) and the ratio of non-motorized vehicles where Table 6 shows the Adjustment factors for FRSU.

Table 6. Adjustment factors for FRSU

Road Environment Type Class (RE)	Side Resistance Class (sf)	Non-motorized vehicle ratio (P_{UM})					
		0,00	0,05	0,10	0,15	0,20	≥ 0,25
Commercial	High	0,93	0,88	0,84	0,79	0,74	0,70
	Medium	0,94	0,89	0,85	0,80	0,75	0,70
	Low	0,95	0,90	0,86	0,81	0,76	0,71
Residential	High	0,96	0,91	0,86	0,82	0,77	0,72
	Medium	0,97	0,92	0,87	0,82	0,77	0,73
	Low	0,98	0,93	0,88	0,83	0,78	0,74
Limited Access	High/Medium/Low	1,00	0,95	0,90	0,85	0,80	0,75

Source: MKJI, 1997

E. Left-turn adjustment factor (FLT)

$$FLT = 0{,}84 + 1{,}61 \times \mathrm{PLT} \quad (7)$$

Where :

PLT= left turn vehicle ratio (QLT/QTOT)

QLT = total current turn left (pcu/hour)

QTOT = total motorized vehicle traffic at the intersection (pcu/hour)

F. Right-turn adjustment factor (FRT)

Right turn adjustment factor at intersection with 4 arms.

FRT= 1.0. The right turn adjustment factor at the intersection with 3 arms is calculated using the equation.

$$FRT = 1{,}0 - 0{,}922 \times \mathrm{PRT} \quad (8)$$

Where :

PRT= right turn vehicle ratio (QLT/QTOT)

QLT = total current turn right (pcu/hour)

QTOT = total motorized vehicle traffic at the intersection (pcu/hour)

G. Minor road ratio adjustment factor (FMI)

FMI is the basic capacity adjustment factor due to the minor road current ratio. Table 7 shows the Minor road ratio adjustment factor (FMI).

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Vol. 4., No. 1, Mei 2021, pp. 40-51

IT	F_{MI}	P_{MI}
422	$1,19 \times P_{MI}^2 - 1,19 \times P_{MI} + 1,19$	0,1 – 0,9
424	$16,6 \times P_{MI}^4 - 33,3 \times P_{MI}^3 + 1,19 \times P_{MI}^2 - 8,6 \times P_{MI} + 1,95$	0,1 – 0,3
444	$1,11 \times P_{MI}^2 - 1,11 \times P_{MI} + 1,11$	0,3 – 0,9
323	$1,19 \times P_{MI}^2 - 1,19 \times P_{MI} + 1,19$	0,1 – 0,5
	$-0,595 \times P_{MI}^2 + 0,595 \times P_{MI}^3 + 0,74$	0,5 - 0,9
342	$1,19 \times P_{MI}^2 - 1,19 \times P_{MI} + 1,19$	0,1 – 0,5
	$2,38 \times P_{MI}^2 - 2,38 \times P_{MI} + 1,49$	0,5 – 0,9
323 344	$16,6 \times P_{MI}^4 - 33,3 \times P_{MI}^3 + 25,3 \times P_{MI}^2 - 8,6 \times P_{MI} + 1,95$	0,1 – 0,3
	$1,11 \times P_{MI}^2 - 1,11 \times P_{MI} + 1,11$	0,3 – 0,5
	$-0,555 \times P_{MI}^2 + 0,555 \times P_{MI}^3 + 0,69$	0,5 – 0,9

Table 7. Minor road ratio adjustment factor (FMI)

Source: MKJI, 1997

1.2 Degree of Saturation

Degree of saturation is the ratio of traffic flow to capacity [18] [19]. The degree of saturation is an indicator that determines the level of performance of an intersection [20]. An intersection has a good performance level if the degree of saturation is not more than 0.8 at the peak hour of the planning year. Degree of saturation is the ratio of current to capacity, calculated in pcu/hour.

$$DS = Q_{TOT}/\mathrm{C} \tag{9}$$

Where :

QTOT = total motorized vehicle traffic at the intersection (pcu/hour)

C = capacity (smp/hour)

1.3 Delay

Delay is the additional travel time to pass through the intersection when compared to the situation without the intersection, which consists of traffic delays and geometric delays [21] [22]. Traffic delay (DT) is waiting time due to traffic interaction with conflicting traffic and geometric delay (DG) is time delayed due to slowing and acceleration of disturbed and undisturbed traffic [11]. Traffic delays calculated in unsignalized intersections are as follows [15] [23]:

a. Intersection traffic delay (DT1)

The average traffic delay DT1 (seconds/pcu) is the average delay for all vehicles entering the intersection. The delay DT1 is determined from the empirical relationship between the delay DT1 and the degree of saturation DS.

