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The Use of Transport Modeling to Evaluate the Implementation of Pedestrianization in Maliboro Area, Yogyakarta

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***Abstract*—Malioboro Area is the city centre of Yogyakarta. It is a very busy area. There are many shops, public utilities and attractions in this area. Many visitors come to this area, especially during long weekends and holidays. There is a plan to close and pedestrianize Malioboro main street. Traffic surveys were carried out in Malioboro and the surrounding areas. JICA Strada transport modeling software has been used to analyze the effects of pedestrianization in this area. There are some alternatives, i.e.: pedestrianization for the whole area of Malioboro or pedestrianization for only a part of Malioboro. The research result shows that if scenario 1 is applied, the increase of traffic volume on the road network does not give significant impact towards its performance and it still resembles the existing condition. Furthermore, if the scenario 2 is implemented, there would be severe traffic jam on Jl. Mataram with DS value > 3,5 on the weekdays and DS>2 on the weekends. Therefore, if the local government policy related to Malioboro area arrangement is still implemented, the transportation management and transportation engineering must be improved, especially on Jl. Mataram. The OD matrix used is in the form of traffic volume data of the road network node selected for the study. As a result, it enables the achievement of high correlation value between real volume and existing volume of the result modeling.**

Keywords*—pedestrianization, transport modeling, JICA Strada

I. INTRODUCTION

Transportation is one of the main problems in Indonesia, especially in urban area. The problem is currently faced and a very typical problem in most cities in developing countries. Rapid population growth and the increased demand for private vehicles have been confronted by an existing road network totally unsuited to carrying large traffic volume. There is a major conflict between the intended use of road-space for vehicle movement and the actual but inappropriate use of the carriageway by slow-moving vehicles and pedestrians.

In shopping areas, roads are reduced by parked vehicles and pedal-cycle rickshaws (becak) - either carrying or waiting for passengers. The location of shops and small businesses that face directly on to roads, often take up the available verge space.

Actually, the problem is the most familiar one, with the following main elements:

- To define environmental areas
- To minimize traffic in these areas
- To provide better facilities for people who have business in these areas
- To define the identity of the city

The objective of this research is to analyze the impact of the road closing in Malioboro area toward the traffic.

II. LITERATURE REVIEW

Malioboro as one of tourist destinations in Yogyakarta has a massive attraction for visitors. On daily basis, more than 4.000 people make a visit to this area. A significant increase of the growing number of visitors each year causes the sidewalk to be unable to accommodate the coming tourists. The number of pedestrians has increased to 5.2% and it affects the poor condition of Malioboro area especially the pedestrian facility. Therefore, the rearrangement of pedestrian area along Maliboro street needs to be carried out [1]. Based on the research composed by Aloys Borgers and Harry Timmermans, the traffic in shopping area consists of pedestrians. Therefore, it is related to the fact that crowded hours in Malioboro as the biggest shopping area is also contributed by the number of pedestrians [2].

The rapid growth of the number of tourist visiting Malioboro gives impact to the increase of vehicle volume in Yogyakarta which leads into a more populated area, whereas the existing traffic in Malioboro and about is in a saturated condition which is shown through Degree of Saturation (DS) in Malioboro street of 1.26 with the average DS of surrounding road network of 0.52 [3].

To return the function of pedestrian area in Molioboro, the area rearrangement that prioritizes pedestrians, non-motorized vehicle users, and public transportation should be executed. The simulation models of traffic can help to evaluate the traffic

management especially in city area [4]. The rearrangement includes Malioboro road closure and new alternative access to enter and exit the area. Thus, it becomes the reason to provide new parking lots which are evenly distributed, such as parking area in Abu Bakar Ali, Yogyakarta Tourism Office, and Indra Cinema's old building. In this particular condition, the average road network shows traffic delay of 2 minutes and 43 seconds, and the average queue length is 63,1 seconds [5].

The road closure in Malioboro area from motorized vehicles as well as the changing of its function to a Pedestrian Area based on the local regulation in Yogyakarta Number 02 Year 2010 about Spatial Planning in Yogyakarta Year 2010–2029 Article 80 will expectedly give real impact towards the changes on road network system around Malioboro. Traffic engineering is an effort to create solution for the traffic problems that may appear as the impact of the changing Malioboro area into a pedestrian area. In addition, one of the applications which can be applied to help this traffic engineering process is JICA Strada.

