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CASE STUDY ON SUSTAINABLE T-JUNGTION 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-juntion 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 (Hendri, 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
Source: Public Works Departement 1997.

Type of vehicle	EMP	
	Sheltered approach	The opposite aproach
LV	1.0	1.0
HV	1.3	1.3
MC	0.2	0.4

a. Approach ratio

Each approach to the vehicle's left turns ratio of the P_{LT} and the right turn ratio P_{RT}.

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$$P_{LT} = \frac{LT\ (smp/hour)}{Total\ (smp/hour)} \quad (1)$$

$$P_{RT} = \frac{RT\ (smp/hour)}{Total\ (smp/hour)} \quad (2)$$

b. Ratio of non-motorized vehicles

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

$$P_{UM} = Q_{UM} / Q_{MV} \quad (3)$$

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):

$$S_O = 600 \text{ x } W_e \text{ smp/hour-green} \quad (4)$$

1. Adjustment Factor

a. City Size Adjustment Factor (FCS), shown in Table-2 below.

Table-2. City size adjustment factor (FCS) Source: Public Works Departement 1997.

City of population (Million people)	City size adjustment factor(F_{CS})
> 3.2	1.05
1.0 – 3.0	1.00
0.5 – 1.0	0.94
0.1 – 0.5	0.83
< 0.1	0.82

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-3. Side adjustment factor (FSF) Source: Public Works Departement 1997.

Road Environment	Side barriers	Type Fase	Ratio non-motorized vehicle					
			0.00	0.05	0.10	0.15	0.20	≥ 0.25
Commercial (COM)	High	P	0.93	0.88	0.84	0.79	0.74	0.70
		O	0.93	0.91	0.88	0.87	0.85	0.81
	Medium	P	0.94	0.89	0.85	0.80	0.75	0.71
		O	0.94	0.92	0.89	0.88	0.86	0.82
	Low	P	0.95	0.90	0.86	0.81	0.76	0.72
		O	0.95	0.93	0.90	0.89	0.87	0.83
Residence (RES)	High	P	0.96	0.91	0.86	0.81	0.78	0.72
		O	0.96	0.94	0.92	0.89	0.86	0.84
	Medium	P	0.97	0.92	0.87	0.82	0.79	0.73
		O	0.97	0.95	0.93	0.90	0.87	0.85
	Low	P	0.98	0.93	0.88	0.83	0.80	0.74
		O	0.98	0.96	0.94	0.91	0.88	0.86
Risk Access (RA)	High	P	0.99	0.94	0.90	0.85	0.82	0.74
		O	0.99	0.97	0.95	0.93	0.91	0.90
	Medium	P	1.00	0.95	0.90	0.85	0.80	0.75
		O	1.00	0.98	0.95	0.93	0.90	0.88
	Low	P	1.11	0.92	0.93	0.91	0.81	0.78
		O	1.11	0.99	0.98	0.96	0.92	0.89

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

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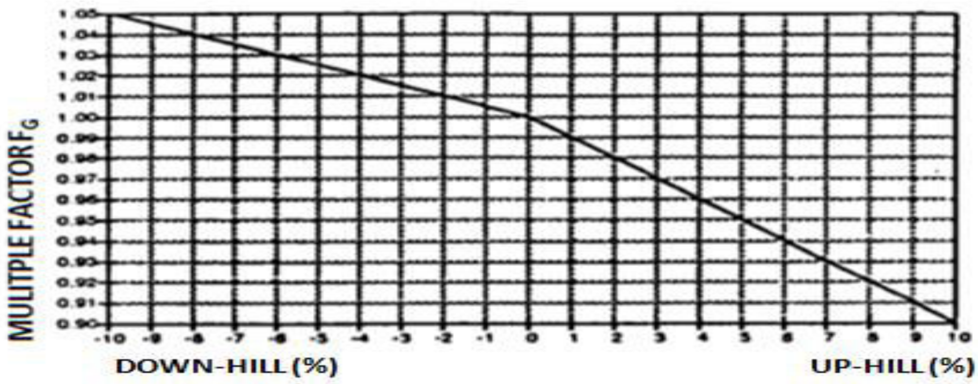

Figure-1. Adjustment factor for skill (F_G) Source: Public Works Departement 1997.

