CASE STUDY ON SUSTAINABLE T-JUNCTION CIBINONG CITY MALL (CCM) IN BOGOR INDONESIA

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ABSTRACT
The problem of transportation in Indonesia is congestion. Bogor District precisely Cibinong District is the center of government where there is the office the Regent Bogor. Intersection Cibinong City Mall began packed by motor vehicles, especially urban transport and private vehicle transportation. Also supported by the irregular rickshaw and ojeg parking base on the street, as well as for the transportation that began to bloom now is an online vehicle transport. The latter cause the traffic jams of users of public facilities causing congestion. T-junction Road Tegar Beriman can be illustrated as follows: from the direction of Cimanggis which is the 2nd North Bogor Highway, while from Bogor City, 1st section of South Road and the direction the Regency Tegar Beriman in the West. Based on the above study, the purpose of the study was to assess the performance and capacity of the intersections using the regulation of the signal periodically.

Keywords: congestion, delay, intersection performance, signal settings.

1. INTRODUCTION
Good transportation is a transportation system with a pattern of balanced arrangement between the population with existing infrastructure (Syaiful, 2005; Syaiful and Elvira, 2017). If an area experiencing population growth and technology is not balanced then it will lead to the emergence of various problems in the field of transportation (Syaiful, 2017). Developing countries like Indonesia, for example, the increasing population and the need for high transportation facilities, the ingredients are not able to accommodate so that there will be congestion everywhere. Disturbances in traffic will cause prolonged congestion, especially in the absence of effective arrangements on traffic signs, intersection arrangements and regulation of densely populated and dense areas of motor vehicles (Syaiful, 2017). The CCM intersection is a triple intersection that includes a strong road of faith-the Bogor-Depok. The congestion caused on this road is due to less intersecting cycles at the signal intersection and the number of public transport stops at the side of the road (Alhadar, 2011; Wikrama, 2011; Indri, S., 2016). This case will disrupt the activity of the surrounding population (Syahriah, B., Mariana, M.O& Zakiah, P, 2018). This problem occurs mainly in the peak hour of the morning and the peak hour of the afternoon. Especially for this T-junction has traffic problems and traffic growth rate is fast and solid. Finally, the conflict of vehicles passing through the intersection is more complicated, therefore the authors will conduct an evaluation of the intersection of this intersection performance (Hendi, 2013; Putro, 2010; Public Works Department, 1997; Indri, S., 2016).

A. Cibinong city crossroads
To obtain the length of the queue in accordance with the conditions at the intersection of the experimental way to do with changes in the value of constants (Gati Rahayu, 2009). While the capacity is the flow of vehicles passing through a certain segment is calculated based on the maximum value obtained (Public Works Department, 1997; Paul, D.G.P, 2010). Furthermore, the intersection capacity of the intersection at this fork is to calculate the capacity of the intersection by maintaining the condition of the traffic flow at the time specified. The intersection means the state achieved or the ability to work in the intersection on the turn conditions, straight in a certain time. Crossroads has a performance when calculated the number of queue lengths and vehicles that stop at the intersection (Public Works Department, 1997). In Indonesia in establishing the signal there are three namely, red stop, yellow caution and green road. Traffic signals mean the ability to signal the lights in reminding the driver in stick with it. Further evaluation of the performance of intersections based on queue length, delay and number of vehicle stops (Public Works Department, 1997).

B. Input data in intersection performance
Data on road geometry, traffic and environmental arrangements include, city size, left turn phase movement, approach code, environmental type and others, shown in Table-1 below.

Table-1. Equivalent passenger car

<table>
<thead>
<tr>
<th>Type of vehicle</th>
<th>EMP</th>
<th>The opposite approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sheltered approach</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LV</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>HV</td>
<td>1.3</td>
<td></td>
</tr>
<tr>
<td>MC</td>
<td>0.2</td>
<td></td>
</tr>
</tbody>
</table>

a. Approach ratio
Each approach to the vehicle's left turns ratio of the P_LT and the right turn ratio P_RT.
\[ P_{LT} = \frac{LT \text{ (smp/hour)}}{\text{Total (smp/hour)}} \]  
(1)

\[ P_{RT} = \frac{RT \text{ (smp/hour)}}{\text{Total (smp/hour)}} \]  
(2)

b. Ratio of non-motorized vehicles

By dividing non-motorized vehicle \( Q_{UM} \) Vehicles/hour with \( Q_{MV} \) motor vehicle current/hour.

