Analysis of Unsignalized Intersection Using PKJI 2014 Method (Study Case: Intersection of Jalan Sukajadi - Jalan Sukawangi-Jalan Sindang Sirna, Bandung)

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Abstract. Unsignalized intersection between Jalan Sukajadi, Jalan Sukawangi, Jalan Sindang Sirna is a strategic intersection in Bandung as the main access to the North Bandung area (Ledeng and surrounding areas). The intersection is often congested, especially at peak hours. This research tried to find a solution by exercising two scenarios, i.e. scenario (1) eliminating the main conflict and scenario (2) applying Traffic Signal (APILL). Analysis conducted using the Indonesian Road Capacity Guidelines (PKJI 2014) to the traffic data collected in peak hours of three workdays, i.e. morning peak, noon peak, and afternoon peak at December 2018. The existing condition shows the degree of saturation (DJ) value of 1.31, delay (T) about 153.93 sec/pceu, a potency of queuing (PA) about 70.71 to 46.7%, and level of service at F. Scenario (1) gives a DJ value smaller than the existing condition, T remains, PA becomes bigger and the level of service still in F. Scenario (2) results in a DJ value below 0.85, T and PA gets smaller, and service level increased to level C. In accordance to the simulation results, it recommended to apply traffic signal (APILL) on the intersection to relieve the congestion.

1. Introduction

Intersections are the meeting of two or more arms that can cause traffic conflicts. The four-arm unsignalized intersection between Jalan Sukajadi - Jalan Sukawangi - Jalan Sindang Sirna is a strategic intersection in the city of Bandung which is access to the North Bandung area (Ledeng, Lembang, and surrounding areas). Seen from the conditions of the surrounding environment, this intersection is in a mixed zone namely commercial, educational and office areas with quite high activity. Unsignalized intersection setting cause movement at this intersection to become irregular and frequent congestion. This is indicated by a decrease in the performance of the intersection that is an increase in density/degree of saturation [1][4], increasing delays [2], queues and downs of the high opportunity level of service.

2. Approach and methodology

In general, unsignalized intersections with the regulation of road rights (priority from the left) are used in urban and rural areas for intersections between local roads with low traffic flow. PKJI 2014 guidelines distinguish between the signalized intersection and the unsignalized intersection [7][8]. Unsignalized intersections are controlled by the basic rules of Indonesian traffic which give way to vehicles from the left, while signaled intersections are controlled by traffic lights.
The parameters calculated in this study will be calculated using the PKJI 2014. The total capacity (C) for all intersection arms is multiplying the basic capacity by the adjustment factors in the field conditions [3][6]. Then the road performance will be calculated, namely the degree of saturation (DJ), Delay (T) and potency of queuing (PA) and the level of service (LOS). The implementation of this research is conveyed in a flowchart of the research stages shown in Figure 1.

![Flowchart](image)

**Figure 1.** Research flow chart cycle

### 3. Results and discussion

Intersection performance testing is done by comparing the existing conditions with the 2 scenarios offered as discussed in the section below.

#### 3.1 Existing geometry conditions and intersection performance

Existing conditions draw the intersection traffic conditions without any intervention to the traffic that occurs. Survey results in the field, geometry data and the condition of the four intersections Jl. Sukajadi, Jl. Sukawangi, Jl. Sindang Sirna can be seen in Figure 2 below.
Figure 2. Geometrics of Jalan Sukajadi intersection, Jalan Sukawangi, Jalan Sindang Srima

Vehicle classification consists of light vehicles (KR), Medium Vehicles (KS), Motorcycles (SM) with a calculation interval of 1 (one) hour. This data is then converted into light vehicle units (pcu) according to the conversion factor of light vehicle equivalents (ekr) for each type of vehicle. Data collected in peak hours of three workdays, i.e. morning peak (06.00 to 09.00 a.m.), noon peak (11.00 a.m. to 14.00 p.m.), and afternoon peak (16.00 to 19.00 p.m.) as shown in Figure 3.