III. METHODOLOGY

This study is initiated by collecting data of the road networks which will be used as model. Afterward, the basic road networks on existing condition will be made. Besides the road network, Origin-Destination Matrix is required and it will be followed with road network loading. The result of the road networking loading validity will then be examined. Once the validity value is gained and it is close to the required value, the scenario of Malioboro area road closure will be created. Several data must be collected to reach the objective consist of:

A. Area of Study

Area study is determined by considering several roads which are estimated enduring the traffic flow devolution starting from Malioboro - Ahmad Yani Street in which motorized vehicles are restricted in these streets. The study area is shown in Fig. 1.

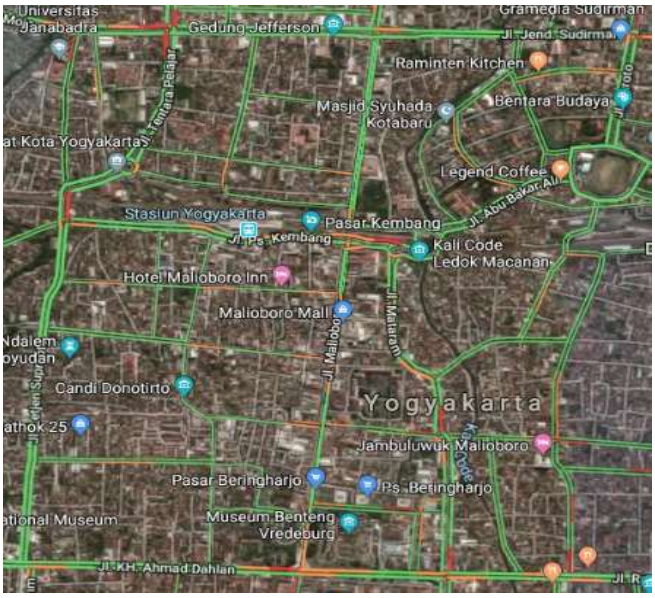

Fig.1. Area of Study

B. Road Characteristics

The data of road characteristics, such as type of road and road width are obtained from Yogyakarta Transport Agency. Then, referring to the Indonesia Highway Capacity Manual 1997, this manual calculates the road capacity and the free flow speed as the result is revealed in Table I.

TABLE 1. ROAD CHARACTERISTICS

Name of Street	Type	Width (m)	FFS (kph)	C (pcu/h)
Malioboro	2/1 UD	7	34.24	1,941
Ahmad Yani	2/1 UD	7	38.77	1,941
Mataram	4/2 D	13	36.18	1,804
Mangkubumi	2/1 UD	12	41.54	2,348
Ahmad Dahlan	4/2 UD	13	45.54	2,491
Pasar Kembang	2/2 UD	9	35.57	2,658
Bhayangkara	2/1 UD	9	39.41	2,613
Abu Bakar Ali	4/2 UD	12	42.36	4,619

C. Traffic Flow

When a traffic model is successfully created, this data is used to evaluate whether or not the model traffic flow is statistically similar to the field traffic flow. This data is obtained from the Yogyakarta Transport Agency based on traffic counting survey in 2010. Traffic flow on Thursdays as weekdays and Sundays as weekends are chosen as representation of day's traffic flow. The peak-hour traffic is shown in Table II.

TABLE II. TRAFFIC FLOW AT PEAK HOURS
(PASSENGER CAR UNIT PER HOUR)

Name of Street	Week Day (Thursday)	Weekend Day (Sunday)
Malioboro	2016	1804
Ahmad Yani	2541	2337
Mataram	3096	1699
Mangkubumi	1875	1657
Ahmad Dahlan	1203	1242
Pasar Kembang	978	861
Bhayangkara	1056	991
Abu Bakar Ali	4836	4750

D. Origin Destination Data

The origin-destination matrix is an exceptionally important data in conducting transportation planning and modeling in particular study area. The method of on-field interviewing survey applied in order to obtain the origin-destination matrix needs high cost, spends more energy, takes more time, and also it disturbs the existing traffic [6].

