Micro-Simulation Analysis of Traffic on Underpass Processing Plan at the Intersection of Mandai in Makassar

Algifar, Muhammad Isran Ramli, Arifin Lipoeto

***Abstract:** The rapid growth of population in Makassar City directly increases the vehicles on road and causing traffic congestion. The intersection of Mandai in Makassar City experience heavy traffic flow condition and Mandai Underpass is developed. This study simulates and analyzes the condition of traffic flow at the Mandai intersection using the Mikro-Simulasi technique which is Vissim software program. The peak hour season of traffic flow is considered in this study which is morning (07.00–08.00), afternoon (12.00–13.00) and evening (16.00–17.00). The calibration and validation process of the simulation model using the volume and length of the queue of vehicles in the field and GEH Test analysis (Geoffrey E. Havers). The simulation model was successfully demonstrated and results pass the Chi-square test. The result show that, Frontage Toll Road DR. Ir. Sutami has the longer queue length in morning about 342.45m, while Makassar-Maros Axis Road has the longer queue length in afternoon and evening which is 503.49m and 602.69m respectively.*

***Keywords:** GEH test, Vissim simulation, Traffic flow, Underpass*

I. INTRODUCTION

Makassar City is the fifth largest city in Indonesia and the largest in the Eastern Region of Indonesia which has an area of 199.26 km^2 with a population of 1,652,305 in 2015 [1]. The Makassar City Samsat data explained that the growth of vehicles from 2015 to 2016 contained 1,425,151 or an increase of around 87,009 units from 2014 which passed through the Makassar City road [2, 3]. This population growth has caused urbanization flows from several regions in South Sulawesi to continue to increase so that the government of South Sulawesi must improve the flow of transportation in the city, especially the City of Makassar in order to improve the comfort of the residents of Makassar City. Traffic conditions are characterized by high density especially at intersections.

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Algifar, Civil Engineering Department, Faculty of Engineering, University of Hasanuddin, Jl. PerintisKemerdekaan Km. 10, Tamalanrea Indah, Tamalanrea, Kota Makassar, Sulawesi Selatan, 90245, Indonesia,

Muhammad Isran Ramli, Civil Engineering Department, Faculty of Engineering, University of Hasanuddin, Jl. PerintisKemerdekaan Km. 10, Tamalanrea Indah, Tamalanrea, Kota Makassar, Sulawesi Selatan, 90245, Indonesia

Arifin Lipoeto, Civil Engineering Department, Faculty of Engineering, University of Hasanuddin, Jl. PerintisKemerdekaan Km. 10, Tamalanrea Indah, Tamalanrea, Kota Makassar, Sulawesi Selatan, 90245, Indonesia

In other words the existing intersection capacity if not proportional to the volume of the vehicle may cause congestion on the main road sections [4]. The implementation of signs, roundabouts, and traffic lights are commonly used to resolve the congestion problem caused by vehicle conflicts. Reduce in level of service usually indicated by increasing congestion and accidents. Besides construction of new road infrastructure and road widening, the traffic congestion problem can be solves by utilizing the existing road network and optimizing traffic facilities properly and efficiently [3, 5, 6]. However, for the movement of vehicles in the national segment, the construction of Underpasses or underground roads is considered. In calculating the level of performance of the traffic flow starting at the intersection as a critical point of the traffic system, because all the vehicles from various directions are meet at the intersection.

The heavy traffic conditions at intersection Mandai make this intersection performance far more difficult to improve. At intersection Mandai, there are five intersection does not equipped with the signified sign which is the corner of the intersection towards Jl. The Maros-Makassar shaft in the direction of Jl. Dakota (AURI), Jl. Baru Airport, Jl. DR. Ir. Sutami and Jl. Makassar-Maros Axis(PerintisKemerdekaan), Therefore, Mandai Underpass is developed to improve the inappropriate intersection performance. This study simulates and analyzes the condition of traffic flow at the Mandai intersection using the Vissim software program.

II. METHODOLOGY

The study was carried out at the intersection of the Mandai intersection underpass. The primary analysis of primary data consists of intersection geometric, the volume and speed of traffic at the intersection whichobtained from survey. The types of vehicles analyzed in this study are light vehicles, heavy vehicles and motorbikes. The survey and data collection were carried out in the period between 6:00 a.m. and 11:00 p.m. for two days (6th and 7th October 2016), which are one working day and one holiday. Vehicle speed is measured by speed gun in the field and taken randomly on all types of vehicles. The analysis of intersection is performance using the Vissim PTV Program.

