

Conference Paper

Performance Analysis of Signaled Intersections to Improve Safety in Depok Intersection, Depok City

Sony Widyawan, Darul Prayogo, Rukman, Diajeng Ayu D. P, and Abdul Rokhim, SE, M.Sc

DIV Road Safety Transport Management, Polytechnic of Road Safety, Semarang Merchant Marine Polytechnic (PIP)

Abstract

Transportation problems are one of the issues faced in Depok, especially at intersections. The problems of traffic congestion and conflict often occur at intersections, especially at Depok intersection in which one of the efforts made to reduce the conflicts is made by managing the intersection. The method used in analyzing intersection performance is the use of calculations at IHCM, while the analysis of traffic conflicts to determine the seriousness of traffic conflicts is to use traffic conflict techniques (TCT) compared to the conflicts. Recommendations are made with a scheme using the selection of 3 phases and 3.5 phases then making a comparison with the third phase and choosing the most appropriate scenario. From the recommendation scheme made using the VISSIM 10 PTV software, the most appropriate scheme is obtained by using three-phase settings. The results of phase 3 simulations are effective in reducing the number of traffic conflicts and service levels are still in good condition.

Corresponding Author:

Sony Widyawan

Widyawansony12@gmail.com

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1. Introduction

Depok City is one of the cities that supports activities in Jakarta and Bogor Regency with quite busy transportation conditions. Productivity in Depok can accelerate the pace of economic growth, which will have an impact on increasing mobility. The development of the city and the increasing growth in the use of motorized vehicles could potentially cause new problems, especially in the transportation sector.

In addition to the problem of providing road infrastructure that is not proportional to the number of vehicles, issues such as road and crossing obstacles also cause traffic congestion. Transportation problems such as traffic jams, delays or obstacles, traffic accidents, passenger ups and downs, parking of public transport and pedestrian crossings affect the performance of intersections.

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Intersection problems have causes that can affect the performance of intersections. The intersection is a knot in the network in which roads meet and cut the trajectory of vehicles causing high traffic volumes. Moreover, other problems also include the design geometry and low intersection visibility, the lack of regulation of public transport, pedestrian and intersections crossings do not have the right controls.

The intersection is an essential factor in the road network system. Control at each intersection is always an important factor in determining the performance and overall capacity of the road network. For this reason, control of traffic flow at intersections is crucial to improve crossing performance and safety.

The Depok intersection is a meeting between Bogor Highway and Tole Iskandar Road. Bogor Highway is a primary arterial road with high traffic volume and Tole Iskandar Road is a primary collector road that has a fairly busy volume. The meeting between the two roads causes congestion at Depok Intersection to have an impact on vehicle delays and congestion.

In Depok, the closing intersection is shops and public transport stops on the shoulder of the road which causes vehicle delays due to public transportation. Pedestrian activities along the roadside or intersections around the Intersection are quite high even though there are no road equipment facilities available at Depok Intersection.

Regarding the transportation conditions that occur in Depok at this time, especially at the Depok Intersection, it is necessary to conduct research on transportation problems by analyzing the performance of signalized intersections to improve safety at the Depok Intersection. Therefore it is necessary to build regional intersections that have a good phase of adjustment or control.

2. Literature Study

Performance Analysis. According to Spradley in Sugiyono (2015: 335) analysis is an activity to look for patterns other than analysis which is a way of thinking that is related to systematic testing of something to determine parts, relationships between parts and their relationship as a whole. Analysis is an attempt to break down the problem or focus of research into parts (decomposition) so that the arrangement of the form of a decomposed thing is clearly visible and therefore its meaning can be more clearly captured or the case is more clearly understood (Satori and Komariyah, 2014: 200) In general, analysis is the activity of summarizing a large amount of data that is still raw and then grouping or separating relevant components and parts and then connecting the data collected to answer the problem of traffic flow

The number of motorized vehicles that pass the point on the road per unit of time is expressed in vehicle/ hour (Q_{kend}), pcu / hour (Q_{smp}) or LHRT (Average Daily Traffic) (MKJI, 1997). Traffic flow, Q , is expressed in hours per hour for one or more periods, for example in the peak hours of the morning, afternoon or night. Q is converted from vehicle units per hour to hourly curves using a value equivalent to a light vehicle (ekr) for each protected and resisted approach.

Traffic lights are mechanically operated or electrical equipment to order vehicles to stop or run. This standard equipment consists of a pole, and the main lamp with three different colored lights (red, yellow, green).