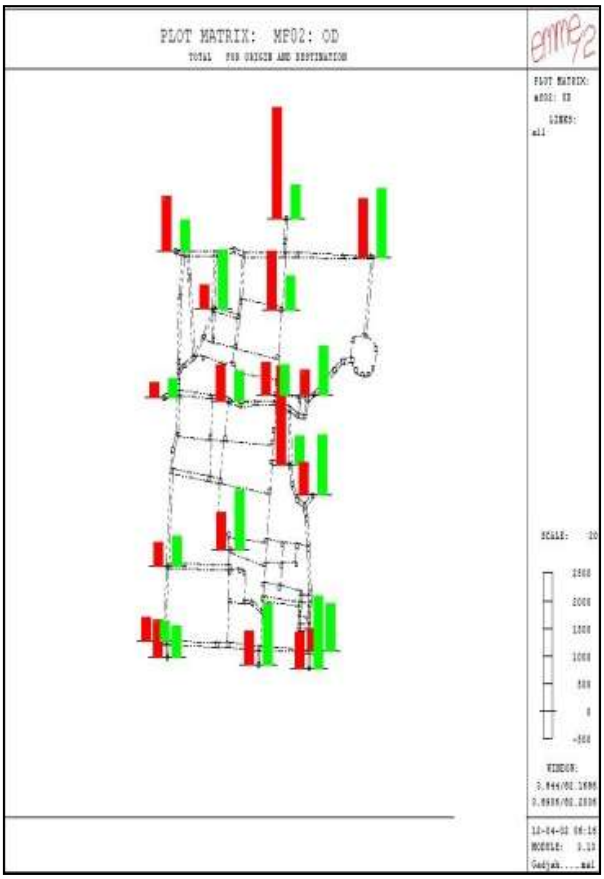

Fig. 2. Weekend Trip-based Origin Destination Matrix

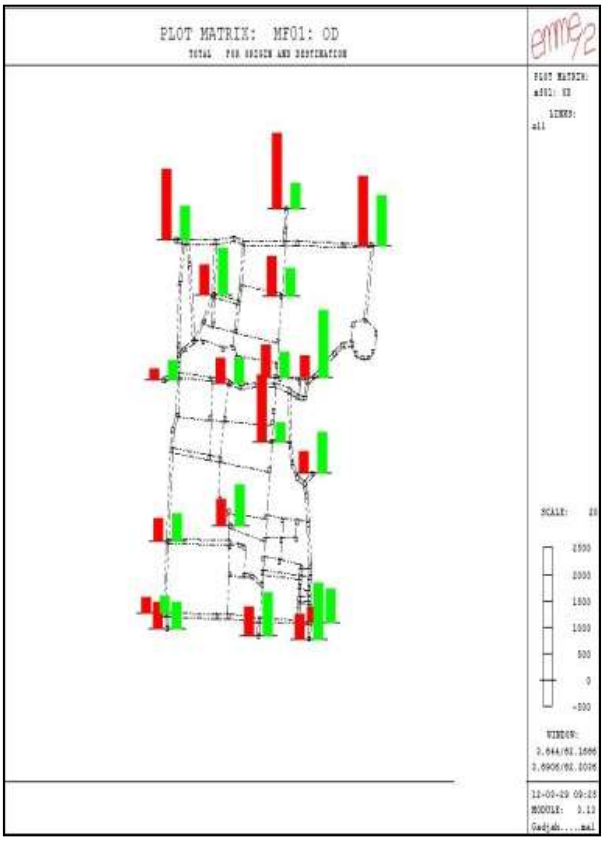

Fig. 3. Weekday Trip-based Origin Destination Matrix

The origin-destination data in this research is secondary data taken from study result of Irawan [7]. This secondary data is gained by using entropy maximum method shown in Fig. 2 and Fig. 3. afterward, the conversion of the data in the Fig. is done to determine the moving spread by applying Furness method. The result can be viewed in Table III and Table IV.