d. Parking adjustment Factor (F_P)equation (5):

$$F_P = [L_P/3 - (W_A-2) \times (L_P/3-g) / W_A] / g \quad (5)$$

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

e. Adjustment factor turn right (F_{RT})

Function of right turn vehicle ratio P_{RT}.

$$F_{RT} = 1.0 + P_{RT} \times 0.26 \quad (6)$$

f. Adjustment factor turn left (F_{LT})

Function of left turn vehicle ratio P_{LT}.

$$F_{LT} = 1.0 + P_{LT} \times 0.26 \quad (7)$$

g. Saturation flow

Saturation flow on the equation (8):

$$S = S_0\ x\ F_{CS}\ x\ F_{SF}\ xF_G\ x\ F_P\ x\ F_{RT}\ x\ F_{LT} \quad (8)$$

1. Ratio of flow/saturation flow
a. Flow Ratio (FR)

$$FR = Q / S \quad (9)$$

b. Intersection flow Ratio (IFR)

$$IFR = \sum (FR_{CRIT}) \quad (10)$$

c. Phase ratio (PR)

$$PR = \sum FR_{CRIT} / IFR \quad (11)$$

2. Cycle time and green time
a. Cycle time before adjustment

$$C_{UA} = (1.5 \times LTI + 5) / (1- IFR) \quad (12)$$

C_{UA} = Cycle time before adjustment (det)
LTI = Repeater time per cycle (det)
IFR = The current ratio of the intersection $\sum (FR_{CRIT})$

b. Green time

Green time for each phase

$$g_i = (C_{UA} - LTI) \times PR_i \quad (13)$$

g_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

$$c = \sum g / LTI \quad (14)$$

1.3 Capacity

Determination of the capacity, equation (15):

$$C= S \times g/c \quad (15)$$

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

Calculation of degree of saturation, equation (16):

$$DS= Q/C \quad (16)$$

DS = Degree of saturation,
Q = Traffic flow on the approach, and
C = Intersection capacity.

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:

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$$NQ_1 = 0.25 \times C \times + \left((DS - 1) + \sqrt{(DS - 1)^2 + \frac{8 \times (DS - 0.5)}{C}} \right) \quad (17)$$

For $DS \leq 0.5$: $NQ_1 = 0$

NQ_1 = The number of smp left from the previous green phase
DS = Degree saturation
GR = Green ratio
C = Capacity (smp/hour) = Saturation current multiplied by green ratio (S x GR), shown in Figure-2 below.

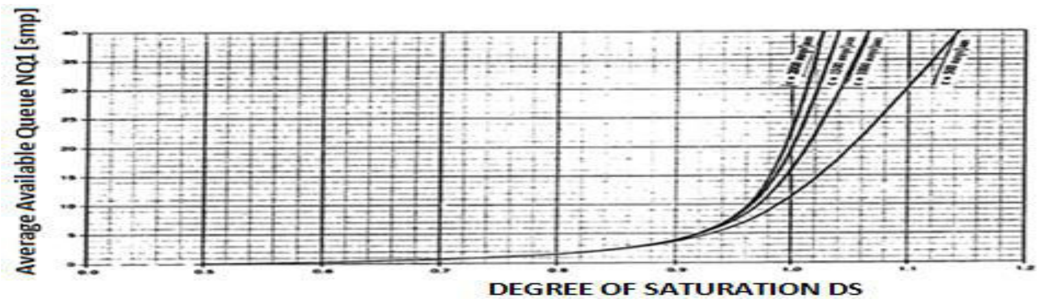

Figure-2. Number of vehicles quening up (smp) (NQ_1) Source: Public Works Departement 1997.

The Number of queues (smp) that come during the red phase (NQ_2), quetion (18):

$$NQ_2 = C\ x\ \frac{1-GR}{1-(GR-DS)}\ x\ \frac{Q}{3600} \quad (18)$$

NQ_2 = The number of smp left from the previous green phase
DS = Degree saturation
GR = Green ratio
c = Time cycle (sec)
Q_{in} = Traffic flow at the outside entrance LTOR (smp/hour).

$$NQ = NQ_1 + NQ_2 \quad (19)$$

Queue Length (QL) by multiplying NQ_{MAX} with the average area used per (smp) (20 m^2) than divide by the width of entry.

$$QL = \frac{NQ_{MAX}\ x\ 20}{W_{In}} \quad (20)$$

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):

$$NS = 0{,}9\ x\ \frac{NQ}{Q\ x\ c}\ x\ 3600 \quad (21)$$

where :
c = Cycle time (sec)
Q = Traffic flow (smp/hour)