Traffic conflict is that traffic flow from various directions will meet at the intersection, this condition causes conflict between road users from different directions (Hobbs, 1995 in Setiawan, A.T., 2015). According to Awalata, Greece Maria (2010),

Safety is disaster avoidance, safe sentiment, prosperity, no less, healthy, undisturbed, damaged, lucky, successful, not failed (Poerwadarminta 1976). The meaning of congratulations can also mean a situation that is safe and protected and protected physically, socially, work or other consequences of failure, damage, error, accident, loss, or various other desired events.

Road safety is an inseparable part of the concept of sustainable transportation which emphasizes the principle of being safe, comfortable, fast, clean (reducing pollution/air pollution) and accessible to everyone and all groups, both people with disabilities, children - children, mothers, and parents (Soejachmoen, 2004).

Vissim PTV Computer Program

According to PTV-AG (2011), VISSIM is a multimodal simulation software for microscopic flow of traffic. VISSIM was developed by PTV (Planung Transportation Verkehr AG) in Karlsruhe, Germany.

VISSIM comes from Germany which has the name "Verkehr Städten - SIMulationsmodell" which means an urban traffic simulation model. VISSIM was launched in 1992 and has developed very well to date.

3. Methodology

This research was carried out at the Depok intersection to have a 4-leg national road crossing with 2 leg and another intersection of a 2-leg city road. The following is the study flow chart shown in Figure 1 below:

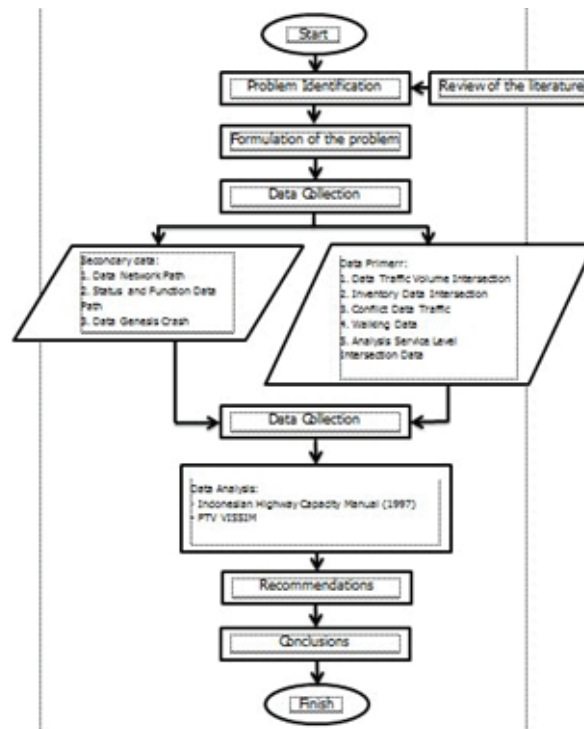


Figure 1: Research Flow Chart.

3.1. Data collection technique

3.1.1. Road inventory

Service level inventory is an activity of collecting data to determine the level of service in each road and/or intersection including data and geometric road dimensions, data on road equipment including the number, type, and condition of road equipment installed,

3.1.2. Vehicle Turning Movement Unclassified / classified turning movement counting (CTMC)

Data traffic volume is used to obtain accurate data about the number of vehicle movements along with vehicles that pass through the intersection and to find out peak hours.

3.1.3. Intersection Level Survey

After conducting a service level crossing survey with existing conditions to obtain data related to the intersection service level. Then the data will be included in the formula to get the Simpang Depok Depok service level to provide the right handling solution.

3.1.4. Conflict Traffic

Surveys do conflict to produce reliable data. Conflict reliability testing is done to ensure that the data obtained is reliable. The reliability testing used the chi-square table. Once the data is reliable, then use the time table for accidents to classify conflicts, including serious conflicts or non-serious conflicts.

Then the time value for conflict accidents by comparing the distance and speed of time to do a comparison between the level of seriousness of the accident to classify the conflict.

Given the seriousness of the conflict, the seriousness of the conflict is calculated per 1000 vehicles. This is done to analyze how many vehicles are involved in the conflict in every 1,000 vehicles (in the current unit).

3.1.5. Pedestrian

Following the Law No. 22 of 2009 concerning Traffic and Transportation, pedestrians are everyone who walks in the traffic space. Because of its moving activities, pedestrians are considered part of traffic movements. To ensure pedestrian safety, rights and obligations are set in traffic.