TABLE III. WEEKDAY TRIP-BASED ORIGIN DESTINATION MATRIX

WEEK DAY	DESTINATION										
	O/D	1	2	3	4	5	6	7	8	9	10
ORIGIN	1	0	38	41	28	26	42	27	34	112	17
	2	37	0	35	24	22	36	23	30	96	14
	3	18	17	0	12	11	18	11	15	48	7
	4	12	11	12	0	8	12	8	10	33	5
	5	17	15	17	11	0	17	11	14	45	7
	6	36	32	35	23	22	0	22	29	94	14
	7	29	26	28	19	18	28	0	23	75	11
	8	34	30	32	22	21	33	21	0	88	13
	9	17	16	17	11	11	17	11	14	0	7
	10	11	10	11	7	7	11	7	9	30	0
	11	18	17	18	12	11	18	11	15	48	7
	12	17	16	17	11	11	17	11	14	46	7
	13	29	26	28	19	18	28	18	23	75	11
	14	20	18	19	13	12	19	12	16	52	8
	15	34	31	33	22	21	34	21	28	90	13
	16	19	17	18	12	11	18	12	15	49	7
	17	21	19	20	14	13	21	13	17	54	8
	18	40	36	38	26	24	39	25	32	104	15
	19	69	62	67	45	42	68	43	56	182	27
	20	69	62	67	45	42	68	43	56	182	27
	21	69	62	67	45	42	68	43	56	182	27
	22	69	62	67	45	42	68	43	56	182	27

WEEK DAY	DESTINATION												
	O/D	11	12	13	14	15	16	17	18	19	20	21	22
ORIGIN	1	41	36	28	64	27	62	124	69	103	103	100	103
	2	35	31	24	55	23	53	106	60	88	88	88	88
	3	18	15	12	27	12	27	53	30	44	44	44	44
	4	12	10	8	19	8	18	36	20	30	30	30	30
	5	17	14	11	26	11	25	50	28	41	41	41	41
	6	35	30	24	53	22	52	104	58	86	86	86	86
	7	28	24	19	43	18	42	83	47	69	69	69	69
	8	32	28	22	50	21	49	98	55	81	81	81	81
	9	17	15	12	26	11	25	51	28	42	42	42	42
	10	11	9	8	17	7	16	33	19	27	27	27	27
	11	0	15	12	27	12	27	53	30	44	44	44	44
	12	17	0	12	26	11	25	50	28	42	42	42	42
	13	28	24	0	43	18	42	83	47	69	69	69	69
	14	19	16	13	0	12	29	57	32	47	47	48	47
	15	33	29	23	51	0	50	100	56	83	83	83	83
	16	18	16	12	28	12	0	54	30	45	45	45	45
	17	20	17	14	31	13	30	0	34	50	50	50	50
	18	38	33	26	59	25	57	115	0	95	95	96	95
	19	67	58	46	103	43	100	201	113	0	167	167	167
	20	67	58	46	103	43	100	201	113	167	0	167	167
	21	67	58	46	103	43	100	201	113	167	167	0	167
	22	67	58	46	103	43	100	201	113	167	167	167	0

TABLE IV. WEEKEND TRIP-BASED ORIGIN DESTINATION MATRIX

WEEKEND DAY	DESTINATION										
	O \ D	1	2	3	4	5	6	7	8	9	10
ORIGIN	1	0	31	27	14	23	27	16	22	70	11
	2	20	0	21	11	18	21	13	17	55	8
	3	12	15	0	7	11	13	8	10	33	5
	4	8	10	8	0	7	8	5	7	21	3
	5	13	15	13	7	0	14	8	11	35	5
	6	18	21	18	10	16	0	11	15	48	7
	7	15	18	16	8	14	16	0	13	41	6
	8	18	22	19	10	17	19	12	0	50	8
	9	9	11	10	5	8	10	6	8	0	4
	10	10	11	10	5	9	10	6	8	26	0
	11	14	16	14	8	12	14	9	12	37	6
	12	12	15	13	7	11	13	8	10	33	5
	13	31	38	33	17	28	33	20	26	84	13
	14	13	16	14	7	12	14	8	11	35	5
	15	22	26	23	12	20	23	14	18	59	9
	16	16	19	17	9	15	17	10	14	43	7
	17	12	14	12	7	11	13	8	10	32	5
	18	26	31	27	14	23	27	16	22	69	11
	19	43	52	45	24	39	45	27	36	116	18
	20	43	52	45	24	39	45	27	36	116	18
	21	43	52	45	24	39	45	27	36	116	18
	22	43	52	45	24	39	45	27	36	116	18