Survey Methods

The primary data is collected from survey process. The implemented field survey methods in this study are:

- The intersection inventory survey is conducted to obtain the information about the conditions of land use and the transverse profiles at intersections manually.
- The vehicle flow survey is conducted to calculate the flow of vehicles and vehicle composition and the ratio of turning movements that passed at the intersection. A camcorder / survey camera can be used to record for the crossing geometric designs, control studies and intersection capacities.
- The vehicle speed survey is conducted to determine the speed of the vehicle when crossing each approach at the intersection and Speed Gun is used to collect the data.

Geometric Conditions of Intersection

The geometric data of intersections such as conditions of road and lane are collected from survey and tabulate in Table 1.Figure 1illustrates the Mandai Intersection Plan with the points of conflict at this intersection.

Table. 1 Geometric Condition of Intersections

Name	Road Name	Quantity		Line Width (m)
		Road	Lane	
Mandai intersection	JalanPoros Makassar-Maros	2	6	15.02
	JalanPorosMaros-Makassar	2	6	12.22
	TunelPoros Makassar Maros	2	4	16
	JalanTol DR. Ir. Sutami	2	5	20.86
	Frontage Tol DR. Ir. Sutami	2	4	11.14
	JalanBandaraBaru	2	6	15.24
	Frontage BandaraBaru	2	4	10
	Jalan Dakota (AURI)	2	2	6.34

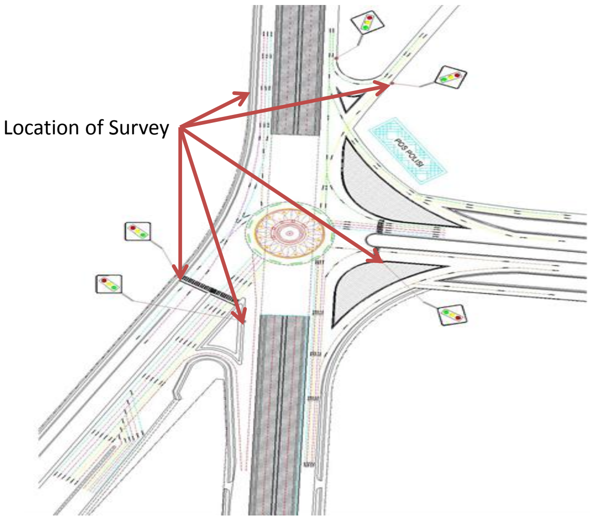


Fig. 1 Point of Conflict and survey locations of Mandai Traffic

Survey Equipment and Placement

The survey tools used for this study are laptop, roll meter, tripod, speed gun, survey form and stationery. The primary data is collected at the research location either through recording or measurement directly at the survey location with the survey equipment for 18 hours with a total of 20 participants at 5 (five) points as shown in Figure 1.The data taken for this study is data on vehicle traffic volume.

Data Analysis Method

Data compilation is data from survey forms then recap and tabulated using excel software such as inventory data, vehicle volume data, and speed data. Besides that, this study used micro simulation software PTV Vissim 9 which functions to simulate the junction model.

Calibration and Validation Using GEH Statistical Test

The simulations parameter inVissimis calibrated using vehicle volume in order to calculate the intersection performance in this study. The GEH test is used to validate the simulation result by comparing the results of the model with the results in the field. In this stud, the volume of the vehicle from the results of the model is compared with the volume of vehicles in the field.

III. RESULT AND DISCUSSION

Composition of Vehicles at Intersections

The composition of vehicles passing through each intersection will greatly affect the results of the calculation of intersection performance, especially the length of the queue of the vehicle so that the composition of vehicles that cross the intersection according to the category or type of vehicle is needed, the flow of traffic passing through each approach or the foot of the intersection. The types of vehicles are categorized namely light vehicles, heavy vehicles and motorbikes. This type of light vehicle is categorized into several types, namely small city car, big city car, sedan, MVP (Multi-Purpose Vehicle), SUV (Sport Utility Vehicle), Transportation, Small Bus, and Pick Up. Heavy vehicle types are categorized in several types, namely Big Bus, Truck 2 Axles, Truck 3 Axles, Truck 4 Axles and Trailers. The type of motorcycle is categorized in several types, namely Duck Motor, Matic Motor, and Sport Motor.