3.2. Data analysis technique

3.2.1. Service Level of Intersection

a. Capacity (C)

Capacity is the maximum flow of traffic into the intersection can be maintained for at least an hour in weather conditions and geometric existed at that time in units smp / hour (MKJI, 1997).

$$C = S.g/c$$

Where:

C = Capacity (smp / green hour)

S = Flow saturated (smp / green hour)

g Green = Time (sec)

c = Long cycle (seconds)

b. The degree of saturation (DS)

The degree of saturation is defined as the ratio of the flow of traffic on a capacity for closers. The degree of saturation is calculated using the equation:

$$DS = \frac{Q}{C}$$

Where:

DS = Degree of saturation

Q = Traffic (smp / hour)

C =Capacity (smp / hour)

c. delay

According MKJI (1997), the delay is a necessary additional travel time for the vehicle through the intersection when compared to the track without going through an intersection. The delay can be obtained through the calculation:

$$DT_j = c \cdot \frac{0,5 \cdot (1 - GR_j)}{(1 - GR_j \cdot DS_j)} \cdot \frac{NQ_1 \cdot 3600}{C_j}$$

Where:

C = Capacity (smp / hour)

C = Cycle time (sec)

DS = Degree of saturation.

GR = Green ratio (g / c) seconds)

NQ = Total smp remaining from previous green phase

3.2.2. Conflict Traffic

Using the method STCT (Swedish Traffic Conflict Tehnnique) is a direct observation method to get the data traffic conflicts that occur due to the maneuvers of entry and exit of vehicles and parking conflicts between road users with both wrote down a pedestrian or defected. Time to Accident

Figure 2: Time to Accident.

After knew value Time to Accident (TA) by comparing the distance with pace, and to determine the seriousness of the conflict it is necessary to do a comparison between

time to Accident (TA) with speed. Then we will get how serious conflicts at intersections carefully.

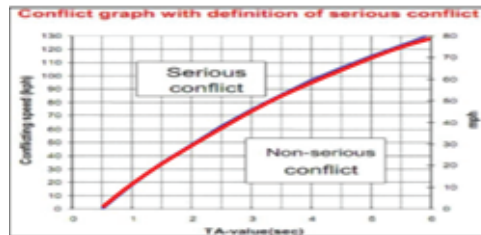


Figure 3: Graph seriousness of Conflict.

4. Results and Discussion

4.1. Existing condition

4.1.1. Road inventory

The Depok intersection located in Depok City has four legs, namely:

- North Leg: Bogor Street
- South Leg: Bogor Street
- West Leg: Tole Iskandar Street
- East Leg: Jatijajar Street

TABLE 1: Geometry of intersections.

Approach	Street Name	Geometric Intersection				Visualized
North	Bogor Depok City Street	The Road Status	National			
		Wide	(m)	11.6		
		Road Type	4/2 D			
		Shoulder	Right (m)	0.3		
		Width	Left (m)	0.3		
		Slope Of The Road	%	2.3		
		Type Pavement	Asphalt			
		Obstacles Inside	medium			
South	Bogor Depok City Street	The Road Status	National			
		Wide	(m)	11.3		
		Road Type	4/2 D			
		Shoulder	Right (m)	0.3		
		Width	Left (m)	0.3		
		Slope Of The Road	%	2.3		
		Type Pavement	Asphalt			
		Obstacles Inside	medium			
West	Tole Iskandar Street Depok City	The Road Status	National			
		Wide	(m)	18.5		
		Road Type	4/2 D			
		Shoulder	Right (m)	0.5		
		Width	Left (m)	0.5		
		Slope Of The Road	%	2		
		Type Pavement	Concrete			
		Obstacles Inside	High			
East	Jatijajar Street Depok City	The Road Status	National			
		Wide	(m)	20		
		Road Type	4/2 D			
		Shoulder	Right (m)	0.5		
		Width	Left (m)	0.5		
		Slope Of The Road	%	2		
		Type Pavement	Asphalt			
		Obstacles Inside	High			

Intersection Performance (Existing)

The calculation phase at this intersection is to use three-phase warning lights and 1 where the total cycle time is 140 seconds. Following is the phase diagram of Depok intersection which can be seen in the following picture:

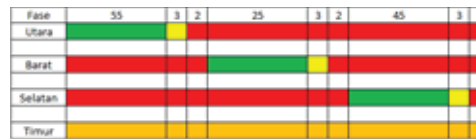


Figure 4: Depok Intersection Phase Diagram.