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

$$N_{SV} = Q \times NS \text{ (smp/hour)} \quad (22)$$

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):

$$NS_{TOT} = \frac{\sum N_{SV}}{Q_{TOT}} \quad (23)$$

1.5 Delay

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

$$DT = (c \text{ cycle time} \times A) + \frac{NQ_1 \times 3600}{C \text{ capacity}} \quad (24)$$

DT = Average traffic delay (sec/smp)
c = Customized cycle time (sec)
A = $\frac{0.5 \times (1-GR)^2}{((1-(GR \times DS)}$
GR = Green ratio (g/c)
DS = Degree of saturation
NQ_1 = The number of smp left from the previous green phase
C = Capacity (smp/hour)

The geometry delay (DG) is the wait time on the slow or fast movement at the intersection viewed when the red light illuminates the equation (25):

$$DG_j = (1-P_{SV}) \times P_T \times 6)) + (P_{SV} \times 4) \quad (25)$$

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

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$$D_I = \frac{\Sigma(QxD)}{Q_{TOT}} \qquad (26)$$

dengan:
Q_{TOT} = Total flow,
Q = traffic Flow, and
D = 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-4. Criteria level service intersection signal Source: Highway Capacity Manual 1985

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

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.

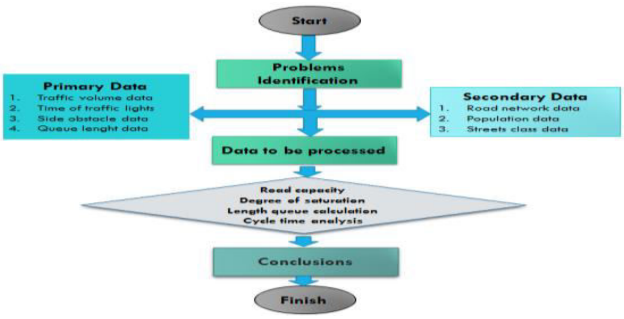

Figure-3. Research methods.

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

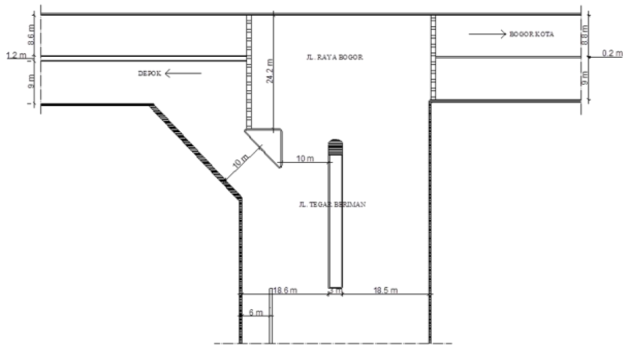

Figure-5. Research location.

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.

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Table-5. Intersections examined Source: Data Analysis, 2017

No	Name Intersections	Number lenght intersections	Controled	Number length intersections (Roads)	Type
1	Intersections Cibinong City Mall	3	*APILL*	T-Jungtions Rd Tegar Beriman	4/2 D
				Rd Bogor- Depok	2/2 D
				Rd Depok-Bogor	2/2 D

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-Tungtions Rd Tegar Beriman = West
Rd Bogor-Depok = South
Rd Depok-Bogor = North

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

b. Side obstacle Level
T-Jungtions Rd Tegar Beriman = Low
Rd Bogor-Depok = High
Rd Depok-Bogor = Low

The height is the amount of traffic flow that departs at the entry and exit by the road activity on approaches such as public transport stops, pedestrians crossing the road or walking along the approach. While low is the amount of traffic flow that departs at the entry and exit and is not reduced by side barriers from the above-mentioned types.

c. Median

Median on the right of the stop line in the approach.
T-jungtions Rd Tegar Beriman = Yes
Rd Bogor-Depok = Yes
Rd Depok-Bogor = Yes

c. Clevernes

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

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

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-Jungtions Rd Tegar Beriman (W) Source: Data Analysis 2017

