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SIMULATION OF TRAFFIC MANAGEMENT AND ENGINEERING TO IMPROVE THE PERFORMANCE OF THE FIVE-POINT INTERSECTION ON KEPUTIH STREET SURABAYA

Desi Aura Lestari[1], Kurnia Hadi Putra[2], Theresia Maria Chandra Agusdini[3]

[1,2,3] Civil Engineering Department, Adhi Tama Institute of Technology Surabaya, Surabaya, 60117, Indonesia

e-mail: desiaura821@gmail.com

ABSTRACT

The five-point intersection on Keputih Street is one of the unsignaled intersections in the city of Surabaya with traffic problems. At certain times, especially rush hour, traffic problems will occur. At 07.00 WIB it was seen that several drivers were trying to cut through the traffic jam by squeezing in between other vehicles, this was done by road users to avoid long queues of vehicles. Queues can be approximately 1.2km long and the surrounding existing conditions are commercial or shopping areas, housing with several sides of the road used as a means for vehicles to stop or park as an additional congestion factor. Thus, there is a need for management planning and traffic engineering to improve the quality of intersections in serving road users. The method used for data analysis is based on existing data obtained directly from the field and processed according to PKJI 2023. The results obtained were that the degree of saturation at the intersection was much different before and after the traffic engineering planning was carried out. Projection results with the installation of traffic light signs and geometric widening of Keputih Tegal, the degree of saturation value obtained was 0.78 where previously DJ = 0.98 ≥ 0.85.

Keywords: *Management and Traffic Engineering; PKJI 2023; Delay; Five-point Unsignalized Intersection in Keputih Surabaya.*

1. Introduction

One of the largest metropolitan cities which is the capital of East Java is Surabaya. In 2020 the population of Surabaya reached 2,904,751 people [7]. The increase in population every year can affect the number of vehicles operating. This percentage is a contributing factor to the density that occurs on certain road segments, the situation is called a traffic jam. Congestion usually arises due to the growth of transportation facilities and road infrastructure which tends to be unbalanced.

The five-point intersection on Keputih Tegal – Keputih Timur – Marina Emas road is one of the unsignaled intersections in the city of Surabaya with traffic problems. At certain times, especially rush hour, traffic problems will occur. At 07.00 WIB it was seen that several drivers were trying to cut through the traffic jam by squeezing in between other vehicles, this was done by road users to avoid long queues of vehicles [8]. Based on direct surveys by researchers in the field, it can be seen that along Keputih road - Keputih Tegal road, the queue of vehicles during the morning peak can reach 1.2 kilometers. Heavy traffic conditions crept along Keputih (north side) during the day and queues of vehicles were approximately 500 meters long on Jalan Keputih Tegal (south and east side). Several other conflicts that occurred were vehicles from each road segment crossing the intersection seen cutting each other irregularly. This causes traffic flow to tend to become stuck in traffic jams,

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especially in the afternoon. So, it is necessary to optimize intersection performance to overcome these problems.

2. Methods

Calculations to determine the level of traffic service according to the 2023 Indonesian Road Capacity Guide (PKJI) with primary data (existing). The volume of traffic vehicle flow is obtained using traffic counting and camera tools called CCTV. The level of service roads is based on the 2015 Minister of Transportation Regulation No. 96, Guidelines for Implementing Traffic Management and Engineering Activities [15].

2.1. Data Type

a. Primary Data
Road geometric measurements for each road section at intersections and land use, where the parameters obtained are used to calculate intersection capacity. LHR data is obtained through recording and counting vehicles using the traffic count application, taken for 4 days, with 2 (two) days each on weekdays and weekends. The number of surveyors was 10 people with each surveyor observing 2 different directions of movement. The types of vehicles observed were comprehensive (MC, LV, HV, and UM)

b. Secondary Data
Based on 2020 Central Statistics Agency Population census results and accessing other Surabaya City-related web pages as secondary data collection. Which includes population numbers, maps, and information within a specific scope at the unsignalized intersection of Keputih Tegal Road – Keputih Timur Road – Marina Emas Road Surabaya.