TABLE 2: Performance of Each Leg in Depok intersection with 3 phases (Existing).

Kaki Samping	Kapasitas (C)	Waktu Siklus	Derajat Kejenuhan (DS)	Panjang Antrian (NQ)	Kendaraan Terehend (NS)	Tundaan (D)	Tingkat pelayanan (LOB)
Utara	1449,05	140	0,99	71,13	1,15	87,24	F
Selatan	1176,80	140	0,99	60,94	1,21	98,86	F
Barat	951,75	140	0,99	51,05	1,25	115,65	F
Timur	951,75	140	0,99	51,05	1,25	115,65	F

Conflict Traffic

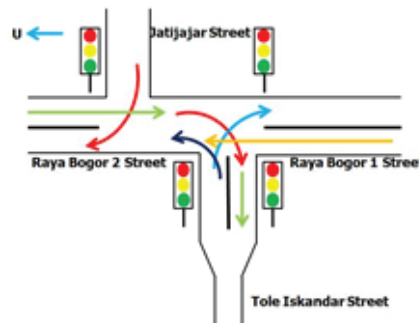


Figure 5: Movement Illustration of Traffic Conflict.

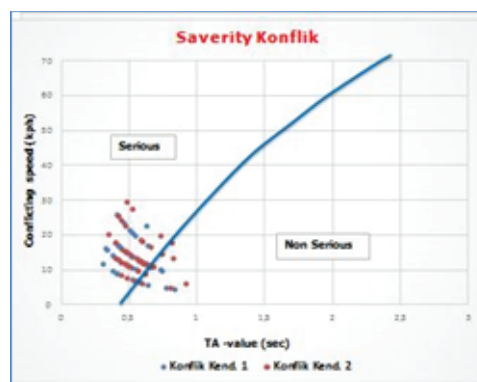


Figure 6: Seriousness Level of the Conflict.

From Figure 6, there have been 127 motor vehicle traffic conflicts at the Depok intersection and there are 63 conflict points, with 81 motor vehicles involved in serious

conflicts and as many as 46 vehicles involved in non-serious conflicts. Whereas the type of conflict itself will be represented in the diagram shown in Figure 7 below.

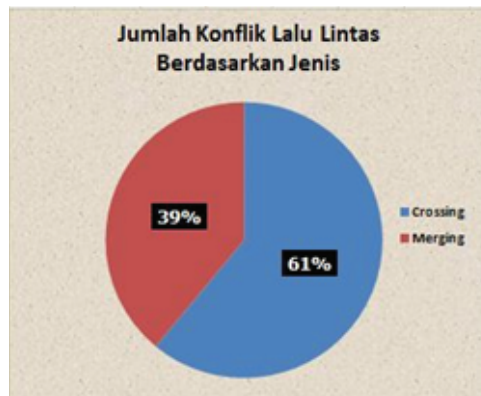


Figure 7: Percentage type of conflict.

In the figure above, chart 7 illustrates the types of traffic conflicts that occur at the Depok peak intersection of 61% dominated by crosses and 39% is a combination of conflicts.

B. Recommendations Proposed Handling

Intersection Performance (Recommendation using 3 Phases and 3.5 Phases)

TABLE 3: Every Leg of Depok Intersection is shown with 3 Phases (Recommended).

Kaki Simpang	Kapasitas (C)	Waktu Siklus	Demot Kelelahan (DE)	Penjang Antrian (NQ)	Kendaraan Tertend (NB)	Tundaan (D)	Tingkat pelayanan (LOB)
Utara	1438,8	211	0,98	98,50	1,08	99,55	F
Baratan	1221,95	211	0,97	79,35	1,04	98,79	F
Barat	1026,65	211	0,91	65,07	1,06	112,38	F
Timur	1026,65	211	0,91	65,07	1,06	112,38	F

TABLE 4: Walking Performance of Every Leg of Depok Intersection 3.5 Phase (Recommended).