	T-Jungtions Rd Tegar Beriman (West)			
Period	**Traffic flow (smp/hour)**			**Information**
	LT/LOR	**RT**	**ST**	
06.00-07.00	409.40	1.019	-	
07.00-08.00	407.10	899	-	
11.00-12.00	318.90	647	-	
12.00-13.00	317.10	599	-	
16.00-17.00	520.30	783	-	
17.00-18.00	716.30	728	-	Maximum traffic flow

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

	Rd Bogor-Depok (South)			
Period	**Traffic flow (smp/hour)**			**Information**
	LT/LOR	**RT**	**ST**	
06.00-07.00	97	-	665	
07.00-08.00	85	-	874	
11.00-12.00	180	-	678	
12.00-13.00	138	-	682	
16.00-17.00	254	-	897	Maximum traffic flow
17.00-18.00	315	-	805	

Table-8. Traffic flow directions Rd Depok-Bogor (N) Source: Data Analysis 2017.

	Rd Depok-bogor (North)			
Period	**Traffic flow (smp/hour)**			**Information**
	LT/LOR	**RT**	**ST**	
06.00-07.00	-	337	1.496	
07.00- 08.00	-	380	1.596	Maximum traffic flow
11.00- 12.00	-	260	657	
12.00-13.00	-	384	741	
16.00-17.00	-	351	894	
17.00-18.00	-	591	1.102	

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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-9. Total traffic flows T-Jungtions Rd Tegar Beriman Source: Data Analysis 2017.

	T-Jungtions Rd Tegar Beriman (West)	
Period	Traffic flow (smp/hour)	Information
	Q	
06.00-07.00	1.428,70	
07.00-08.00	1.306,30	
11.00-12.00	966,00	
12.00-13.00	915,80	
16.00-17.00	1.303,00	
17.00-18.00	1.444,05	Maximum traffic flow

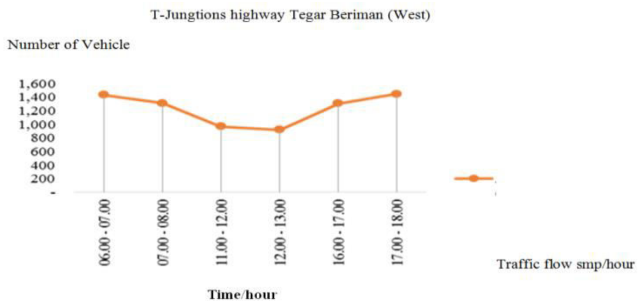

Figure-7. Flow fluctuations traffic Rd Tegar Beriman (West) Source: Data Analysis 2017.

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

	Rd Bogor-Depok (South)	
Period	Traffic flow (smp/hour)	Information
	Q	
06.00 - 07.00	762,80	
07.00 - 08.00	959,40	
11.00 - 12.00	857,70	
12.00 - 13.00	819,40	
16.00 - 17.00	1.150,40	Maximum traffic flow
17.00 - 18.00	1.120,30	

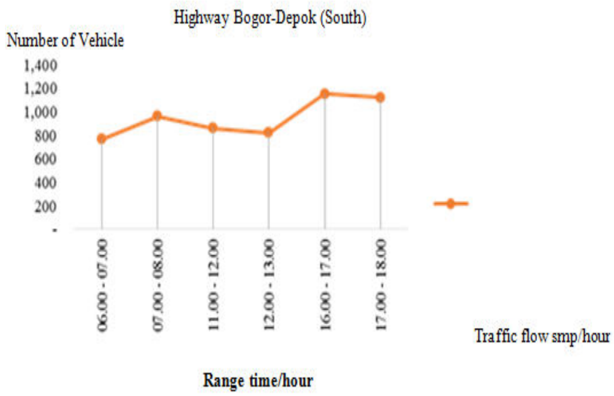

Figure-8. Fluctuation traffic flow Rd Depok-Bogor (S) Source: Data Analysis 2017.

Table-11. Total traffic flow Rd Depok-Bogor (N) Source: Data Analysis 2017.

