

# Intersection Design to Prevent Congestion

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**Abstract**— *The problems of congestion and queuing in Makassar city generally occur at the intersection. One of the intersections in Makassar City that experienced the problem is St. Dr. Ratulangi – St. Lanto Dg. Pasewang – St. Kasuawri.*

*This study was conducted to analyze the junction of the bermal by the method Indonesian Road Capacity Manual (MKJI1997), it is necessary to review the characteristics and composition of the traffic so that it can be calculated the level of saturation and service level of each approach at the intersection, as well as the amount of delay that occurs. The data used for the analysis is obtained by primary data collection and secondary data collection in accordance with the needs of the research. Data analysis begins with the secermination of field conditions, traffic flow, capacity and degree of saturation, and traffic behavior.*

*The maximum saturation value (DS) for each approach is the SOUTH DRAFT. Ratulangi of 1.071259 WEST approach of Street Kasuawri equal to 0,74914776, NORTH approach of St. Dr. Ratulangi of 1.112907, and EASTERN approach of St. Lanto Dg. Passing for 1.11291. Traffic performance / Level Of Service (LOS) is obtained by looking at the Average Pausage value. From the analysis result got average delay of intersection that is 82,407 sec / Vehicle to get Level of Service that is LOSE.*

**Keywords:** *capacity, Level of Service, delay*

## I. INTRODUCTION

Transportation problem is one of the problems facing Makassar City. One of the important factors in the effort towards a good transportation infrastructure system is the ability of road performance, especially the performance of the intersection as one part of the road system as a whole [1]-[5]. Problems of congestion and queue in Makassar city generally occur at intersections (either signaled or unmarked intersections), especially in the area before or after the intersection [7]. When they want to switch to using public transport, it should be in terms of travel costs and travel time at least as cheap and fast when using private transport modes.

From the results of the survey conducted can be seen in the period 2015-2016 population growth rate reached 1.39% (Makassar City In Figures, 2017). The growth rate of vehicles in 2015 for two-wheeled city of Makassar is 6.29%, passenger cars 10.20%, buses 0.74% and trucks 7.55% (Statistics Makassar, 2016). The private transport users prioritize more on travel time, waiting time and total

rate factor to be willing to move to modes of public transport which is also followed by other factors [6].

The above conditions resulted in a decrease in the level of service from the intersection. This can be seen from the long queues on the legs of the intersection. At the intersection St. Dr. Ratulangi – St. Lanto Dg. Pasewang – St. Kasuari is one of the busy intersections in the Makassar area where the area around the intersection is a commercial area because it is located in downtown of Makassar.

To anticipate the above conditions as well as to improve the service level of St. Dr. Ratulangi – St. Lanto Dg. Pasewang – St. Kasuari in the present and future, it is necessary to conduct a study and performance evaluation on the service level of this intersection.

## II. LITERATURE REVIEW

### A. Definition of Intersection

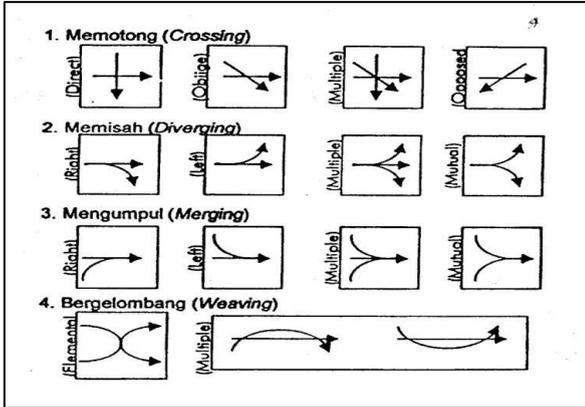
Intersections are an integral part of the road. When driving within the city, one can see that most roads in urban areas usually have intersections. Where the driver can decide to go on or turn and move to another street. The intersection is the node on the road network where the roads meet and the trajectory of the vehicle intersects. The traffic on each of the junction feet uses the road space at the intersection together with the other traffic.

Intersection

At the intersection, especially the intersection of a plot there are 4 types of traffic flow movements that can cause conflict, namely :

1. Cutting (crossing)
2. Split (diverging)
3. Collecting (merging)
4. Wavy (weaving)

Movements and Conflicts on Signal Intersection Optimization



Resource: *Guisecrafting Engineering Practice: Intersection at grade, NAASRA, 1988*

Figure 1. Traffic Flows that may cause conflicts

In optimizing a signal intersection it is necessary to adjust the traffic through the intersection. The main purpose of traffic management generally is to provide instructions which is directed and does not create any doubt. Traffic settings deviated can be achieved using a lamp traffic, markers and signs that govern, direct and pay attention to traffic.