WEEKEND DAY	DESTINATION												
	O \ D	11	12	13	14	15	16	17	18	19	20	21	22
ORIGIN	1	25	32	24	41	31	72	79	74	65	65	63	65
	2	20	25	19	32	24	57	62	58	51	51	51	51
	3	12	15	11	19	15	34	37	35	31	31	31	31
	4	8	10	7	13	10	22	24	23	20	20	20	20
	5	13	16	12	21	16	36	39	37	33	33	33	33
	6	17	22	17	28	21	50	54	51	45	45	45	45
	7	15	19	14	24	18	42	46	43	38	38	38	38
	8	18	23	17	30	22	52	56	53	47	47	47	47
	9	9	12	9	15	11	26	28	27	24	24	24	24
	10	9	12	9	15	11	27	29	27	24	24	24	24
	11	0	17	13	22	17	38	42	39	35	35	35	35
	12	12	0	11	19	15	34	37	35	31	31	31	31
	13	31	39	0	50	38	88	96	90	79	79	80	79
	14	13	16	12	0	16	37	40	38	33	33	33	33
	15	21	27	21	35	0	61	67	63	55	55	56	55
	16	16	20	15	26	19	0	49	46	41	41	41	41
	17	12	15	11	19	14	34	0	34	30	30	30	30
	18	25	32	24	41	31	72	78	0	65	65	65	65
	19	42	54	41	69	52	121	131	123	0	109	109	109
	20	42	54	41	69	52	121	131	123	109	0	109	109
	21	42	54	41	69	52	121	131	123	109	109	0	109
	22	42	54	41	69	52	121	131	123	109	109	109	0

IV. RESULTS & ANALYSIS

A. Existing Condition

After the traffic model is examined by using JICA Strada, the traffic flow model on roads within area of study is shown in Fig. 4 and Fig. 5 for weekday and weekend peak hour respectively, with the detailed traffic flow are shown in Table 5. It should be noted that the traffic flow considered is only on major roads, whereas minor roads traffic flow are negligible due to the consideration of the unavailability of field traffic flow data.

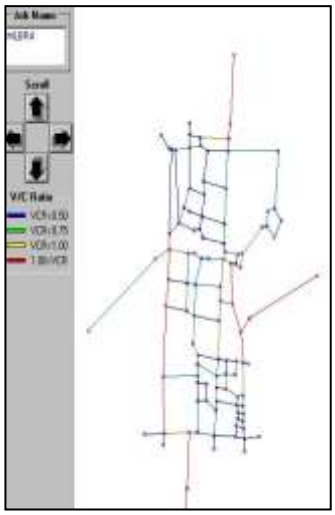

Fig. 4. Existing Traffic Flow Model on Weekday Peak Hour

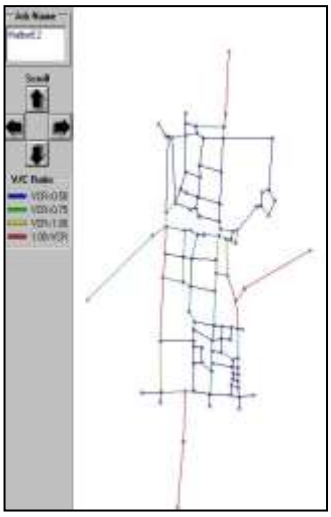

Fig. 5. Existing Traffic Flow Model on Weekend Peak Hour

TABLE V. EXISTING TRAFFIC FLOW MODEL (PCU/HOUR)

Name of Street	Weekday	Weekend
Malioboro	1832	1737
Ahmad Yani	1686	1218
Mataram	3452	1724
Mangkubumi	1848	1373
Ahmad Dahlan	1838	1204
Pasar Kembang	1637	1348
Bhayangkara	1798	1221
Abu Bakar Ali	3407	3087

B. Calibration and Validation

When the traffic flow model was obtained, it is thus compared to the filed traffic flow to recognize whether there are significant difference between them. R^2 statistic method as shown in Fig. 6 confirms that there is no significant difference proven by $R^2 = 0.7038$ and 0.8129 for weekday and weekend traffic flow model respectively, and therefore it can be concluded that the model traffic flow is accepted for the traffic simulation.

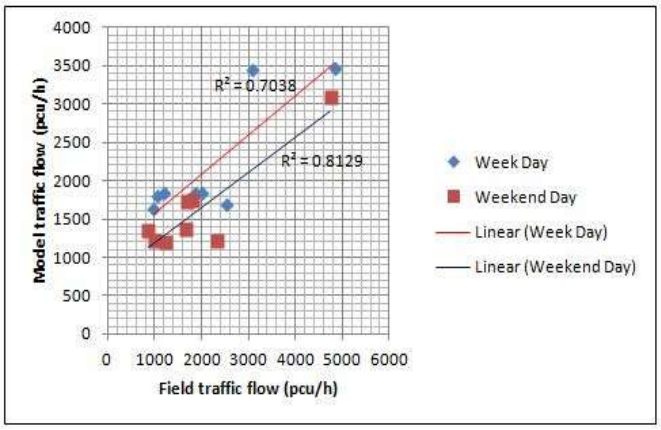

Fig. 6. Validation Result

It should be remembered that the best R^2 is equal to one which means that there is no difference or there is a similarity between model and actual traffic flow.