	Rd Depok-bogor (North)	
Period	Traffic flow (smp/hour)	Information
	Q	
06.00 - 07.00	1.832,90	
07.00 - 08.00	1.975,50	Maximum traffic flow
11.00 - 12.00	917,70	
12.00 - 13.00	1.124,30	
16.00 - 17.00	1.244,60	
17.00 - 18.00	1.692,90	

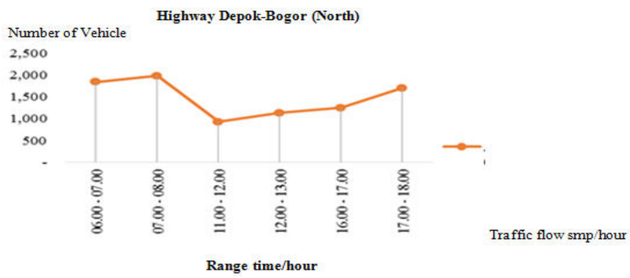

Figure-9. Fluctuation of traffic Flow Rd Depok-Bogor (N) Source: Data Analysis 2017.

D. Signal time

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

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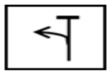
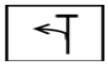
Table-12. Type of approach.

Approach type	Description	Pattern approach
Shielded P	T-Jungtions Rd Tegar Beriman (West)	
Shielded P	Rd Bogor-Depok (South)	
Shielded P	Rd Depok-Bogor (North)	

1. Effective approach width W_E

T-Jungtions Rd Tegar Beriman(W) = 10 m
Rd Bogor-Depok (S) = 9 m
Rd Depok-Bogor (N) = 5.6 m

2. Basic saturation flow

Basic saturation flow (S_o) for each approach, calculated using the formula # 4
T-Jungtions Rd Tegar Beriman(W)
600 x 10 = 6.000 smp/hour-green
Rd Bogor-Depok (S)
600 x 9 = 5.400 smp/hour-green
Rd Depok-Bogor (N)
600 x 5.6= 3.360 smp/hour-green

3. Adjustment factor

a. Adjustment factorof city size (F_{CS}), based on the Table-12.

Than obtained the following detail :
T-Jungtions Rd Tegar Beriman (W) = 1.00
Rd Bogor-Depok (S) = 1.00
Rd Depok-Bogor (N) = 1.00

a. Side Adjustment Factor (F_{SF}), obtained from Table-3.

T-Jungtions Rd Tegar Beriman (W)
= 0.93
Rd Bogor-Depok (S) = 0.95
Rd Depok-Bogor (N) = 0.93

b. Clever adjustment factor (F_G), obtained from Figure-1.

T-jungtions Rd Tegar Beriman (W) = 1.00
Rd Bogor-Depok (S) = 1.00
Rd Depok-Bogor (U) = 1.00

c. Parking adjustment factor (F_P), calculated using the formula#5

T-Jungtions Rd Tegar Beriman (W) = 0.81
Rd Bogor-Depok (S) = 0.86
Rd Depok-Bogor (N) = 0.80

d. Adjustment factor turn right (F_{RT}), calculated using the formula#6

T-Jungtions Rd Tegar Beriman (W) = 1.15
Rd Bogor-Depok (S) = 1.03
Rd Depok-Bogor (N) = 1.03

e. Adjustment factor turn left (F_{LT}), calculated using the formula#7

T-jungtions Rd Tegar Beriman (W) = 1.00
Rd Bogor-Depok (S) = 1.00
Rd Depok-Bogor (N) = 1.00

4. Basic saturation flow (S)

Calculated using the formula#8
T-Jungtions Rd Tegar Beriman(W)
6.720x 1.00 x 0.93 x 1.00 x 0.81 x 1.15 x 1.00 = 5.799 smp/hour-green
Rd Bogor-Depok (S)
11.100x 1.00 x 0.95 x 1.00 x 0.86 x 1.03 x 1.00 = 9.346 smp/hour-green
Rd Depok-Bogor (N)
8.400x 1.00 x 1.00 x 1.00 x 0.77 x 1.00 x 1.00 = 6.467 smp/hour-green

5. Flow ratio (FR)

a. Flow ratio of each approach (FR), calculated using the formula#9

T-Jungtions 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

∑ FR = 0.506

c. Phase ratio (PR), calculated using the formula#11

T-Jungtions Rd Tegar Beriman (W)
0.169 / ∑ FR 0.506 = 0.334
Rd Bogor-Depok (S)
0.026 / ∑ FR 0.506 = 0.051
Rd Depok-Bogor (N)
0.048 / ∑ FR 0.506 = 0.096

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

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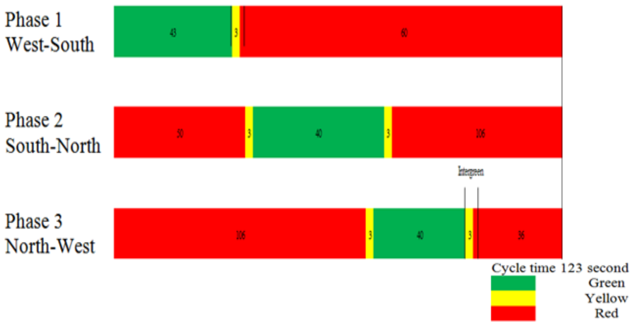

Figure-10. Cycle time diagram
Source: Data Analysis 2017.