Furthermore, the selection of the intersection setting can be determined with purpose to be achieved as follows:

- Reduce or avoid the possibility of accidents which comes from a variety of points of conflict.
- Maintain the capacity of the intersection in operation so that it can be achieved utilization of the appropriate intersection with a plan.
- In operation, the intersection setting should provide clear instructions and sure and simple, directing the flow of traffic in its appropriate place.

Cross-sectional arrangements with traffic signals are among the most effective, especially for traffic volumes on relatively high legs.

This setting can reduce or eliminate conflict points at intersections by separating the movement of traffic flows at different times. Hobbs (1979) explains that the tabs of junction capacity in all conditions are impossible to implement and often the capacity at the track is more comprehensive than the capacity of the closed area. However, road meetings will largely determine the limits of capacity and security of the entire track. The difficulty is to decide the number of units, either pedestrians or vehicles, that will use the facility, and with a level of security and comfort. From a social point of view, at some level, we must be prepared to receive greater traffic delays in order to increase the level of security. However, in most calculations improving traffic flow will reduce the potential for accidents.

Factors that can be used to influence the capacity of an intersection include:

- A sufficient number of lanes provided to prevent high volumes will not reduce the speed to below the optimum under the conditions of the plan, and large flows should be separated.
- High capacity that requires uniformity of speed vehicle and speed difference relatively small at the entrance and exit.
- Multiple turn movements Requires privileges such as separate additional lines.
- Radius enough for different types of vehicles available to avoid:
- The border violation of the adjacent path and pavement edge should be free of obstacles.
- Suitable skeletons for different types and quantities of existing vehicles or special provisions shall be made for certain levels.

B. Level of Service / Road Performance

Level of service (Level of Service) or road performance is a qualitative measurement that explains about operational conditions in a traffic stream.

Level of service an intersection (usually at a lighted intersection then cross) according to the American HCM'85 is obtained by looking at the additional travel time required to pass an intersection compared to an uninterrupted situation or called Delay.

The service level criteria for the berignal intersection can be seen in the table the following.

Table 1. Service Level

Service Level	(Delay) (sec/Vehicle)
A	≤ 5,0
B	5,1 – 15
C	15,1 – 25
D	25,1 – 40
E	40,1 – 60
F	≥ 60

Source: HCM 85

Level of Service A:

The movement is smooth / excellent and most of the vehicles arrive at a green light.

Level of Service B:

Good movement, vehicles that stop at this level more than vehicles in LOS A.

Level of Service C:

Improper movement and / or longer cycle times. The number of vehicles that stop is very influential at this level, although there are still many vehicles passing through this intersection.

**Level of Service D:**

Poor movements and congestion effects are more noticeable at this level. Due to long cycle times or high vehicle ratios and decreased vehicle ratios.

**Level of Service E:**

Bad movements resulting from high delays are usually addressed. Long cycle time value and high vehicle ratio.

**Level of Service F:**

The condition is completely stuck or when the stream of arrival exceeds the capacity of the intersection.

**C. Delay**

The delay is the additional travel time required to go through the intersection when compared to the path without going through an intersection. The delay consists of a traffic delay that is the wait time caused by traffic interactions and geometric delays caused by the slowing and accelerating of vehicles that veer off and / or are stopped due to traffic lights.

The delay is used as an indicator of the level of service of each approach and a deviation overall is the average delay. According to the Indonesian Road Capacity Manual (MKJI), the delay (D) at an intersection can occur due to 2 (two) things, namely:

- a. Traffic delay (DT) caused by traffic interaction with movement the other on an intersection;
- b. The delay of geometry (DG) caused by slowing and acceleration when turning at an intersection and / or stopping by a red light.

The average delay for an approach is the number of traffic delays average (DT<sub>j</sub>) with geometric delay average (DG<sub>j</sub>) whose equations can be written as follows:

$$D_j = DT_j + DG_j \tag{1}$$

According to the Akcelik, 1998, the average traffic delay (DT) on an approach can be determined by the following equation:

$$DT = c \times \frac{0,5 \times (1 - GR)^2}{1 - (GR \times DS)} + \frac{NQ_1 \times 3600}{c} \tag{2}$$

The average geometric delay (DG) of an approach can be estimated by the following equation:

$$DG = (1 - p_{sv}) \times pT \times 6 + p_{sv} \times 4 \tag{3}$$

with:

psv = the ratio of the vehicle stops on an approach

pT = the ratio of vehicles turning on an approach

**D. Capacity and Degree of Saturation**

**Capacity**

According to MKJI 1997, capacity calculations can be made with path each approach, on one arm may consist of one or more approaches, for example divided into two or more sub-approaches.