Vehicle Types and Dimensions at Mandai Intersection

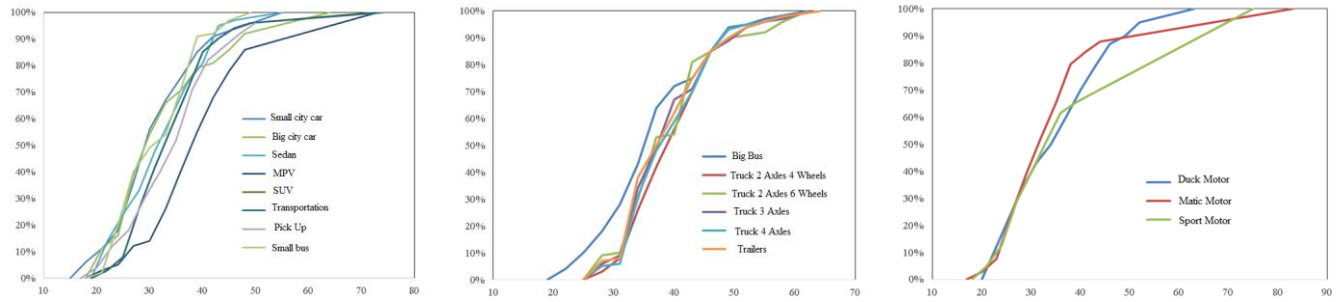
The characteristics and types of vehicles that pass the Mandai intersection are different based on vehicle dimensions. The differences size of vehicle will greatly affect the results of performance calculations at the intersection. The dimensions of the different vehicle are shown in Table 2.

Table. 2 Vehicle Types and Dimensions at Mandai Intersection

Categories	Vehicles Dimensions (m)		Categories	Vehicles Dimensions (m)	
	Length	Width		Length	Width
Small city car	3.600	1.600	Truck 3 Axles	8.200	2.612
Big city car	4.135	1.755	Truck 4 Axles	9.777	2.632
Sedan	4.395	1.715	Trailers	12.283	2.640
MVP (Multi-Purpose Vehicle)	4.580	1.770	Small Bus	6.711	2.303
SUV (Sport Utility Vehicle)	4.600	1.820	Big Bus	9.895	2.700
Transportation	4.445	1.855	Duck Motor	1.970	0.670
Pick Up	3.930	2.042	Matic Motor	1.860	0.680
Truck 2 Axles	5.830	2.100	Sport Motor	1.983	0.690

Speed profile of vehicle traffic flows at intersections

Vehicle speed is very important and greatly influences the time required for vehicle to speed. Figure 2(a, b and c)illustrate the speed of distribution for the type of veliclein all approaches to the Mandai intersection. The graphs in Figure 2 shows that the phenomenon of vehicle speed frequency at intersections which tends to be normally distributed, the graph shows that the frequency of speed distribution based on vehicle types is also almost the same except for the types of trucks and buses that have relatively little frequency.



(a) (b) (c)

Fig. 2 Graph of speed of distribution for the type of vehicle(a) Light Vehicle Speed, (b) Speed of Heavy Vehicle Speed and (c) Speed of two-wheeled vehicles

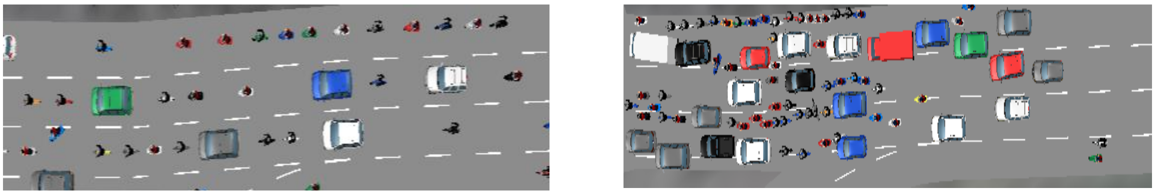
Micro-Model Calibration - Simulation

The implemented micro-simulation model is calibrated to ensure the results of the analysis are in accordance with reality in the field. The simulation parameter is established with the aril and error method and follow by the GEH Test analysis (Geoffrey E. Havers). The parameters in the Vissim simulation tool are defined correspond to heterogeneous traffic conditions. The calibration process is conducted on the vehicle volume in peak hour periods for morning, afternoon and evening. The calibration values and calibration results in the GEH Test are shown in Table 3.

Table. 3 Calibration Values at Intersections

Parameter	Time Period		
	07.00–08.00	12.00–13.00	16.00-17.00
Average Standstill Distance	0.3	0.5	0.5
Add. Part of Desired Safety Distance	0.5	0.5	0.5
No. of Observed Vehicle	2	2	2
Minimum Headway	0.50	0.50	0.50
Lane Change Rule	Free Lane Change	Free Lane Change	Free Lane Change
Overtake at Same Line	yes	yes	Yes
Desired Lateral Position	any	any	Any
Lateral Distance Standing	0.2	0.2	0.2
Lateral Distance Driving	0.4	0.6	0.5

Table 3 presents a selection of parameters along with their calibration values, the results of the calibration show that some parameters have the same value in each period, while the Average Standstill Distance and Lateral Distance Driving parameters have different values based on the simulation time period. Parameter values in the subsequent simulation model are validated to measure the accuracy of the model and parameters that have been formed previously. The reference used in the micro-model calibration is the vehicle volume which used as a parameter to measure the model by comparing the volume of model vehicles and observations in the field. The micro model calibration results - simulations are presented in the form of GEH Table 4 and visualized in Figure 3(a) and (b).