For DS ≤ 0,6

$$DT1 = 2 + 8{,}2078 \times \mathrm{DS} - (1 - \mathrm{DS}) \times 2 \tag{10}$$

For DS ≥ 0,6

$$DT1 = 1{,}0504/(0{,}2742 - 0{,}2042 \times \mathrm{DS}) - (1 - \mathrm{DS}) \times 2 \tag{11}$$

b. Main road traffic delay (DTMA)

The average traffic delay for the major road is the average traffic delay for all vehicles entering the intersection through the major road.

For DS ≤ 0,6

$$DT1 = 1{,}8 + 5{,}8234 \times \mathrm{DS} - (1 - \mathrm{DS}) \times 1{,}8 \tag{12}$$

For DS ≥ 0,6

$$DT1 = 1{,}0504/(0{,}346 - 0{,}246 \times \mathrm{DS}) - (1 - \mathrm{DS}) \times 1{,}8 \tag{13}$$

c. Main road traffic delay (DTMA)

The average traffic delay for minor roads is determined based on the average traffic delay (DTI) and the average traffic delay for the major roads (DTMA).

$$DTM1 = \mathrm{QTOT} \times \mathrm{DT1} - \mathrm{QMA} \times \mathrm{DTMA}/\mathrm{QMI} \tag{14}$$

Where:

QMA= total flow of main/major roads

QMI= total flow of minor roads

d. Intersection geometric delay (DG)

The geometrical delay of the intersection is the average geometric delay of all motorized vehicles entering the side [24]. DG is calculated using the equation.

For DS ≤ 1,0

$$DG = (1 - \mathrm{DS}) \times (\mathrm{PT} \times 6 + (1 - \mathrm{PT}) \times 3) + \mathrm{DS} \times 4 \tag{15}$$

For DS ≥1,0, DG = 4
Where:

DG = geometrical delay of the intersection (sec/pcu)

DS = degree of saturation

PT = total turning ratio

e. Intersection delay

The intersection delay is calculated using the equation.

$$D = \mathrm{DG} + \mathrm{DT1} \tag{16}$$

Where:

DG = intersection geometric delay (sec/pcu)

DT1= intersection traffic delay (sec/pcu)

1.4 Queue Probability

The queue probability (QP %) is the probability that there will be queues with more than two vehicles in any of the approach areas and unsignalized intersections [25]. The limit of the queue probability value can be estimated from the relationship between the queue probability curve/degree of saturation. The limit value of the queue QP (%) is determined from the empirical relationship

International Journal of Engineering and Applied Technology (IJEAT)
Vol. 4., No. 1, Mei 2021, pp. 40-51

between the probability of the queue QP (%) and the degree of saturation (DS). The probability of a queue with an upper and lower bound can be obtained by using equation.

$$QP\ \%\ Upper\ Limit = 47{,}71 \times \mathrm{DS} - 24{,}68 \times \mathrm{DS2} + 56{,}47 \times \mathrm{DS3} \tag{17}$$

$$QP\ \%\ lower\ Limit = 9{,}02 \times \mathrm{DS} - 20{,}66 \times \mathrm{DS2} + 10{,}49 \times \mathrm{DS3} \tag{18}$$

2. Method

2.1. Research Site

The location of this research is the intersection of Jl. Raya Bogor – Sukabumi, Jl. Siliwangi – Cibolang, Jl. Perintis Kemerdekaan where it can see on figure 1.

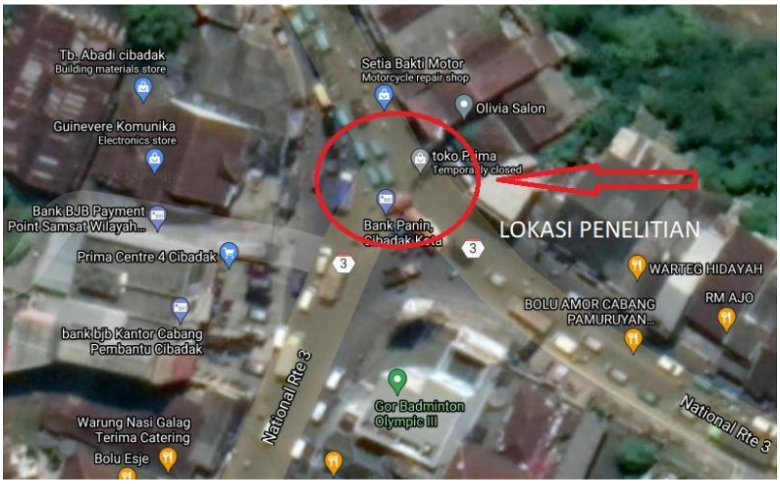

Figure. 1. Research Site

2.2. Research Equipment

In this study, several tools were used to support the implementation of research in the field as follows:

1. Research forms and stationery, to record traffic flow.
2. Length measuring device (meter), to measure the geometric dimensions of the road.
3. Counter, counting the number of vehicles that pass the T-junction.
4. The watch is used to measure the start and end time of the observation.