2.2. Survey Methods

Observation and data collection are carried out both directly and with tools. The research was conducted on Monday 17 October 2022 to represent a working day and Sunday 16 October 2022 to represent a weekend with a manual counting of 18 hours, based on the traffic volume data is considered to represent density. It's starting from 6 am to 11 pm (WIB). Data is presented at peak hours as follows:

- Morning Peak (06.00 - 09.00 WIB)
- Afternoon Peak (11.00 - 13.00 WIB)
- Evening Peak (16.00 - 19.00 WIB).

2.3. Data analysis

a. Transportation Type
- Light vehicles (LV) vehicle with 4 or 7 seats, can accommodate small/medium transport, vehicle length ≤ 5.5 meters. [16].
- Heavy vehicles (HV) in the form of medium buses and two-axle goods transport cars with a vehicle length of approximately 9 meters. [16].
- Motorcycle (MC) motorized vehicles with 2 or 3 wheels, and less than 2.5 meters long. [16].
- Non-motorized vehicles (UM) including bicycles, rickshaws, wheelbarrows, and delmans or animal-drawn vehicles. [16].

b. Road Capacity
The ability of the road to accommodate all road users, including vehicles and non-motorized ones. The more vehicles there are, the road capacity will be low. The symbol of road capacity is C. Calculations for the capacity of unsignalized intersections can use the equation (1) while at signalized intersections use the equation (2).

$$C = C_o \times F_{LP} \times F_M \times F_{UK} \times F_{HS} \times F_{BKi} \times F_{BKa} \times F_{Rmi} \quad (1)$$

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$$C = J \times \frac{WH}{s} \quad (2)$$

c. Degree of Saturation (DS or DJ)

$$D_J = q \div C \quad (3)$$

q = Existing traffic volume (pcu/hour)
C = Road Capasity (pcu/hour)

d. Level of Services

At intersections, service levels are classified into delays and measured for each type of road section according to the road network function system.

1. Level A, driving delay condition of less than 5 seconds;
2. Level B, driving delay conditions of more than 5 seconds to 15 seconds;
3. Level C, condition of delay of more than 15 seconds to 25 seconds of driving;
4. Level D, condition of delay of more than 25 seconds to 40 seconds of driving;
5. Level E, condition of delay of more than 40 seconds to 60 seconds of driving;
6. Level F, condition of delay of more than 60 seconds of driving.

Based on the primary road network according to its function, including:

1. Arterial roads, service level of at least B;
2. Collector road, service level at least B;
3. Local roads, service level of at least C;
4. Toll roads, service level of at least B.

Based on the secondary road network according to its function, including:

1. Arterial roads, service level of at least C;
2. Collector road, service level of at least C;
3. Local roads, service level at least D;
4. Neighborhood roads, service level of at least D.

e. Delay

Unsignalized Intersections

- DJ ≤ 0.60

$$T_{LL} = 2 + 8.2078 \times D_J - (1 - D_J)^2 \quad (4)$$

- DJ > 0.60

$$T_{LL} = \frac{1.0504}{(0.2742 - 0.2042 \times DJ)} - (1 - D_J)^2 \quad (5)$$

Signalized Intersections

$$TL = s \times \frac{0{,}5\ x\ (1-RH)^2}{(1-RH\ x\ DJ)} + \frac{NQ1 \times 3600}{C} \quad (6)$$

3. Result and Discussion

3.1. Existing Traffic Flow Volume

A five-point intersection without a traffic signal device with each road section assigned a segment code. 2/2 undivided road type without median with commercial environmental conditions.