Figure 3. Traffic flows at morningpeak, noonpeak, and afternoonpeak

Table 1. Total traffic flow

| Approach          | Direction | Light Vehicle | Medium Vehicle | Motorcycle | Total         |
|-------------------|-----------|---------------|----------------|------------|---------------|
|                   |           | Vehicle/hr    | pcu/hr         | Vehicle/hr | pcu/hr        | Vehicle/hr    | pcu/hr |
| Jl. Sukawangi     | BKi       | 234           | 234            | 7          | 9             | 1022          | 511    | 1263 | 754 |
|                   | BKa       | 1159          | 1159           | 10         | 13            | 4431          | 2216   | 5600 | 3388 |
| Minor Road        | Total     | 1716          | 1716           | 23         | 30            | 5947          | 2974   | 7686 | 4720 |
| Jl. Sukajadi      | BKi       | 61            | 61             | 1          | 1             | 97            | 49     | 159  | 111 |
|                   | BKa       | 0             | 0              | 0          | 0             | 0             | 0      | 0    | 0   |
| Minor Road        | Total     | 335           | 335            | 17         | 22            | 1076          | 539    | 1428 | 896 |
| Mayor Road        | Total     | 2051          | 2051           | 40         | 52            | 7023          | 3513   | 9114 | 5616 |
| Vehicle Type Composition |      | 37%           | 1%             |            |               |               |        | 63%  |
Figure 3. explains that the highest traffic flow at morning peak, afternoon peak and afternoon peak hours occurs on Monday. The amount of traffic flow in the morning at 07.00 - 07.59 a.m is 9114 vehicles/hr, during the day at 12.00 - 12.59 a.m at 6839 vehicles/hr and afternoon at 16.00 - 16.59 p.m is 7611 vehicles/hr. Table 1 explains that the total traffic flow of major and minor roads used for the analysis of 5616 pcu/hr consisted of 37% light vehicles, 1% medium vehicles and 63% motorcycle.

The observed intersection traffic performance is capacity, degree of saturation, delays and queuing opportunities as presented in Table 2. The results obtained are the capacity of the intersections that are affected by various adjustment factors is 4290 pcu/hour or smaller than the traffic volume that occurs in crossing.

According to the PKJI 2014, with an intersection volume of 5616 pcu/hr and an intersection capacity of 4290 pcu/hr then the degree of saturation can be calculated by dividing the traffic volume by the actual capacity value so as to obtain a DJ = 5616/4290 = 1.31. Intersection delay at 153,93 sec/pcu is greater than the requirements [5]. Traffic conditions with DJ values greater than 1 indicate forced-flow conditions, low speed, greater volume than capacity, traffic often stops, causing long queues. Thus, the condition of this intersection falls into the level of service F.

Table 2. Existing intersection traffic performance

| Approach width and Intersection Type | Number of Arms | Approach Width m | Mayor Road | LRP | Number of Lane | Type Intersection |
|-------------------------------------|----------------|-----------------|------------|-----|----------------|-------------------|
|                                     | Minor Road                | LAC             | LB         | LD  | Minor          | Mayor             |
|                                     | 4                           | 12,3            | 14,7       | 13.5| 8              | 2                 |
|                                     |                              |                 |            | 8,6 | 11,7           | 10,15             |
|                                     |                              |                 |            | 11,7| 10,15          | 8                 |
|                                     |                              |                 |            | 8   | 2              | 2                 |
|                                     |                              |                 |            | 422 |                 |                   |

2. Calculating Capacity C = C0 x FLP x FM x FUK x FHS x FBKx x FRmi

Basic Capacity

| Capacity Co | Average Approach Width | Median Mayor Road | City Size | Side Friction | Turn Left | Turn Right | Ratio Minor/Total |
|-------------|------------------------|------------------|-----------|---------------|-----------|------------|------------------|
| Pcu/hr      | FLR                    | FM               | FUK       | FHS           | FBKx      | FRmi       | Pcu/hr           |
| 2900        | 1.42                   | 1                | 1         | 0,93          | 1,09      | 1          | 1,03             |
| 4290        |                        |                  |           |               |           |            |                  |

3. Calculating DJ, T dan PA

Total Traffic Flow

| Traffic Flow | Degree of Saturation | Intersection Traffic | Mayor Road | Minor Road | Geometry | Interception Delay | Queue Opportunity |
|--------------|----------------------|----------------------|------------|------------|----------|---------------------|-------------------|
| qTOT         | DJ                   | TLL                  | TLLma      | TLllmi     | TG       | T                   | PA                |
| Pcu/hr       | sec/pcu              | sec/pcu              | sec/pcu    | sec/pcu    | sec/pcu  | sec/pcu             | sec/pcu           |
| 5616         | 1,31                 | 149,93               | 43,48      | 170,01     | 4        | 153,93              | 70,7-146,7        |

3.2 Scenarios performance

To see the improvements being made, a simulation is carried out by removing the vehicle conflict from Jalan Sukajadi Bawah towards Jalan Sukajadi Atas by turning the vehicle into Jalan Sukawangi. The results obtained are presented in Table 3. The degree of saturation dropped to 1.08, the intersection delay was reduced to 23.89 sec/pcu, and the potency of queuing about 47.4 to 94.7% but the level of service was still in the F category. The second simulation uses a traffic signaling device with North approach (Jl. Sukajadi Atas), South approach (Jl. Sukajadi Bawah), East approach (Jl. Sukawangi) and Western approach (Jl. Sindang Sirna ). The simulation results obtained the value of the degree of saturation down to 0.74, the intersection delay reduced to 14.46 sec/pcu, the queue length ranged from 31.86 to 53.28 meters and the level of service increased to category C with the characteristics of a stable traffic flow with restrictions speed.
Table 3. Traffic performance scenario 1

| Basic Capacity Co | Capacity Correction Factor | Capacity C | Note |
|-------------------|----------------------------|------------|------|
| Pcu/hr 2900       |                            |            |      |
| FLP               | Median                   | Approach   | Width |
| FM                | Mayor Road               | City Size  | FUK   |
| FHS               | Friction                | Turn Left  | FBKi  |
| FBKa              | Turn Right              | FRmi       |       |
| FRmi              |                          | Pcu/hr     | 5177  |