\[ P_{UM} = \frac{Q_{UM}}{Q_{MV}} \]  
(3)

Determination of Signal Time

1. Type of approach
2. Width of Effective Approach
3. Basic Saturation Flow

Basic saturation current \( (S_o) \) for each P type approach (sheltered current) using the equation (4):

\[ S_o = 600 \times W_e \text{ smp/hour-green} \]  
(4)

c. Clever adjustment factor \( (F_G) \), shown in Figure-1 below.

b. Side adjustment factor barriers \( (F_{SF}) \)

Calculation of traffic performance on side barriers with pedestrian attention, vehicles parked on the road and slowing of vehicles at intersections. Seen in Table-3 adjustment to side obstacles:


<table>
<thead>
<tr>
<th>Road Environment</th>
<th>Side barriers</th>
<th>Type Fase</th>
<th>0.00</th>
<th>0.05</th>
<th>0.10</th>
<th>0.15</th>
<th>0.20</th>
<th>≥ 0.25</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercial (COM)</td>
<td>High</td>
<td>P</td>
<td>0.93</td>
<td>0.88</td>
<td>0.84</td>
<td>0.79</td>
<td>0.74</td>
<td>0.70</td>
</tr>
<tr>
<td></td>
<td></td>
<td>O</td>
<td>0.93</td>
<td>0.91</td>
<td>0.88</td>
<td>0.87</td>
<td>0.85</td>
<td>0.81</td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>P</td>
<td>0.94</td>
<td>0.89</td>
<td>0.85</td>
<td>0.80</td>
<td>0.75</td>
<td>0.71</td>
</tr>
<tr>
<td></td>
<td></td>
<td>O</td>
<td>0.94</td>
<td>0.92</td>
<td>0.89</td>
<td>0.88</td>
<td>0.86</td>
<td>0.82</td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>P</td>
<td>0.95</td>
<td>0.90</td>
<td>0.86</td>
<td>0.81</td>
<td>0.76</td>
<td>0.72</td>
</tr>
<tr>
<td></td>
<td></td>
<td>O</td>
<td>0.95</td>
<td>0.93</td>
<td>0.90</td>
<td>0.87</td>
<td>0.83</td>
<td></td>
</tr>
<tr>
<td>Residence (RES)</td>
<td>High</td>
<td>P</td>
<td>0.96</td>
<td>0.91</td>
<td>0.86</td>
<td>0.81</td>
<td>0.78</td>
<td>0.72</td>
</tr>
<tr>
<td></td>
<td></td>
<td>O</td>
<td>0.96</td>
<td>0.94</td>
<td>0.92</td>
<td>0.89</td>
<td>0.86</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>P</td>
<td>0.97</td>
<td>0.92</td>
<td>0.87</td>
<td>0.82</td>
<td>0.79</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>O</td>
<td>0.97</td>
<td>0.95</td>
<td>0.93</td>
<td>0.90</td>
<td>0.87</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>P</td>
<td>0.98</td>
<td>0.93</td>
<td>0.88</td>
<td>0.83</td>
<td>0.80</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>O</td>
<td>0.98</td>
<td>0.96</td>
<td>0.94</td>
<td>0.91</td>
<td>0.88</td>
<td></td>
</tr>
<tr>
<td>Risk Access (RA)</td>
<td>High</td>
<td>P</td>
<td>0.99</td>
<td>0.94</td>
<td>0.90</td>
<td>0.85</td>
<td>0.82</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>O</td>
<td>0.99</td>
<td>0.97</td>
<td>0.95</td>
<td>0.93</td>
<td>0.91</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>P</td>
<td>1.00</td>
<td>0.95</td>
<td>0.90</td>
<td>0.85</td>
<td>0.80</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>O</td>
<td>1.00</td>
<td>0.98</td>
<td>0.95</td>
<td>0.93</td>
<td>0.90</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>P</td>
<td>1.11</td>
<td>0.92</td>
<td>0.93</td>
<td>0.91</td>
<td>0.81</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>O</td>
<td>1.11</td>
<td>0.99</td>
<td>0.98</td>
<td>0.96</td>
<td>0.92</td>
<td></td>
</tr>
</tbody>
</table>

c. Clever adjustment factor \( (F_G) \), shown in Figure-1 below.
d. Parking adjustment Factor (F_p)
equation (5):
\[ F_p = \frac{[L_p^3 - (W_A^2) x (L_p/3 - g)] / W_A} / g \]  
(5)