2.3. Research Data

The required data can be taken from several sources, namely:

1. Primary data is data obtained by direct observation in the field. The primary data needed in this research include:
   a. Traffic flow data for each road section
   b. Geometric data for each road segment
2. Secondary data, data obtained from related agencies related to the observations made. This secondary data functions as supporting data from the primary data in this study. The secondary data include:
   a. City size data

b. Population dat

c. Research site plan data

2.4. Survey Implementation

The survey was carried out at a predetermined time, for primary data, namely traffic flow data which was carried out on ...... at WIB, which is peak hour. Meanwhile, the geometric measurements were carried out on the date of…. In the implementation of this survey, 4 surveyors were required with the following tasks:

1. One surveyor counts the number of motorcycles, light vehicles, heavy vehicles, and non-motorized vehicles that move west to east and west to south.

2. One surveyor counts the number of motorcycles, light vehicles, heavy vehicles, and non-motorized vehicles moving from the north to the south.

3. One surveyor counts the number of motorcycles, light vehicles, heavy vehicles, and non-motorized vehicles that move from the south to the north.

4. One surveyor counts the number of motorcycles, light vehicles, heavy vehicles, and non-motorized vehicles moving from the north to the east and also from the east to the north.

5. One surveyor counts the number of motorcycles, light vehicles, heavy vehicles, and non-motorized vehicles moving from south to east and also from east to south.

The process of calculating the number of vehicles is recorded in 15 minutes internally on the traffic volume survey form with the division of vehicle types including HV, LV, MC, UM.

2.5. Explanation

In order to make it easier to obtain precise and accurate survey data, explanations must be made to all surveyors with their respective duties and responsibilities consisting of:

a. Filling the traffic volume survey form is recorded at 15 minute intervals.

b. The division of tasks involves the distribution of directions and types of vehicles according to the form held.

c. Geometric condition data collection, measuring the width of the approach on each arm carried out by 2 (two) people using a measuring tape.

d. Traffic condition data is obtained by recording the number of types of vehicles in each arm movement, namely turning left, turning right and going straight. The results of the enumeration based on the type of vehicle in each direction of movement in each arm are entered into the survey form.

2.6. Data Collection Time

Time for sampling is on Saturday. Considerations in the selection of days are based on activities that occur around the intersection where the research will be carried out. Saturday is a weekend where it is estimated that there will be a surge in traffic flow at the fork in the Pakuningratan road. Saturday is the beginning of the week and a working day, so it is estimated that there is a high traffic flow. As for the geometric measurements carried out on. The research was conducted during peak hours so that the maximum volume can be obtained, sampling was carried out for 8 hours because these 8 hours represent working hours and peak hours, namely at 16.00 WIB This traffic volume needs to be observed because related to time of observation, period of rush hour, direction and number of vehicles. The survey was conducted during peak hours, because during peak hours the maximum volume of vehicles will be obtained.

Observation time per 15 minutes for 8 hours. Each observation records vehicles passing through for all vehicle motions, according to the following classification:

a. Non-motorized vehicles, include: bicycles, tricycles, horse carts, and so on

International Journal of Engineering and Applied Technology (IJEAT)
Vol. 4., No. 1, Mei 2021, pp. 40-51

b. Motorcycles (motor cycles)

c. Light vehicles, include: passenger cars, minibuses, jeeps and small buses.

d. Heavy vehicles, include: large trucks and buses

2.7. Data Analysis

The data obtained from research in the field were analyzed based on the Indonesian Road Capacity Manual (MKJI, 1997) to determine the performance conditions of the intersections studied. From these results, the capacity values, degrees of saturation, delays and queuing opportunities are obtained based on the methods contained in the Indonesian Road Capacity Manual (Directorate General of Highways, 1997). If the intersection under study does not meet the requirements according to the Indonesian Road Capacity Manual (Directorate General of Highways, 1997), it is necessary to improve the level of service and performance of the intersection.