E. Capacity of crossroad

a. Capacity of each approach is calculated using the formula#15

T-Jungtions Rd Tegar Beriman (W)
5.799x (45 / 173) = 1.933 smp/hour
Rd Bogor-Depok (S)
9.346x (40 / 173) = 3.461 smp/hour
Rd Depok-Bogor (N)
6.467x (40 / 173) = 1.869 smp/hour

b. The degree of saturation of each approach is calculated using the formula#16
T-Jungtions Rd Tegar Beriman (W)
981 / 1.508 = 0.51
Rd Bogor-Depok (S)
241 / 2.701 = 0.07
Rd Bogor-Depok (E)
313 / 253 = 0.44
Rd Depok-Bogor (N)
1628 / 483 = 1.42

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

Table-13. Intersection capacity Source: Analysis Data 2017.

Intersection number	Lenght intersection number	Saturation flow S	Green time g	Cycle time c	Capacity C=sx9G/C)
Intersection Cibinong City Mall (CCM)	T-jungtions Rd Tegar Beriman (W)	4518	43	123	1579
	Rd Bogor-Depok (S)	3955	40	123	1286
	Rd Depok-Bogor (N)	10349	40	123	3366

F. Performance intersection

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

Queue lenght

a. NQ_1 calculated using the formula#17
T-Jungtions Rd Tegar Beriman (W)

$$NQ_1 = 0.25 \text{ x } 1933 + \left((0.51 - 1) + \sqrt{(0.51-1)^2 + \frac{8\,x\,(0.51-0.5)}{1933}} \right) = 0.01$$

Rd Bogor-Depok (S)
Untuk DS ≤ 0.5:NQ_1 = 0
NQ_1 = 0
Rd Bogor-Depok (E)

$$NQ_1 = 0.25 \text{ x } 719 + \left((0.44 - 1) + \sqrt{(0.44-1)^2 + \frac{8 \text{ x } (0.44-0.5)}{719}} \right) = 0.11$$

Rd Depok-Bogor (N)

$$NQ_1 = 0.25 \text{ x } 1146 + \left((1.42 - 1) + \sqrt{(1.42-1)^2 + \frac{8\,x\,(1.42-0.5)}{1146}} \right) = 40$$

b. NQ_2 calculated using the formula# 18
T-Jungtions Rd Tegar Beriman (W)

$$NQ_2 = 135\,x\,\frac{1-0.33}{1-(0.33-0.51)}\,x\,\frac{981}{3600} = 29.5$$

Rd Bogor-Depok (S)

$$NQ_2 = 135\,x\,\frac{1-0.37}{1-(0.37-0.07)}\,x\,\frac{241}{3600} = 5.8$$

Rd Bogor-Depok (E)

$$NQ_2 = 135\,x\,\frac{1-0.11}{1-(0.11-0.44)}\,x\,\frac{313}{3600} = 11.0$$

Rd Depok-Bogor (N)

$$NQ_2 = 135\,x\,\frac{1-0.19}{1-(0.19-1.42)}\,x\,\frac{1628}{3600} = 67.5$$

c. Then NQ1 and NQ_2 summed to find NQ using the formula#19 :
T-Jungtions Rd Tegar Beriman (W)
0.01 +29.5 = 29.5
Rd Bogor-Depok (S)
0 + 5.8 = 5.8
Rd Bogor-Depok (E)
- 0.11 + 11.0 = 10.8
Rd Depok-Bogor (N)
40 + 67.5 = 107.5

d. To find NQ_{MAX} is used Figure-3. Calculation Number of Queues (NQ_{MAX}) in (smp), so obtained:
T-Jungtions Rd Tegar Beriman (W)
NQ_{MAX} = 68