L_p = The distance between the stop line and the parked vehicle first (m)
W_A = the width of the approach (m)
g = green time on the approach

b. Green time

Green time for each phase
\[ g_i = (C_{UA} - LTI) \times PR_i \]  
(13)
ge_i = The green time display in phase i (det)
C_{UA} = Cycle time before adjustment (det)
LTI = Total repetition time per cycle (det)
PR_i = Phase ratio FR_{CRIT} / \sum (FR_{CRIT})

c. Customized cycle times

\[ c = \frac{\sum g}{LTI} \]  
(14)

1.3 Capacity

Determination of the capacity, equation (15):
\[ C = S \times g / c \]  
(15)

C = Intersection capacity [smp/hour],
S = Saturation flow [smp/hour-green],
g = green time [second],
c = time cycle [second].

1.4 Traffic Behavior

The length of the queue counts the number of vehicles in the event of a stop or red light (Public Works Department, 1997). The average number of queues is calculated based on the number of (smp) left from the previous green phase (N_{Q1}) plus the number of (smp) coming during the red phase (N_{Q2}) can be seen in the equation (17):

For DS > 0.5:
\[ NQ_1 = 0.25 \times C \times x + \left( (DS - 1) + \sqrt{(DS - 1)^2 + \frac{8 \times (DS - 0.5)}{C}} \right) \]  

\( (17) \)

For \( DS \leq 0.5 \) : \( NQ_1 = 0 \)

\( NQ_1 \) = The number of smp left from the previous green phase

\[ DS = \text{Degree saturation} \]
\[ GR = \text{Green ratio} \]
\[ C = \text{Capacity (smp/hour)} = \text{Saturation current multiplied by green ratio (S x GR), shown in Figure-2 below.} \]

\[ NQ_2 = C \times \frac{1 - GR}{1 - (GR - DS)} \times \frac{Q}{3600} \]  

\( (18) \)

\( NQ_2 \) = The number of smp left from the previous green phase

\( DS = \text{Degree saturation} \)
\( GR = \text{Green ratio} \)
\( c = \text{Time cycle (sec)} \)
\( Q_{in} = \text{Traffic flow at the outside entrance LTOR (smp/hour).} \)

\[ NQ = NQ_1 + NQ_2 \]  

\( (19) \)

\( NQ \) = Number of queues (smp) that come during the red phase (NQ2), question (18):

Queue Length (QL) by multiplying \( NQ_{MAX} \) with the average area used per (smp) (20 m²) than divide by the width of entry.

\[ QL = \frac{NQ_{MAX} \times 20}{W_{in}} \]  

\( (20) \)

Vehicle Stopped

Numbers (NS) by counting the average number of stops per smp (including repeated queues in the queue). NS is a function of NQ divided by the cycle time of the equation (21):

\[ NS = 0.9 \times \frac{NQ}{Q \times c} \times 3600 \]  

\( (21) \)

where:
\( c = \text{Cycle time (sec)} \)
\( Q = \text{Traffic flow (smp/hour)} \)

Number of vehicles stalled (\( N_{SV} \)) equations (22):

\[ N_{SV} = Q \times NS \text{ (smp/hour)} \]  

\( (22) \)

The stop number of all intersections by dividing the number of vehicles stops at all approaches with the total Q intersection of Q in vehicle/hour, equation (23):

\[ NS_{TOT} = \frac{\sum N_{SV}}{Q_{TOT}} \]  

\( (23) \)

1.5 Delay

Delay of traffic (DT) is the recurrent number of vehicles at the intersection reviewed (Akcelik, 1988).

\[ DT = (c \text{ cycle time x A}) + \frac{NQ_1 \times 3600}{C \text{ capacity}} \]  

\( (24) \)

\( c = \text{Customized cycle time (sec)} \)
\( A = \frac{0.5 \times (1 - GR)^2}{(1 - (GR \times DS))^2} \)
\( GR = \text{Green ratio (g/c)} \)
\( DS = \text{Degree of saturation} \)

Delay of all intersections by dividing the number of vehicles stalled at all approaches with the total Q intersection of Q in vehicle/hour, equation (25):

\[ DG_j = (1 - P_{SV} \times P_T \times 6)) + (P_{SV} \times 4) \]  