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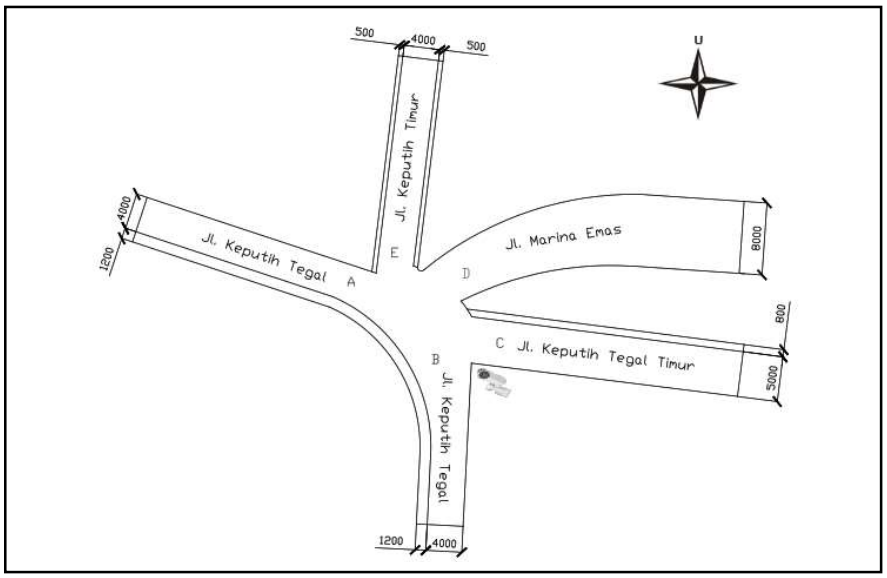

Figure 1. Existing Geometric Intersection

Table 1. Results of Data Processing Existing Peak Conditions

Basic Capacity (C_o) pcu/hour	Capacity (C) pcu/hour	Traffic Flow (Q) pcu/hour	Degree of saturation (DJ)	LOS	Delay (TLL) sec/pcu	Queue Probability (Pa) %
2900	3243	3006	0,93	B	12,37	34,48 – 68,02
2900	3218	2754	0,88	B	11,11	31,12 – 61,43
2900	3219	3299	1,02	C	16,17	42,22 – 83,72

In the main conditions, the capacity for each peak hour is 3243 passenger car units every hour for the Morning peak; 3128 for the Afternoon; and 3219 for the Evening peak with a traffic flow of 3006 pcu/hour; 2754 pcu/hour; and 3299 pcu/hour. Delay value in the morning peak = 12.37 sec/pcu; afternoon peak = 11.11 sec/pcu; and evening peak = 16.17 sec/pcu, resulting in a degree of saturation (DJ) = 0.93; 0.88; 1.02. The probability of queuing respectively is 34.48–68.02 %; 31.12–61.43 %; 42.22–83.72 %. Therefore, traffic management and engineering are needed as an alternative solution to this problem.

3.2. Alternative 1

The first solution option is to widen the road on the three sections of the intersection. The width of Keputih Tegal Barat (A) and Keputih Tegal Seletan Street (B) has been increased by 3 meters. The width of Jalan Keputih Tegal Timur (C) is increased by 2 meters.

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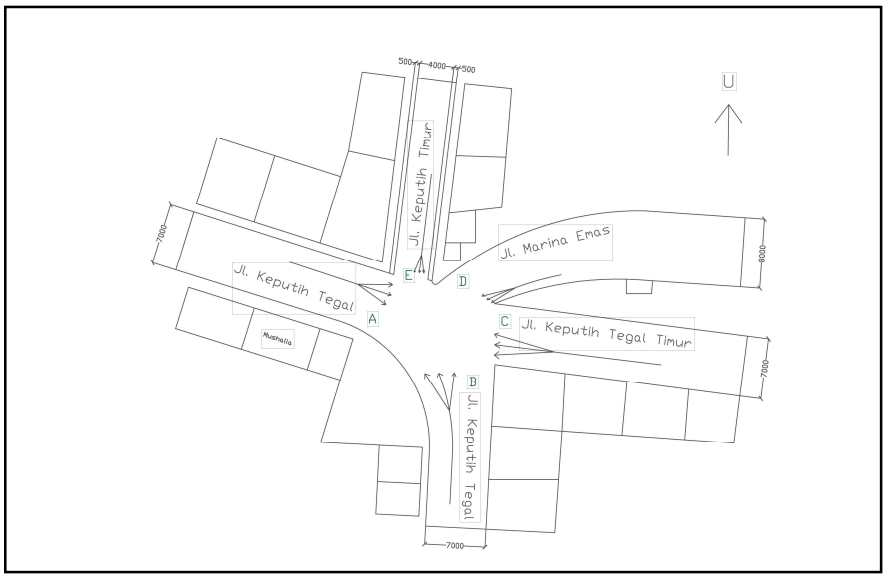