This is applied if the right turn movement has a different phase of the traffic is straight or it can also change the physical path is to divide the approach with the island traffic (canalization). Capacity (C) of an approach at the berigned intersection is expressed as follows:

$$C = S \times \frac{g}{c} \tag{4}$$

where:

C = Capacity (smp / hour)

S = Saturated Current (smp / hour)

g = Green time (sec)

c = cycle time (sec)

**Degree of Saturation**

The saturation flow rate is assumed to be fixed during the green phase, but in reality the vehicle still stops when it starts to green, then slowly rise and reach the peak between 10-15 seconds and will decrease slowly until the green ends. Relatively fixed vehicles during yellow and red time all end up down for 5-10 seconds after the start of the red signal.

$$DS = \frac{Q}{C} \tag{5}$$

Where:

DS = Degree of saturation

Q = Traffic flow

C = Capacity

**III. RESEARCH METHODOLOGY**

The methodology used in this study is survey method and model experiment. The data used for the analysis obtained by primary data collection and secondary data collection in accordance with the needs of research. Inventory data obtained by conducting direct surveys to the field and related agencies.

Field conditions were obtained from field survey data including number of phases, cycle time, total lost time, intersection geometry plan, approach width, and environmental condition of intersection. The determination of traffic flow is obtained from traffic flow data from field survey results.

Because the survey data are taken every 15 minute interval, it must first be added to each type of vehicle for each type of vehicle for each direction of traffic flow of each type of vehicle for each direction of movement, so that the total value of movement is obtained.

Methods for Calculating Capacity and Pavement Abstinence were used the Indonesian Road Capacity Manual (MKJI) Method 1997 while the Service Level was obtained using Highway Capacity Manual (HCM) 1985.

IV. DISCUSSION OF RESULTS

A. Road Inventory Survey Crossroads Dr. Ratulangi Street - Lanto Dg. Pasewang Street – Kasuwari Street

In conducting the road inventory survey, a geometric survey of intersections to obtain the physical data of the intersection will be used to calculate the capacity and survey signs and road markings.

a. East approach

Attachment type	= shielded
Median	= None
Gradient	= 0 %
The Width of approach (WA)	= 2,5 m
(WENTRY)	= 2,5 m
(WEXIT)	= 2,5 m

b. North Approach

Attachment type	= Shielded
Median	= None
Gradient	= 0%
The width of the approach (WA)	= 7 m
(WENTRY)	= 7 m
(WEXIT)	= 7 m

c. Southern Approach

Attachment type	= Protected Median = exist
Gradient	= 0%
The width of the approach (WA)	= 7m
(WENTRY)	= 7 m
(WLTOR)	= 7 m
(WEXIT)	= 7 m

d. Western approach

Attachment type	= Shielded Median = None
Gradien	= 0%
Width of (WA)	= 2,5m
(WENTRY)	= 2,5m
(WEXIT)	= 2,5m

Surveys of signal systems are performed to obtain time / operating system data that regulates the movement of incoming vehicles. The data collected are phase number, phase shape, phase sequence and cycle time duration consisting of 3 (three) aspects ie green, yellow and red.

From the field survey the phase division, signal time and each cycle are obtained phase. The first phase secermination starts from west to east.

From the observation at this intersection there are 4 phases as can be seen in the picture below.