\( (25) \)

for:
\( DG_j = \text{The average geometric delay on the approach j (sec/smp),} \)
\( P_{SV} = \text{The ratio of the vehicle stops on an approach, and} \)
\( P_T = \text{The ratio of the vehicle turns on an approach.} \)

The average delay (\( D_I \)) is to divide the total value of the total current delay (\( Q_{TOT} \)) in the smp / hour.
\[ D_I = \frac{\sum (Q \times D)}{Q_{TOT}} \]  

(26)

dengan:
\[ Q_{TOT} = \text{Total flow}, \]
\[ Q = \text{traffic Flow}, \]
\[ D = \text{Delay} \]

1.6 Service Level

The service level (LOS) is a measure of the quality of the actual traffic conditions felt by the driver of the vehicle. LOS is used to determine the level from the best A to the worst F (HCM, 1985). Also tested about the delay relationship with LOS shown on Table-4 below.

<table>
<thead>
<tr>
<th>Delay per vehicle (sec/vehicle)</th>
<th>Characteristics</th>
<th>Los of service</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 5</td>
<td>Free traffic conditions with high speed and low traffic volume</td>
<td>A</td>
</tr>
<tr>
<td>5.1 – 15</td>
<td>The current is stable, but the operating speed begins to be limited by traffic conditions</td>
<td>B</td>
</tr>
<tr>
<td>15.1 – 25</td>
<td>The current is stable, but the speed and motion of the vehicle are controled</td>
<td>C</td>
</tr>
<tr>
<td>25.1 – 40</td>
<td>The current is close to stable, the speed can still be controled. Still tolerable</td>
<td>D</td>
</tr>
<tr>
<td>40.1 – 60</td>
<td>The current is unstable, the speed sometimes stalled, the demand is near capacity</td>
<td>E</td>
</tr>
<tr>
<td>&gt; 60</td>
<td>Forced stream, low speed, volume above capacity, long queue (stuck)</td>
<td>F</td>
</tr>
</tbody>
</table>

Table-4. Criteria level service intersection signal Source: Highway Capacity Manual 1985

2. RESEARCH METHODS

This study uses a method as described in the work step and is shown in Figure-3 below. And Figure The following location of the research is Cibinong City Mall T-junctions with three way lane, shown in Figure-4, Figure-5 and Figure-6 below.

Figure-3. Research methods.

Figure-4. T-junctions Rd Tegar Beriman (a), Rd Depok-Bogor (b), Rd Bogor-Depok (c) and T-Junctions Rd Tegar Beriman from East (d).

Figure-5. Research location.

Figure-6. Intersections research location.

3. RESULTS AND DISCUSSIONS

A. Signal intersection

The scope of activity of the intersection location is examined as one crossing as shown in Table-5.
Table-5. Intersections examined Source: Data Analysis, 2017

<table>
<thead>
<tr>
<th>No</th>
<th>Name Intersections</th>
<th>Number lenght intersections</th>
<th>Controled</th>
<th>Number length intersections (Roads)</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Intersections Cibinong City Mall</td>
<td>3</td>
<td>APILL</td>
<td>T-Jungtions Rd Tegar Beriman</td>
<td>4/2 D</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Rd Bogor-Depok</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Rd Depok-Bogor</td>
<td>Yes</td>
</tr>
</tbody>
</table>

B. Geometric, traffic management, and environmental conditions

The following information is inputted into the GIS - I form, but described first.

a. Code of Approach
T-Jungtions Rd Tegar Beriman = West
Rd Bogor-Depok = South
Rd Depok-Bogor = North

a. Environment type roads
T-Jungtions Rd Tegar Beriman = COM (Commercial)
Rd Bogor-Depok = COM (Commercial)
Rd Depok-Bogor = COM (Commercial)

d. Turn left instantly
Direct Left Turn (L_{TOR}) on the approach according to the existing signal phase.
T-Jungtions Rd Tegar Beriman = Yes
Rd Bogor-Depok = Yes
Rd Depok-Bogor = No

c. Cleverness
Adjustment of the cleverness is determined using Figure 1 so that for each arm a value is obtained:
T-Jungtions Rd Tegar Beriman = 1.00
Rd Bogor-Depok = 1.00
Rd Depok-Bogor = 1.00

e. The distance of the vehicle to the parking lot
Between the stop line and the first vehicle in the park next to the upstream approach.
T-Jungtions Rd Tegar Beriman = 22.00 m
Rd Bogor-Depok = 5.00 m
Rd Depok-Bogor = 5.00 m

f. The width of the approach (W_{a})
Taken from the nearest ten meters to each arm.
T-Jungtions Rd Tegar Beriman (W) = 18.60 m
Rd Bogor-Depok (S) = 9.00 m
Rd Depok-Bogor (N) = 8.60 m