3. Conclusion

From the results obtained from the analysis of traffic flow at the unsignalized intersection as follows:

1. Analysis of the performance of the unsignalized intersection at the intersection of three Jl. Raya Bogor – Sukabumi, Jl. Siliwangi – Cibolang, Jl. Perintis Kemerdekaan from MKJI, obtained the highest traffic flow on the day….at…. – … WIB of cur/hour. The degree of saturation of the intersection is…the delay of the intersection is .... sec/skr, and the queue probability is around ...%.

4. Suggestion

Based on the results of the analysis of the performance analysis of the unsignalized intersection at the Simpang Tiga Jl. Raya Bogor – Sukabumi, Jl. Siliwangi – Cibolang, Jl. Perintis Kemerdekaan, some suggestions were given, including:

1. The development of traffic needs to be analyzed continuously so that it can overcome the influence of the development of the number of vehicles on traffic performance and the existing problems.

2. It is better if the local government, in this case the transportation department, can regulate traffic order.

References

[1] C. Y. F. Haryoputri, "Analisis Tundaan Pada Ruas Jalan Majapahit Kota Semarang Dan Pengaruhnya Terhadap Konsumsi Bahan Bakar Minyak (BBM)," Universitas Diponegoro, 2005. Available at: Google Scholar

[2] G. P. Kurniawan, S. Z. Shalikhah, H. Shofiati, N. N. Azizah, and M. Mochtar, "Analisis Permasalahan Transportasi di Perkotaan: Studi Kasus pada Kawasan Perkotaan Yogyakarta," *Jurnal Tana Mana*, vol. 2, no. 1, pp. 44–49, 2021. doi: 10.33648/jtm.v2i1.119

[3] A. Y. Permana, "Eco-architecture Sebagai Konsep Urban Development di Kawasan Slums dan Squatters Kota Bandung," 2012. Available at: Google Scholar

[4] Z. Zahara and M. Lubis, "Analisa Pemilihan Moda Transportasi Umum Rute Medan-Rantau Prapat dengan Metode Analytic Hierarchy Process," *JOURNAL OF CIVIL ENGINEERING BUILDING AND TRANSPORTATION*, vol. 1, no. 2, pp. 80–86, 2017. doi: 10.31289/jcebt.v1i2.1662

[5] A. E. Ms, "Kajian Efektifitas Kinerja Angkutan Umum Penumpang Antar Kota Dalam Provinsi Riau," Universitas Islam Riau, 2021. Available at: Google Scholar

[6] P. J. Romadhona, "Evaluasi Kinerja Simpang Bersinyal UPN Yogyakarta," 2020. Available at: Google Scholar

[7] M. Kananlua, "Analisis Simulasi Kinerja Lalu Lintas Pada Simpang Jalan di Kawasan Losari Kota Makassar dengan Vissim," Universitas Hasanuddin, 2020. Available at: Google Scholar

[8] R. Hidayati and S. Widodo, "PENGGUNAAN SOFTWARE VISSIM UNTUK ANALISA SIMPANG BERSINYAL (STUDI KASUS: JL. SULTAN HAMID–JL. TANJUNG RAYA I–JL. PERINTIS KEMERDEKAAN–JL. TANJUNG RAYA II PONTIANAK)," *JeLAST: Jurnal PWK, Laut, Sipil, Tambang*, vol. 5, no. 3. Available at: Google Scholar

[9] M. Rahmad, "EVALUASI KINERJA SIMPANG BERSINYAL JALAN SRIWIJAYA DAN JALAN BUNG KARNO (Studi Kasus Simpang Empat Sriwijaya Mataram)," Universitas_Muhammadiyah_Mataram, 2022. Available at: Google Scholar

[10] R. M BAYU, "PENGARUH PENEMPATAN U-TURN PADA SIMPANG TAK BERSINYAL DI JALAN SRIWIJAYA, SAPTA MARGA KECAMATAN CAKRANEGARA KOTA MATARAM," Universitas_Muhammadiyah_Mataram, 2021. Available at: Google Scholar

[11] D. P. Umum, "Manual Kapasitas Jalan Indonesia," *Direktorat Jenderal Bina Marga, Jakarta*, 1997. Available at: Website

[12] M. Haryadi, "Analisis Kinerja Simpang Tak Bersinyal Jalan Selokan Mataram Yogyakarta Menggunakan Metode Mkji 1997," 2018. Available at: Google Scholar

[13] M. A. Prajita, "ANALISA KINERJA LALU LINTAS SIMPANG TAK BERSINYAL (STUDI KASUS SIMPANG JALAN PALA RAYA, JALAN WERKUDORO, JALAN SIKLEPUH KABUPATEN TEGAL)," UNIVERSITAS PANCASAKTI TEGAL, 2020. Available at: Google Scholar