1. Calculating

\[ \text{Capacity } C = C_0 \times \text{FLP} \times \text{FM} \times \text{FUK} \times \text{FHS} \times \text{FBKi} \times \text{FBKa} \times \text{FRmi} \]

| Basic Capacity Co | Calculating | Traffic Flow |
|-------------------|-------------|--------------|
| Pcu/hr 2900        |             |              |
| FLP                | Median      | Approach     |
| FM                 | Mayor Road  | Width        |
| FUK                | City Size   | FHS          |
| FBKi               | Friction    | Turn Left    |
| FBKa               | Turn Right  | FRmi         |
| FRmi               |             | Pcu/hr 5177  |

2. Calculating DJ, T dan PA

| Total Traffic Flow | Degree of Saturation | Traffic Performance | Target | Note |
|--------------------|----------------------|---------------------|--------|------|
| qTOT               |                       | DJ                  | PA     |      |
| Pcu/hr 5616        | DJ                    | TLL                 | TLLma  |      |
|                    |                       | sec/pcu             | sec/pcu|      |
|                    |                       | TLLni               | TG     |      |
|                    |                       | sec/pcu             | sec/pcu|      |
|                    |                       | 4                   | 23,9   |      |
|                    |                       | 47,4-94,7           |        |      |
|                    |                       | DJ<0,85             | Scenario 1 |      |

Table 4. Traffic performance scenario 2

| Approach Code | Traffic Flow Q | Capacity C | Degree of Saturation Dj | Gain Ratio RH | NQ1/pcu | NQ2/pcu | NQ/pcu | NQ MAX | NQ MAX pcu | Queue Length PA m | Vehicle Stopped Ratio RKH | Number of Vehicles Stopped NKH | Average Traffic Delays TLL sec/pcu | Average Geometry Delays TG sec/pcu | Average Delay T=TT+TG sec/pcu | Total Delay T x Q sec/pcu |
|---------------|----------------|------------|-------------------------|---------------|---------|---------|--------|--------|-------------|---------------------|----------------------------|-----------------------------|--------------------------------|--------------------------------|-----------------------------|------------------------|
| U             | 0.00           | 0.00       | 0.00                    | 0.3           | 0.00    | 0.00    | 0.00   | 0.00   | 0.00        | 0.00                | 0.00                        | 3.88                        | 5.88                        | 0                           |
| S             | 491            | 666        | 0.78                    | 0.3           | 0.80    | 6.05    | 6.85   | 13.00  | 31.86       | 0.92                | 453.26                      | 20.26                       | 23.9                        | 24.25                      | 11889                   |
| T             | 2488           | 3375       | 0.74                    | 0.5           | 0.80    | 26.63   | 27.44  | 41.00  | 53.28       | 0.75                | 1813.75                     | 10.56                       | 9.97                        | 14.33                      | 35638                   |
| B             | 0.00           | 0.00       | 0.00                    | 0.5           | 0.00    | 0.00    | 0.00   | 0.00   | 0.00        | 0.00                | 0.00                        | 3.88                        | 5.88                        | 0                           |
|               | 0.00           | 0.00       | 0.00                    | 0.6           | 0.00    | 0.00    | 0.00   | 0.00   | 0.00        | 0.00                | 0.00                        | 3.88                        | 5.88                        | 0                           |
|               | 0.00           | 0.00       | 0.00                    | 0.7           | 0.00    | 0.00    | 0.00   | 0.00   | 0.00        | 0.00                | 0.00                        | 3.88                        | 5.88                        | 0                           |

BKJ = 528
Q-total = 3506
Total number of vehicles stopped = 2269.01
Average vehicle stopped on average period = 0.05
Average intersection delay, sec/pcu = 14.46

4. Conclusions

Existing conditions show, the degree of saturation value of 1.31 or theoretically exceed the value limit. At that time, traffic conditions are in a saturated state in which the value of the comparison of traffic volumes is greater than its capacity, forced-flow conditions, very low speed, traffic often stops, and long queues occur. The crossing delay is 153.93 sec/pcu and the potency of queuing is 70.7- 146.7%. Scenario one produces a degree of saturation of 1.08 or decreases by 17% but the level of service is at level F. Delay is 23.89 sec/pcu and a potency of queuing of 47.4 to 94.7%. In this scenario no significant improvement has been seen. The second scenario produces a degree of saturation of 0.74 or down 43.44% so that the service level rises to level C with the characteristics of a more stable traffic flow even though it is still with speed restrictions. The average intersection delay of 14.46 sec/pcu and the queue length of 31.86-53.28 meters. In accordance with the target success determined by PKJI 2014 is <0.85, then the second scenario using APILL is chosen to meet the target.

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