The result of validation on Fig. 6 does not show the expected validation yet, however, from several experiments that are done, that result is the model with the best validation.

C. Traffic Prediction

When the traffic flow model can replicate the actual traffic condition, the closing scenario Malioboro with two scenarios is then made. The first scenario (Model 1) is by closing half part of Malioboro area (Jl. Malioboro) and the second scenario (Model 2) is by closing the entire Malioboro area (Jl. Malioboro and Jl. Ahmad Yani) and cange it into pedestrian route.

The modeling result of traffic flow volume is shown in Table VI or Fig. 7, whereas the Degree of Saturation value (DS) is shown in Table VII or Fig. 6.

TABLE VI. MODELING RESULT OF TRAFFIC FLOW VOLUME

Name Of Street	Weekday			Weekend		
	Existing	Model 1	Model 2	Existing	Model 1	Model 2
Malioboro	1832	1909	0	1737	1725	0
Ahmad Yani	1686	0	0	1218	0	0
Mataram	3452	3748	6452	1724	1808	4453
Mangkubumi	1848	1808	1453	1373	1250	959
Ahmad Dahlan	1838	2181	3214	1204	1574	2398
Pasar Kembang	1637	1705	2572	1348	1477	2350
Bhayangkara	1798	2149	2188	1221	1320	1748
Abu Bakar Ali	3471	3616	2572	3087	3204	2350

The modeling result of traffic flow volume is shown in Table VI or Fig. 7, whereas the degree of saturation value (DS) is shown in Table VII or Fig. 6.

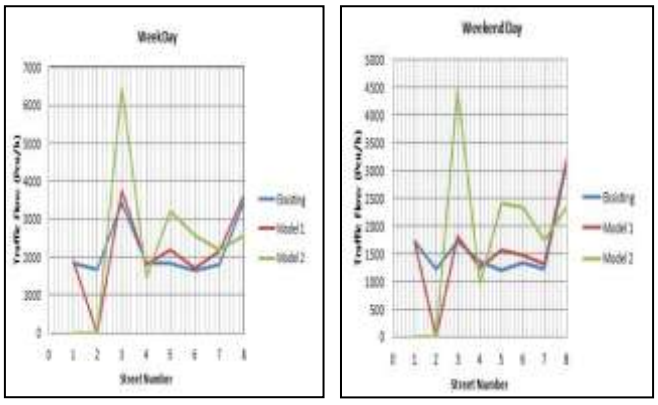

Fig. 7. Modeling Result of Traffic Flow Volume

Based on Table VI or Fig. 7 on Scenario 1, the volume increases during the weekdays shows insignificant increase of traffic volume on Jl. Mataram, Jl. Ahmad Dahlan, Jl. Bhayangkara and Jl. Pasar Kembang with the percentage of 4% to 20%, whereas the data gained during the weekends shows 8% to 31% increase. Moreover, the Scenario 2 illustrates a considerable increase of traffic flow volume such as on Jl. Mataram (87%), Jl. Ahmad Dahlan (75%), Jl. Pasar Kembang (57%) and Jl. Bhayangkara (22%). Still referring to the same scenario, significant increase during the weekends occurs on Jl. Mataram (158%), Jl. Ahmad Dahlan (99%). Jl. Pasar Kembang (74%), and Jl. Bhayangkara (43%).