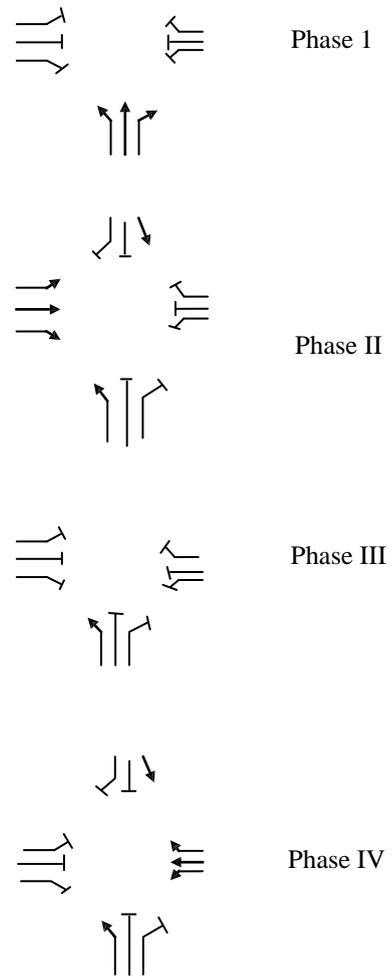


Figure 2. Phase at the Crossroads

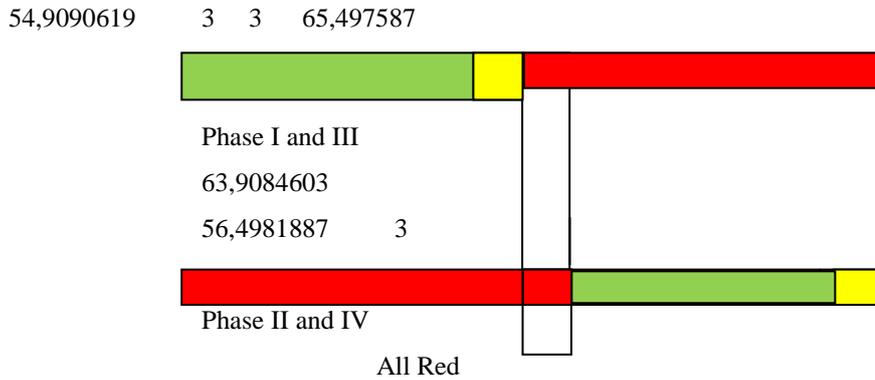


Figure 3. Intersection Cycle Time

**B. Capacity and Degree of Saturation**

According to the saturated flow rate that has been adjusted, the following are presented Table 2 results of calculation of intersection capacity and the degree of saturation for each approach, as well as the saturated current of each approach

Table 2: Saturation Flow, Intersection Capacity and Degree of Saturation

Name of Approach	Code	S	Q	C	DS
Dr.Ratulangi	S	4311,496	1690,6	15,190,847	1,071259
Kasuawri	B	4428,265	1671,4	956,820593	0,74914776
Dr Ratulangi	U	1691,943	716,8	15,190,847	1,112907
Lanto Dg. Pasewang	T	1941,947	1222,2	1098,20182	1,11291

**C. Delays and Levels of Service**

The delay that occurred at the intersection signals can be caused by traffic (DT) and geometric delay (DG). The delay due to traffic is based on the movement of each vehicle that together passes through

1. Traffic Delay (DT)

$$DT = c \times A + \frac{NQ1 \times 3600}{C}$$

$$\rightarrow A = \frac{0,5 \times (1 - GR)^2}{(1 - GR \times DS)}$$

Southern Approach (Tikala) DT = 154,978 sec / vehicle

Western Approach (City Center) DT = 43,4315165 sec / vehicle

North Approach (Pasar kanaka) DT = 172,443481 sec / vehicle

Eastern Approach (Paal2) DT = 81.3919836 sec / vehicle

2. Geometry Delay

$$DG_j = (1 - PSV) \times PT \times 6 + (PSV \times 4) \times PSV = N_S$$

PT = Turn vehicle ratio

South Approach (Tikala) DGj = 5.54394854sec / Vehicle

Western Approach (City Center) DGj = 4,68513047 sec / Vehicle

Approach Utara (Pasarkanaka) DGj = 6.48770709 sec / Vehicle

Seasonal approach (Paal2) DGj = 5,71933596 sec / Vehicle

3. Average vehicle delay (D)

$$D = DT + DG$$

a. The approach of the East (PaalII)

D EAST = 87,1113196sec / Vehicle LOSE

b. The approach of North (Market Kanaka) DUTARA = 178.931188 sec / Vehicle LOSF

c. The South Approach (Tikala)

D SOUTH = 160.522564sec / Vehicle LOS F

d. Western Approach (City Center) DBARAT = 48,116647sec / Vehicle LOSE

4. Total Deferrals

$$\text{Total delay} = D \times Q$$

Southern Approach = 268297,413 sec

Western approach = 34490,0126 sec

Northern approach = 302501,066 sec

East Approach = 106467,455 sec

Total Mortgage = 711755,947 sec

5. Average intersection delay

Total delay intersection = 711755,947 sec

Total traffic flow = 8632 Vehicle

The average inverted delay = 711755,947 / 8637

= 82.407 sec / Vehicle LOSE

**V. CONCLUSION**

From the analysis results can be concluded things as follows:

1. The maximum saturation value (DS) for each approach is the SOUTH DRAFT. Ratulangi Street amounted to 1.071259 WEST approaches Kasuawri Street of 0.74914776, the NORTH approach of the Dr. Ratulangi street is 1.112907, and EASTERN approach is Lanto Dg. Pasewang Street is 1.112912.
2. Traffic performance / Level Of Service (LOS) is obtained by looking at the value Average Delay. From the analysis result got an average delay of intersection

that is 82,407 Sec / Vehicle to get Level of Service that is LOS E which means poor movements resulting from high delays, usually attributing long cycle time values and high vehicle ratios.

3. The Junction of Jl. Ratulangi - Jl Kasuawri - Jl Lanto Dg. Pasewang averages over 82.407 det / kend which means that if a vehicle will pass through this intersection it will experience a delay of 82.407 seconds.

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