C. Current flow conditions
Volume The traffic flow is in the direction of the smp/hour, shown in Table-6, Table-7, Table-8.
Table 6. Traffic flow directions T-Junctions Rd Tegar Beriman (W) Source: Data Analysis 2017

<table>
<thead>
<tr>
<th>Period</th>
<th>Traffic flow (smp/hour)</th>
<th>Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>06.00-07.00</td>
<td>409.40</td>
<td>1.019 -</td>
</tr>
<tr>
<td>07.00-08.00</td>
<td>407.10</td>
<td>899 -</td>
</tr>
<tr>
<td>11.00-12.00</td>
<td>318.90</td>
<td>647 -</td>
</tr>
<tr>
<td>12.00-13.00</td>
<td>317.10</td>
<td>599 -</td>
</tr>
<tr>
<td>16.00-17.00</td>
<td>520.30</td>
<td>783 -</td>
</tr>
<tr>
<td>17.00-18.00</td>
<td>716.30</td>
<td>728 - Maximum traffic flow</td>
</tr>
</tbody>
</table>

Table 7. Traffic flow directions Rd Bogor-Depok (S) Source: Data Analysis 2017.

<table>
<thead>
<tr>
<th>Period</th>
<th>Traffic flow (smp/hour)</th>
<th>Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>06.00-07.00</td>
<td>97</td>
<td>- 665</td>
</tr>
<tr>
<td>07.00-08.00</td>
<td>85</td>
<td>- 874</td>
</tr>
<tr>
<td>11.00-12.00</td>
<td>180</td>
<td>- 678</td>
</tr>
<tr>
<td>12.00-13.00</td>
<td>138</td>
<td>- 682</td>
</tr>
<tr>
<td>16.00-17.00</td>
<td>254</td>
<td>- 897</td>
</tr>
<tr>
<td>17.00-18.00</td>
<td>315</td>
<td>- 805</td>
</tr>
</tbody>
</table>


<table>
<thead>
<tr>
<th>Period</th>
<th>Traffic flow (smp/hour)</th>
<th>Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>06.00-07.00</td>
<td>-</td>
<td>337 1.496</td>
</tr>
<tr>
<td>07.00-08.00</td>
<td>-</td>
<td>380 1.596</td>
</tr>
<tr>
<td>11.00-12.00</td>
<td>-</td>
<td>260 657</td>
</tr>
<tr>
<td>12.00-13.00</td>
<td>-</td>
<td>384 741</td>
</tr>
<tr>
<td>16.00-17.00</td>
<td>-</td>
<td>351 894</td>
</tr>
<tr>
<td>17.00-18.00</td>
<td>-</td>
<td>591 1.102</td>
</tr>
</tbody>
</table>
And in Table-9, Table-10, Table-11 shown the total traffic flow. And than in Figure-7, Figure-8 and Figure-9, flow fluctuations traffic Rd Tegar Beriman (West), Rd Bogor-Depok (South) and Rd Depok-Bogor (North).


<table>
<thead>
<tr>
<th>Period</th>
<th>Traffic flow (smp/hour)</th>
<th>Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>06.00-07.00</td>
<td>1.428,70</td>
<td></td>
</tr>
<tr>
<td>07.00-08.00</td>
<td>1.306,30</td>
<td></td>
</tr>
<tr>
<td>11.00-12.00</td>
<td>966,00</td>
<td></td>
</tr>
<tr>
<td>12.00-13.00</td>
<td>915,80</td>
<td></td>
</tr>
<tr>
<td>16.00-17.00</td>
<td>1.303,00</td>
<td></td>
</tr>
<tr>
<td>17.00-18.00</td>
<td>1.444,05</td>
<td>Maximum traffic flow</td>
</tr>
</tbody>
</table>

Figure-7. Flow fluctuations traffic Rd Tegar Beriman (West) Source: Data Analysis 2017.

Table-10. Total traffic flows Rd Bogor-Depok (S) Source: Data Analysis 2017.