Kaki Simpang	Kapasitas (C)	Waktu Siklus	Demot Kelelahan (DE)	Penjang Antrian (NQ)	Kendaraan Tertend (NB)	Tundaan (D)	Tingkat pelayanan (LOB)
Utara	1490,15	280	0,95	113,03	1,02	104,39	F
Baratan	1200,85	280	0,97	94,06	1,04	122,40	F
Barat	1026,60	280	0,88	79,33	1,09	127,86	F
Timur	623,75	280	1,01	56,94	1,18	183,97	F

C. Conflict Traffic (Recommended 3 phases and 3.5 phases)

The proposal or recommendation for conflict handling traffic at the Depok intersection is to reset the cycle phase and time are 3 phases and 1 warning light (existing) into 3 phases (recommendation) and 3.5 phases (recommendation) to do the test using simulation methods using software VisSim PTV for Students. From the simulation results, it is known that the movement of this vehicle occurs at the intersection of the following

Depok 3-phase and 3.5-phase settings. After observing the movement of the vehicle you can see a simulation of traffic flow and conflict at the intersection.



Figure 8: 3-Phase Simulation (After).

From the simulation results, it is known that a number of traffic conflicts still occur at the Depok intersection. There is a comparison of the number of conflicts between three-phase regulations (there are) with 3 phases (recommendations). Here the number of conflicts that occur at the intersection uses 3-phase settings (recommendations).

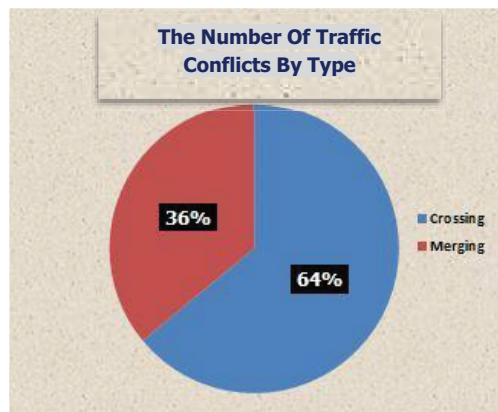


Figure 9: Number of Conflicts Traffic 3.5 Phase (After).

Figure 9 illustrates the number of vehicles involved in the conflict traffic by 63% or by 66 the number of conflicts crossing and 37% or 39 the number of conflicts merging. The graph of the results of an unknown number of existing conflicts ratio (3 phases and 1 warning light) into recommendation (3.5 phase) is reduced.

1. Comparison of Existing and Recommendations

TABLE 5: Comparison of Results of 3 Phase (existing) with phase (recommendation).

No	Number Of Phases	Number Of Conflict	Types of Conflict		Degree Of Saturation (DS)	LOS
			Crossing	Merging		
1	3 fase with 1 warning light	135	88	57	0,99	F
2	3 fase	90	58	32	0,953	F
3	3,5 fase	105	66	39	0,955	F

Based on the analysis, Depok intersection service level that is at the level of service F needs necessary handling and intersection is in critical condition. This statement is the result of the calculation of the service level intersection when on 3 phase has a degree of saturation of the intersection that is 0.953 (F) compared to the existing condition that is 3-phase with one leg intersection at Jalan Jatijajar using the warning light has a degree of saturation of the intersection is 0.99 (F), Recommended uses changes into 3 phases, namely by activating the traffic arrangement on the same road Jatijajar same phase with Tole Jalan Iskandar can reduce the number of conflicts, where the existing condition occurs 135 conflicts with conflict crossing 88 and 32 conflicts merging and after changes into 3 phases without warning light on the road Jatijajar number of conflicts declined to 90 conflict with conflict crossing 58 and 32 merging conflict. Improvements to the intersection for the intersection classified Depok intersection that has a large delay that will impact on congestion.

5. Conclusion

Depok intersection in critical condition and maintenance required at the intersection is 99.56 seconds / pcu with service level F, while the degree of saturation reaches a critical number which is > 0.75 with the value at each leg intersection, namely:

North Intersection Leg: 0.99

South Intersection Leg: 0.99

East Intersection Leg: 0.99

West Intersection Leg: 0.99

Based on the results of the Depok intersection survey, it was found that the seriousness of the conflict at the height of the morning was that 127 vehicles involved in a serious conflict of traffic involving 81 vehicles and 46 vehicles were involved in non-serious conflicts.

It is recommended for the APILL arrangement at the Depok intersection to use phase regulation into 3 phases which reduce traffic conflicts. It is recommended to use three phases that have been analyzed to reduce the number of conflicts where existing conditions occur 135 conflicts with crossing 88 conflicts and 32 conflicts join and after the change the number of conflicts decreases to 90 conflicts with intersection 58 and 32 conflicts combining conflict.

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