TABLE VII. DEGREE OF SATURATION VALUE (DS) OF MODELING RESULT

Name of Street	Week Day			Weekend Day		
	Existing	Model 1	Model 2	Existing	Model 1	Mode l 2
Malioboro	0.94	0.98	0	0.89	0.89	0
Ahmad Yani	0.87	0	0	0.63	0	0
Mataram	1.91	2.08	3.58	0.96	1	2.47
Mangkubumi	0.88	0.86	0.69	0.65	0.59	0.45
Ahmad Dahlan	0.74	0.88	1.29	0.48	0.63	0.96
Pasar Kembang	0.62	0.64	0.97	0.51	0.56	0.88
Bhayangkara	0.69	0.82	0.84	0.47	0.51	0.67
Abu Bakar Ali	0.75	0.79	0.56	0.67	0.69	0.69

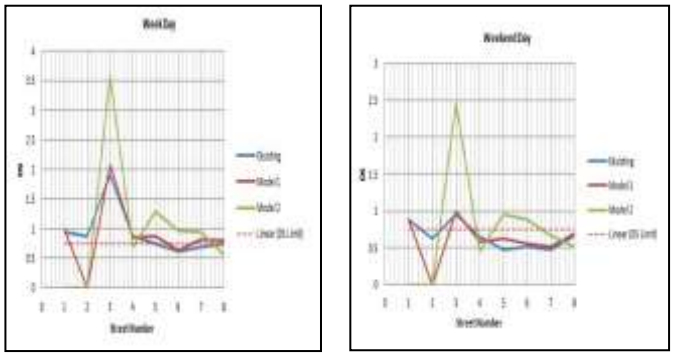

Fig. 8. Degree of Saturation Value (DS) of Modeling Result

Based on [7], the value of DS suggested for particular road must be ≤ 0.75, a road that shows the value of DS=1 means that it suffers from a total traffic jam.

According to the details showed in Table 7 or Fig. 8, the difference of DS value of both existing and modeling condition based on Scenario 1, either on weekdays or weekends is really small. On the other hand, the Scenario 2 shows a moderately significant increase of DS value on the weekdays on Jl. Mataram from DS < 2 to > 3,5, Jl. Ahmad Dahlan from DS < 0,75 to > 1 and Jl. Pasar Kembang from DS < 0,75 to > 0,75. During the weekends, the increase of DS value on Jl. Mataram is from DS < 1 to DS > 2, Jl. Ahmad Dahlan and Jl. Pasar Kembang from DS < 0,75 to > 0,75.

Therefore, it can be elaborated that if pedestrian route is implemented in Malioboro area by closing partial area (only Jl. Ahmad Yani), the increase of traffic flow occurs in several points of road does not affect the road network performance. Simultaneously, if all roads are closed (Jl. Ahmad Yani and Jl. Malioboro), there would be severe traffic jam on Jl. Mataram as an impact. It means that if the local government policy related to Malioboro area arrangement is still implemented, the transportation management and transportation engineering must be improved, especially on Jl. Mataram.

V. CONCLUSION & RECOMMENDATION

According to the data processing and analysis described above, the conclusion that can be made includes:

- The volume of traffic flow on Scenario 1 shows insignificant increase during the weekdays on Jl. Mataram, Jl. Ahmad Dahlan, Jl. Bhayangkara and Jl. Pasar Kembang with the percentage of 4% to 20%, whereas the data gained during the weekends show 8% to 31% increase.
- The volume of traffic flow based on Scenario 2 illustrates a significant increase on Jl. Mataram (87%), Jl. Ahmad Dahlan (75%), Jl. Pasar Kembang (57%) and Jl. Bhayangkara (22%). Whereas significant increase during the weekends occurs on Jl. Mataram (158%), Jl. Ahmad Dahlan (99%). Jl. Pasar Kembang (74%), and Jl. Bhayangkara (43%).
- DS value on Scenario 1 shows a small difference between existing and model condition.
- DS value on Scenario 2 presents significant increase and it occurs on Jl. Mataram from DS < 2 to> 3,5, Jl. Ahmad Dahlan from SD < 0,75 to > 1 and Jl. Pasar Kembang from DS < 0,75 to < 0,75, meanwhile the increase of DS value during the weekends happens on Jl. Mataram from DS < 1 to DS > 2, Jl. Ahmad Dahlan and Jl. Pasar Kembang from DS < 0,75 to > 0,75.

Suggestions that could be provided related to this study are as follows:

- The OD matrix used should be in the form of traffic volume data of the road network node selected for the study. As a result, it enables the achievement of high correlation value between real volume and existing volume of the result modeling.
- The accumulation of traffic data of the road network nodes used for OD matrix can be conducted during the survey on the road volumes which are under study. Thus, it results in a more rigid outcome.
- Revalidation needs to be conducted until higher validation is gained, therefore the volume of running result could be consistent with the one on field.

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