<table>
<thead>
<tr>
<th>Period</th>
<th>Traffic flow (smp/hour)</th>
<th>Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>06.00 - 07.00</td>
<td>762,80</td>
<td></td>
</tr>
<tr>
<td>07.00 - 08.00</td>
<td>959,40</td>
<td></td>
</tr>
<tr>
<td>11.00 - 12.00</td>
<td>857,70</td>
<td></td>
</tr>
<tr>
<td>12.00 - 13.00</td>
<td>819,40</td>
<td></td>
</tr>
<tr>
<td>16.00 - 17.00</td>
<td>1.150,40</td>
<td>Maximum traffic flow</td>
</tr>
<tr>
<td>17.00 - 18.00</td>
<td>1.120,30</td>
<td></td>
</tr>
</tbody>
</table>

Figure-8. Fluctuation traffic flow Rd Depok-Bogor (S) Source: Data Analysis 2017.


<table>
<thead>
<tr>
<th>Period</th>
<th>Traffic flow (smp/hour)</th>
<th>Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>06.00 - 07.00</td>
<td>1.832,90</td>
<td></td>
</tr>
<tr>
<td>07.00 - 08.00</td>
<td>1.975,50</td>
<td>Maximum traffic flow</td>
</tr>
<tr>
<td>11.00 - 12.00</td>
<td>917,70</td>
<td></td>
</tr>
<tr>
<td>12.00 - 13.00</td>
<td>1.124,30</td>
<td></td>
</tr>
<tr>
<td>16.00 - 17.00</td>
<td>1.244,60</td>
<td></td>
</tr>
<tr>
<td>17.00 - 18.00</td>
<td>1.692,90</td>
<td></td>
</tr>
</tbody>
</table>

Figure-9. Fluctuation of traffic Flow Rd Depok-Bogor (N) Source: Data Analysis 2017.

D. Signal time
1. Type of approach, shown in Table-12 below.
Table-12. Type of approach.

<table>
<thead>
<tr>
<th>Approach type</th>
<th>Description</th>
<th>Pattern approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shielded P</td>
<td>T-Juctions Rd Tegar Beriman (West)</td>
<td>[image]</td>
</tr>
<tr>
<td>Shielded P</td>
<td>Rd Bogor-Depok (South)</td>
<td>[image]</td>
</tr>
<tr>
<td>Shielded P</td>
<td>Rd Depok-Bogor (North)</td>
<td>[image]</td>
</tr>
</tbody>
</table>

1. Effective approach width $W_{E}$
   - T-Junctions Rd Tegar Beriman (W) $= 10$ m
   - Rd Bogor-Depok (S) $= 9$ m
   - Rd Depok-Bogor (N) $= 5.6$ m

e. Adjustment factor turn left ($F_{LT}$), calculated using the formula #7
   - T-Junctions Rd Tegar Beriman (W) $= 1.00$
   - Rd Bogor-Depok (S) $= 1.00$
   - Rd Depok-Bogor (N) $= 1.00$

2. Basic saturation flow
   - Basic saturation flow ($S_o$) for each approach, calculated using the formula #4
     - T-Junctions Rd Tegar Beriman (W)
       - $600 \times 10 = 6,000$ smp/hour
       - $600 \times 9 = 5,400$ smp/hour
       - $600 \times 5.6 = 3,360$ smp/hour
   
   4. Basic saturation flow ($S$)
      - Calculated using the formula #8
      - T-Junctions Rd Tegar Beriman (W)
        - $6.720 \times 1.00 \times 0.93 \times 1.00 \times 0.81 \times 1.15 \times 1.00 = 5,799$ smp/hour
        - $11.100 \times 1.00 \times 0.95 \times 1.00 \times 0.86 \times 1.03 \times 1.00 = 9,346$ smp/hour
        - $8.400 \times 1.00 \times 1.00 \times 0.77 \times 1.00 \times 1.00 = 6,467$ smp/hour

3. Adjustment factor
   a. Adjustment factor of city size ($F_{CS}$), based on the Table-12.
      - Than obtained the following detail:
        - T-Junctions Rd Tegar Beriman (W) $= 1.00$
        - Rd Bogor-Depok (S) $= 1.00$
        - Rd Depok-Bogor (N) $= 1.00$
        - T-Junctions Rd Tegar Beriman (W) $= 981 / 5,799 = 0.334$
        - Rd Bogor-Depok (S) $= 241 / 9,346 = 0.051$
        - Rd Depok-Bogor (N) $= 313 / 6,467 = 0.096$