Rd Bogor-Depok (S)
$NQ_{MAX} = 12$
Rd Bogor-Depok (E)
$NQ_{MAX} = 22$
Rd Depok-Bogor (N)
$NQ_{MAX} = 70$

e. To find the QL formula is used#20
T-Jungtions Rd Tegar Beriman (W)

$$QL = \frac{68\ x\ 20}{3.50} = 389\ m$$

Rd Bogor-Depok (S)

$$QL = \frac{12\ x\ 20}{7.00} = 34\ m$$

Rd Bogor-Depok (E)

$$QL = \frac{22\ x\ 20}{4.00} = 110\ m$$

Rd Depok-Bogor (N)

$$QL = \frac{70\ x\ 20}{7.50} = 187\ m$$

Vehicle stalled

a. Counting the stop number (NS) using the formula#21
T-Jungtions Rd Tegar Beriman (W)

$$NS = 0{,}9\ x\ \frac{29.5}{981\ x\ 135}\ x\ 3600 = 0.72$$

Rd Bogor-Depok (S)

$$NS = 0{,}9\ x\ \frac{5.8}{241\ x\ 135}\ x\ 3600 = 0.58$$

Rd Depok-Bogor (N)

$$NS = 0{,}9\ x\ \frac{10.8}{313\ x\ 135}\ x\ 3600 = 0.83$$

b. Counting number of vehicles stalled (N_{SV}) using the formula#22 :
T-Jungtions Rd Tegar Beriman (W), N_{SV}= 981 x 0.72 = 708
Rd Bogor-Depok (S), N_{SV} = 241 x 0.58 = 140
Rd Depok-Bogor (N), N_{SV} = 313 x 0.83 = 260

c. Counting end numbers of all intersections (NS_{TOT}) using the formula#23 :

$$NS_{TOT} = \frac{3689}{7199} = 0.51$$

Delay

a. The average traffic delay of each approach (DT), calculated using the formula#24:
T-Jungtions Rd Tegar Beriman (W)

$$DT\ = (135\ x\ 0.267) + \frac{0.01\ x\ 3600}{1933} = 36$$

Rd Bogor-Depok (S)

$$DT\ = (135\ x\ 0.203) + \frac{0.00\ x\ 3600}{3461} = 27$$

Rd Depok-Bogor (N)

$$DT\ = (135\ x\ 0.415) + \frac{-\ 0.11\ x\ 3600}{719} = 55$$

b. The average geometric delay of each approach (DGj), calculated using the formula#25:
T-Jungtions Rd Tegar Beriman (W)
DG_j = ((1 - 1) x 0.58 x 6)) + (1 x 4) = 4 sec/smp
Rd Bogor-Depok (S)
DG_j = ((1 - 1) x 0.10 x 6)) + (1 x 4) = 4 sec/smp
Rd Depok-Bogor (N)
DG_j = ((1 - 1) x 0 x 6)) + (1 x 4) = 4 sec/smp

c. The Average delay ($D = DT + DG_j$)
T-Jungtions Rd Tegar Beriman(W)
D = 36 + 4 = 40 sec/smp
Rd Bogor-Depok (S)
D = 27 + 4 = 31 sec/smp
Rd Depok-Bogor (N)
D = 186 + 4 = 190 sec/smp

d. The average total (D x Q)
T-Jungtions Rd Tegar Beriman (W)
16 x 1019 = 16571 sec/smp
Rd Bogor-Depok (S)
19 x 897 = 16677 sec/smp
Rd Depok-Bogor (N)
20 x 1102 = 22459 sec/smp

e. The average delay of all intersections (D_I), calculated using the formula#26:

$$D_I = \frac{399854}{7199} = 55.55\ sec/smp$$

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

Table-14. Performance intersection Source: Data Analysis 2017.

Number Intersection	Number lenght	Capacity C smp/hour	Saturation degree	Vehicles number NQ	Vehicle stalled NS	Lenght queue QL	Delay D sec/smp	Loss of service
Intersection	T-jungtions Rd Tegar Beriman (W)	1579	0,65	29,66	0,77	83,00		
Cibinong City	Rd Bogor-Depok (S)	1286	0,77	27,39	0,80	133,33	32,05	E
Mall/CCM	Rd Depok-Bogor (N)	3366	0,33	28,19	0,67	144,64		

4. CONCLUSIONS

a) The result of the CCM intersection study on the existing condition is obtained, the capacity value of each arm on Road Tegar 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 Tegar 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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