[14] M. A. U. Hasanudin, J. A. Timboeleng, and J. Longdong, "ANALISA KINERJA LALU LINTAS PERSIMPANGAN LENGAN EMPAT TAK BERINYAL (Studi Kasus: Persimpangan Jalan Banjer)," *JURNAL SIPIL STATIK*, vol. 7, no. 11, 2019. Available at: Google Scholar

[15] R. GINTING and others, "ANALISIS STUDI KEPADATAN LALU LINTAS SIMPANG TAK BERSINYAL JALAN TIGAPANAH-MEREK," UNIVERSITAS QUALITY, 2019. Available at: Google Scholar

[16] G. M. Maengkom, J. A. Timboeleng, and S. v Pandey, "ANALISA KINERJA SIMPANG TAK BERSINYAL DENGAN ANALISA GAP ACCEPTANCE DAN MKJI 1997 (Studi Kasus: Simpang Tak Bersinyal Lengan Tiga Jln. Wolter Monginsidi dan Jln. Maruasey, Pintu Keluar Masuk Terminal Malalayang)," *Jurnal Sipil Statik*, vol. 6, no. 12, 2018. Available at: Google Scholar

[17] I. Azhara, "Analisis Dampak Lalu Lintas Akibat Pembangunan Ballroom Dan Restaurant Dafam Kayoon Surabaya," Institut Teknologi Sepuluh Nopember, 2018. Available at: Google Scholar

[18] T. P. Sinambela, M. Kumaat, and S. v Pandey, "Analisa Hubungan Kinerja Simpang Bersinyal Dengan Konsumsi Bahan Bakar (Studi Kasus: Simpang Jl. AA Maramis–Jl. Ringroad II)," *TEKNO*, vol. 19, no. 78, 2021. Available at: Google Scholar

[19] R. M. Saputra, “Analisis perencanaan penerapan area traffic control system di kota Pangkal Pinang,” *Palembang: Universitas Sriwijaya*, 2014. Available at: Google Scholar

[20] R. F. Kayori, T. K. Sendow, L. Jefferson, and M. R. E. Manoppo, “Analisa Derajat Kejenuhan Akibat Pengaruh Kecepatan Kendaraan Pada Jalan Perkotaan Di Kawasan Komersil (Studi Kasus: Di Segmen Jalan Depan Manado Town Square Boulevard Manado),” *Jurnal Sipil Statik*, vol. 1, no. 9, 2013. Available at: Google Scholar

[21] G. Y. B. Lumintang, L. I. R. Lefrandt, J. A. Timboeleng, and M. R. E. Manoppo, “Kinerja Lalu Lintas Persimpangan Lengan Empat Bersignal (Studi Kasus: Persimpangan Jalan Walanda Maramis Manado),” *Jurnal Sipil Statik*, vol. 1, no. 3, 2013. Available at: Google Scholar

[22] M. Sa’dillah and R. A. Primasworo, “Kinerja Simpang Bersinyal Ruas Jalan Semeru–Kahuripan–Basuki Rahmat setelah Pembangunan Whiz Prime Hotel Malang,” *Fondasi: Jurnal Teknik Sipil*, vol. 9, no. 2, pp. 103–113, 2020. doi: 10.36055/jft.v9i2.8467

[23] A. A. Paendong, J. A. Timboeleng, and S. Y. R. Rompis, “ANALISA KINERJA SIMPANG TAK BERSIGNAL (STUDI KASUS: SIMPANG TAK BERSIGNAL LENGAN TIGA Jl. HASANUDDIN, Jl. SANTIAGO DAN Jl. POGIDON, TUMINTING),” *JURNAL SIPIL STATIK*, vol. 8, no. 5, 2020. Available at: Google Scholar

[24] D. W. Karels, A. W. Siki, and E. Hunggurami, “ANALISIS KINERJA SIMPANG TAKBERSINYAL PERSIMPANGAN JALAN WJ LALAMENTIK DAN JALAN AMABI KOTA KUPANG,” *Jurnal Teknik Sipil*, vol. 10, no. 1, pp. 9–20, 2021. Available at: Google Scholar

[25] B. Tripoli, D. Febrianti, E. Mawardi, Z. Zulyaden, and S. Supriadi, “Kajian Ulang Perencanaan Geometrik Simpang Simpang Tak Bersinyal Berdasarkan Highway Capacity Manual,” *Tameh: Journal of Civil Engineering*, vol. 10, no. 2, pp. 90–101, 2021. doi: 10.37598/tameh.v10i2.162