   a. Flow ratio (FR)
      - Calculated using the formula #9
      - T-Junctions Rd Tegar Beriman (W)
        - $981 / 5,799 = 0.334$
        - Rd Bogor-Depok (S) $= 241 / 9,346 = 0.051$
        - Rd Depok-Bogor (N) $= 313 / 6,467 = 0.096$

   b. Intersection flow rate (IFR), calculated using the formula #10
      - $\sum FR = 0.506$

   c. Phase ratio (PR), calculated using the formula #11
      - T-Junctions Rd Tegar Beriman (W)
        - $0.169 / \sum FR 0.506 = 0.334$
        - Rd Bogor-Depok (S) $= 0.026 / \sum FR 0.506 = 0.051$
        - Rd Depok-Bogor (N) $= 0.048 / \sum FR 0.506 = 0.096$

   6. Cycle time and green time, show in Figure-10 below,
      Data Analysis, 2017

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E. Capacity of crossroad

a. Capacity of each approach is calculated using the formula:

\[ T_{\text{Rd Tegar Beriman (W)}} = \frac{5.799 \times (45 / 173)}{1.933} = 1.933 \text{ smp/hour} \]

\[ T_{\text{Rd Bogor-Depok (S)}} = \frac{9.346 \times (40 / 173)}{3.461} = 3.461 \text{ smp/hour} \]

\[ T_{\text{Rd Depok-Bogor (N)}} = \frac{6.467 \times (40 / 173)}{1.869} = 1.869 \text{ smp/hour} \]

b. The degree of saturation of each approach is calculated using the formula:

\[ S_{\text{T-junctions Rd Tegar Beriman (W)}} = \frac{981}{1.508} = 0.51 \]

\[ S_{\text{Rd Bogor-Depok (S)}} = \frac{241}{2.701} = 0.07 \]

\[ S_{\text{Rd Bogor-Depok (E)}} = \frac{313}{253} = 0.44 \]

\[ S_{\text{Rd Depok-Bogor (N)}} = \frac{1628}{483} = 1.42 \]

c. In the capacity of the intersection shown in Table-13 below:

<table>
<thead>
<tr>
<th>Intersection number</th>
<th>Length intersection number</th>
<th>Saturation flow S</th>
<th>Green time g</th>
<th>Cycle time c</th>
<th>Capacity C=sx9G/C</th>
<th>Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intersection Cibinong City Mall (CCM)</td>
<td>T-junctions Rd Tegar Beriman (W)</td>
<td>4518</td>
<td>43</td>
<td>123</td>
<td>1579</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Rd Bogor-Depok (S)</td>
<td>3955</td>
<td>40</td>
<td>123</td>
<td>1286</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Rd Depok-Bogor (N)</td>
<td>10349</td>
<td>40</td>
<td>123</td>
<td>3366</td>
<td></td>
</tr>
</tbody>
</table>

F. Performance interaction

The size of the traffic behavior of the intersection can be determined by queue length, vehicle stalled and delay.

Queue length

a. \( NQ_1 \) calculated using the formula:

\[ NQ_1 = 0.25 \times 1933 + \left( (0.51 - 1) + \frac{8 \times (0.51 - 0.5)}{1933} \right) = 0.01 \]

\( NQ_1 = 0 \) for \( DS \leq 0.5 \)

b. \( NQ_2 \) calculated using the formula:

\[ NQ_2 = 135 \times \frac{1 - 0.33}{1 - (0.33 - 0.51)} \times \frac{981}{3600} = 29.5 \]

\[ NQ_2 = 135 \times \frac{1 - 0.37}{1 - (0.37 - 0.07)} \times \frac{241}{3600} = 5.8 \]

\[ NQ_2 = 135 \times \frac{1 - 0.11}{1 - (0.11 - 0.44)} \times \frac{313}{3600} = 11.0 \]

\[ NQ_2 = 135 \times \frac{1 - 0.19}{1 - (0.19 - 1.42)} \times \frac{1628}{3600} = 67.5 \]

c. Then \( NQ_1 \) and \( NQ_2 \) summed to find \( NQ \) using the formula:

\[ NQ = NQ_1 + NQ_2 = 0 + 29.5 = 29.5 \]

\[ NQ = 0 + 5.8 = 5.8 \]

\[ NQ = 0 + 10.8 = 10.8 \]

\[ NQ = 0 + 107.5 = 107.5 \]

d. To find \( NQ_{\text{MAX}} \) is used Figure-3. Calculation Number of Queues (\( NQ_{\text{MAX}} \)) in (smp), so obtained:

\( NQ_{\text{MAX}} = 68 \)
e. To find the QL formula is used:

\[ QL = \frac{NQ}{T} \times 100 \]

\[ QL = \frac{12}{T} \times 20 = 34 \text{ m} \]

\[ QL = \frac{22}{T} \times 20 = 110 \text{ m} \]

\[ QL = \frac{70}{T} \times 20 = 187 \text{ m} \]

Vehicle stalled

a. Counting the stop number (NS) using the formula:

\[ NS = 0.9 \times \frac{L}{3600} \times 3600 = 0.72 \]

\[ NS = 0.9 \times \frac{108}{313} \times 3600 = 0.83 \]

b. Counting number of vehicles stalled (N_{SV}) using the formula:

\[ N_{SV} = 981 \times 0.72 = 708 \]

\[ N_{SV} = 241 \times 0.83 = 260 \]

c. Counting end numbers of all intersections (NS_{TOT}) using the formula:

\[ NS_{TOT} = \frac{3689}{7199} = 0.51 \]

Vehicle stalled

a. The average traffic delay of each approach (DT), calculated using the formula:

\[ DT = \left( \frac{135 \times 0.267}{1933} \right) + \left( \frac{0.01 \times 3600}{135} \right) = 36 \]

\[ DT = \left( \frac{135 \times 0.203}{3461} \right) + \left( \frac{0.00 \times 3600}{135} \right) = 27 \]

\[ DT = \left( \frac{135 \times 0.415}{719} \right) + \left( -0.11 \times 3600 \right) = 55 \]

d. The average geometric delay of each approach (DGj), calculated using the formula:

\[ DG_j = \left( 1 - 1 \right) \times 6 \times 0.58 + \left( 1 \times 4 \right) = 4 \text{ sec/smp} \]

\[ DG_j = \left( 1 - 1 \right) \times 6 \times 0.58 + \left( 1 \times 4 \right) = 4 \text{ sec/smp} \]

\[ DG_j = \left( 1 - 1 \right) \times 6 \times 0.58 + \left( 1 \times 4 \right) = 4 \text{ sec/smp} \]

e. The Average delay (D = DT + DG_j) calculated using the formula:

\[ D = 36 + 4 = 40 \text{ sec/smp} \]

\[ D = 27 + 4 = 31 \text{ sec/smp} \]

\[ D = 186 + 4 = 190 \text{ sec/smp} \]

e. The average total (D \times Q)

\[ D \times Q = 16 \times 1019 = 16571 \text{ sec/smp} \]

\[ D \times Q = 19 \times 897 = 16677 \text{ sec/smp} \]

\[ D \times Q = 20 \times 1102 = 22459 \text{ sec/smp} \]

f. Can be known service level performance intersection Cibinong City Mall i.e:


<table>
<thead>
<tr>
<th>Number Intersection</th>
<th>Number length</th>
<th>Capacity C smp/hour</th>
<th>Saturation degree</th>
<th>Vehicles number NQ</th>
<th>Vehicle stalled NS</th>
<th>Vehicle queue QL</th>
<th>Delay D sec/smp</th>
<th>Loss of service</th>
</tr>
</thead>
<tbody>
<tr>
<td>T-Jungtions Rd Tegar Beriman (W)</td>
<td>1579</td>
<td>0.65</td>
<td>29.66</td>
<td>0.77</td>
<td>83.00</td>
<td>E</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rd Bogor-Depok (S)</td>
<td>1286</td>
<td>0.77</td>
<td>27.39</td>
<td>0.80</td>
<td>133.33</td>
<td>32.05</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rd Depok-Bogor (N)</td>
<td>3366</td>
<td>0.33</td>
<td>28.19</td>
<td>0.67</td>
<td>144.64</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
4. CONCLUSIONS

a) The result of the CCM intersection study on the existing condition is obtained, the capacity value of each arm on Road Tegal Beriman (West) 1.444 smp/hour, Road Bogor-Depok (South) 1.150 smp/hour, and Road Depok-Bogor (North) 1.976 smp/hour.

b) Furthermore, for the intersection value of intersection of CCM is the length of queue on Road Tegal Beriman (West) 83.00 m, Road Bogor-Depok (South) 133.33 m, Road Depok-Bogor (North) 144.64 m, with average delay all arms of the fork are 32.05 sec/smp with service level E which means unstable traffic flow, occurring speed sometimes stalled.

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