Figure 2. Alternative 1 Geometric Intersection

Table 2. Results of Data Processing Alternative 1 on Peak Conditions

Basic Capacity (C_o) pcu/hour	Capacity (C) pcu/hour	Traffic Flow (Q) pcu/hour	Degree of saturation (DJ)	LOS	Delay (TLL) sec/pcu	Queue Probability (Pa) %
2900	3488	3006	0,86	B	10,68	29,42 – 58,95
2900	3364	2754	0,82	B	9,78	26,98 – 53,51
2900	3463	3299	0,95	B	13,18	34,41 – 71,87

In the first alternative, the capacity for each peak hour is 3488 pcu/hour; 3364 for the afternoon peak; 3463 pcu/hour for the evening peak with a traffic flow of 3006 pcu/hour; 2754 pcu/hour; and 3299 pcu/hour. Delay value = 10.68 sec/pcu; afternoon peak = 9.78 sec/pcu; evening peak = 13.18 sec/pcu, with a degree of saturation (DJ) = 0.86; 0.82; 0.95. The Probability of queuing respectively are 29.42–58.95 %; 26.98–53.51 %; 34.41–71.87 %. Because the morning and evening peaks are still at high saturation levels, traffic management and engineering still need to be planned for other alternatives.

3.3. Alternative 2

The second solution option is to widen the roads on the three intersection segment roads and make Keputih Timur road (E) tobe one-way or entry direction only. Details of the widening of road is 3 meters for segment road A and B. Meanwhile, the width of Keputih Tegal Timur Road (C) has been increased by 2 meters.

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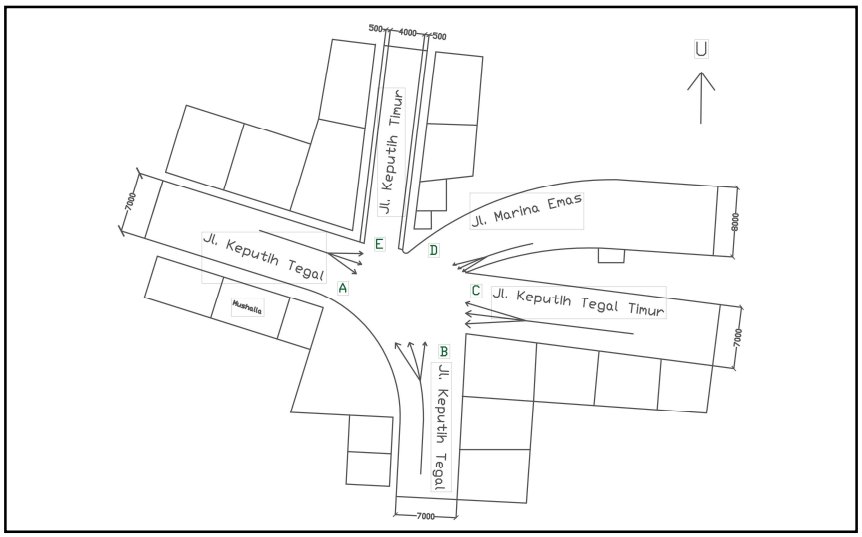

Figure 3. Alternative 2 Geometric Intersection

Table 3. Results of Data Processing Alternative 2 on Peak Conditions

Basic Capacity (C_o) pcu/hour	Capacity (C) pcu/hour	Traffic Flow (Q) pcu/hour	Degree of saturation (DJ)	LOS	Delay (TLL) sec/pcu	Queue Probability (Pa) %
2900	4014	2117	0,53	B	6,10	12,04 – 26,58
2900	3474	2439	0,70	B	7,94	20,15 – 40,88
2900	3754	2644	0,70	B	7,97	20,27 – 41,10