(a) before calibration (b) after calibration

Fig. 3 Micro 3D Visualization - VissimintersectionPettarani - Alauddin

Table. 4 Test Calibration Results of Geoffrey E. Havers in the Volume of Traffic Flow

Conditions		**Period**		
		07.00–08.00	**12.00–13.00**	**16.00–17.00**
Model	Bandara	5020	4484	4536
	Dakota	253	499	673
	PorosMaros	3580	3243	3653
	Frontage Toll	263	479	654
	Toll	4555	4103	5036
	Perintis	4511	4019	4896
Observation	Bandara	5063	4548	4603
	Dakota	268	564	735
	PorosMaros	3483	3190	3557
	Frontage Toll	282	589	753
	Toll	4375	3807	4580
	Perintis	4156	3729	4512
UjiGEH	Bandara	0.61	0.95	0.99
	Dakota	0.93	2.82	2.34
	PorosMaros	1.63	0.83	1.59
	Frontage Toll	0.93	2.82	2.34
	Toll	2.02	3.23	4.51
	Perintis	2.04	3.39	4.59
Conclusion		**Accepted**	**Accepted**	**Accepted**

Table 4.3 show the results of the calibration with the Geoffrey E. HaversTest which indicate that at intersection APPettarani - Sultan Alauddin Road has been well calibrated for all approaches. Figure 4.37 shows the difference in visual appearance in the Vissim before and after calibration. Before the calibration process, vehicle queues and located on the lane regular of each other vehicle, while irregular and the distance between vehicles is close to each other vehicle is demonstrated after the calibration process. This shows traffic behavior in heterogeneous traffic, which means the simulation conditions are in accordance with the traffic conditions in the field. The calibration process is done by changing the parameter of driving behaviour which is Average Standstill Distance and Lateral Distance Driving value.

Micro-Model Result Validation Simulation

Validation process is carried out on the simulation model to measure the accuracy of the model and parameters that have been formed previously. The reference in the validation is the length of the vehicle queue whereby the queue length in the simulation model is comparedwith the observation results in the field. The analysis used is the Chi square test and the probability value of the Chi-square test is determined. Table 5 shows that based on the results of Chi-Square Test with a degree of confidence in Chi-square test of 95% or $\alpha = 0.05$, where the table value x^2 in the Chi-square table is 11.07 while for all approaches the model meets the requirements of x^2 calculated $\leq$ x2 Chi-square table results so that the model is declared valid.

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Table. 5 Validation Results with Chi-square Test on Vehicle Queue Length

Conditions		Period		
		07.00–08.00	**12.00–13.00**	**16.00–17.00**
Model	Bandara	124.48	95.84	128.27
	Dakota	31.46	29.18	10.41
	PorosMaros	250.82	503.49	602.69
	Frontage Toll	342.45	301.61	275.17
	Toll	276.41	310.12	256.59
	Perintis	245.47	327.17	372.45
Observation	Bandara	124.48	105.45	64.56
	Dakota	37.69	30.14	16.25
	PorosMaros	250.82	536.23	582.36
	Frontage Toll	342.45	301.61	275.17
	Toll	276.41	310.12	256.59
	Perintis	245.47	327.17	372.45
.5Chi-square test	Bandara	0.928	2.071	2.780
	Dakota	0.353	0.631	0.543
	PorosMaros	1.236	1.589	2.254
	Frontage Toll	0.353	0.631	1.533
	Toll	0.256	0.543	1.286
	Perintis	0546	2.734	0.353
Conclusion		**Accepted**	**Accepted**	**Accepted**

IV. CONCLUSION

The results of the micro-simulation model of traffic conditions at intersection Mandaiare performed using Vissim software. The calibration and validation process of the simulation model using the volume and length of the queue of vehicles in the field. The calibration process is by changing the parameter values of the driving behavior, namely Average Standstill Distance and Lateral Distance Driving value.

Results of traffic performance of existing conditions at intersection Mandai based on micro-simulation results on Frontage Toll Road DR. Ir. Sutami has the longer queue length and delay on morning which is 342.45 meters, while the length queue and delay for Makassar-Maros Axis Road in afternoon and evening is 503.49 meters and 602.69meters respectively.

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