In the second alternative, the capacity for each peak hour is 4014 passenger car units (pcu) in every hour in the Morning peak; 3474 pcu/hour for the Afternoon; and 3754 pcu/hour for the evening with a traffic flow of 2117 pcu/hour; 2439 pcu/hour; and 2644 pcu/hour. Morning peak delay value = 6.10 sec/pcu; afternoon peak = 7.94 sec/pcu; evening peak = 7.97 sec/pcu. Degree of saturation (DJ) = 0.53; 070; 0.70. The Probability of queuing respectively are 12.04–26.58 %; 20.15–40.88 %; 20.27–41.10 %. A small degree of saturation value was obtained below 0.85. To solve other intersection problems, trials were carried out with the installation of traffic lights.

3.4. Alternative 3

The third solution option is a combination of the second alternative, then changing the direction from Jalan Keputih Tegal Timur (C) to Jalan Marina Emas (D), as well as installing traffic signaling devices on the road segments A, B and C.

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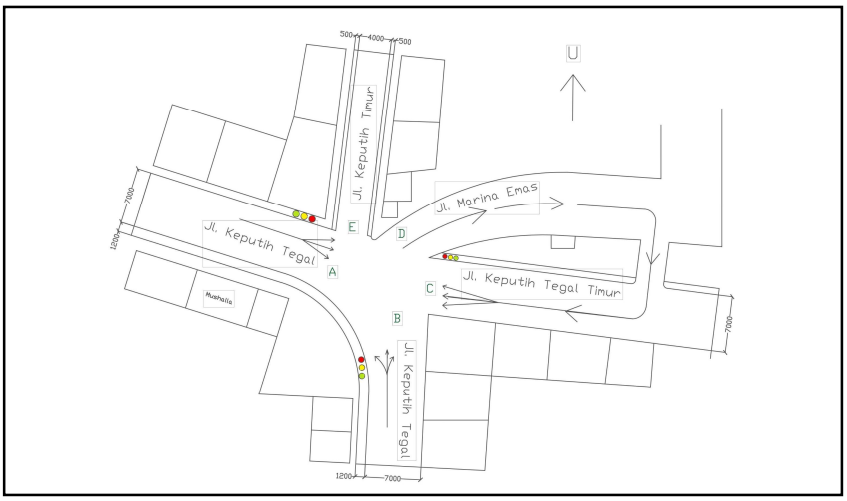

Figure 4. Alternative 3 Geometric Intersection

Table 4. Results of Data Processing Alternative 3 on Peak Conditions with Traffic Light

Segment	Capacity (C) smp/jam	Traffic Flow (Q) smp/jam	Degree of saturation (DJ)	LOS	Delay (TLL) det/smp	Queue Leeway m
A	656	512	0,78	D	38,73	137
B	856	668	0,78	D	26,46	166
C	480	375	0,78	E	51,72	57

According to PKJI procedures for 2023 intersections with APILL show that the capacity of each segment is 656 pcu/hour; 856 pcu/hour; and 480 pcu/hour with a traffic flow of 512 pcu/hour; 668 pcu/hour; and 375 pcu/hour. Delay value A = 38.73 sec/smp; B = 26.46 sec/pcu; C = 51.72 sec/pcu, resulting in a degree of saturation (DJ) = 0.78 for the three segment roads. The length of each queue is 137 meters; 166 meters; and 57 meters. With the provision of APILL, the intersection has a high degree of saturation and a class D level in the LOS category.

4. Conclusions

The performance of the existing intersection has a degree of saturation value above the value recommended by PKJI 2023[16], which is ≤ 0.85. The result is on Morning peak = 0.93; noon = 0.88; and afternoon = 1.025. Three alternative forms are planned, including widening the road on Jalan Keputih Tegal (West, East, and South sides), a one-way system, traffic diversion, and installation of traffic lights. However, from the calculations of the three solutions, the second and third alternative has the most DJ according to PKJI 2023 requirements. The third alternative is Peak hour in the Morning, DS = 0.78; delay value = 40.73 sec/pcu and LOS is D (minimum of level of service stipulation).

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