COMPARISON OF THE MICRO-SIMULATION SOFTWARE AIMSUN & IHCM-1997 FOR HIGHWAY TRAFFIC PERFORMANCE ANALYSIS

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ABSTRACT

In order to make good decisions in transportation, decision-makers need some references to support it. One of the sources for such reference is by performing a micro-simulation; a model for representing real-world conditions including the behavior of travelers, vehicles and the infrastructure. This study examines and presents a comparison between AIMSUN (a commercial micro-simulation software) and Indonesia Highway Capacity Manual 1997(IHCM-1997) in relation to the road traffic performance of the study object Södralänken, E266 and E75, in the southern part of Stockholm, Sweden. A calibration process was conducted in order to find the best value of a set of parameters in each software, selected based on the lowest value of a Root Mean Square Error (RMSE) computed based on observed speed data and the model output. The parameters were then validated using evening peak-hour data. The comparisons were conducted in terms of flow, speed and density by AIMSUN, IHCM-1997 and the observation data on morning and evening peak-hour. The results are from the given experiments with the AIMSUN software with the best set of parameters being when the value of Maximum Desired Speed is at 100 km/h and Speed Acceptance is at 1,1. It shows that the significant difference between AIMSUN, IHCM-1997 and observation lays on the speed. IHCM-1997 gives relatively higher speed than both AIMSUN and observation data.

Keywords: AIMSUN, micro-simulation, comparison, IHCM-1997, speed, flow, density

1 INTRODUCTION

Transportation has an important role in supporting the economic development in a country. Transportation decision would affect the social economic experience in the society, made by considering the optimum benefit to the society and of course, minimum disadvantages to them. A good decision-making in transportation can solve problems in the present or prevent them from happening in the future. The problems are actually similar: congestion, pollution, accident, and so on.

Advanced Interactive Microscopic Simulator for Urban and Non-Urban Networks (AIMSUN) is a popular commercial micro-simulation application which has been used frequently in the transportation research field. AIMSUN stands out for the exceptionally high-speed simulations and for fusing static and dynamic traffic assignment with mesoscopic, microscopic and hybrid simulation all within a single software application (Transport Simulation System, 2010).Indonesia Highway Capacity Manual-1997 (IHCM-1997) is an official guidance to calculate the performance of road traffic on analysis purpose and to make a design of infrastructure needed by society conducted by Ministry of Public Works of Indonesia. The calculation on this manual is taken from an empirical study of road on the several locations in Indonesia. This manual recorded the end result of phases of IHCM which includes the calculation method for urban and sub-urban road (Directorate General of Bina Marga, 1997).

In this report, a simulation model of a short stretch of highway, outside of Stockholm, Sweden, was built, calibrated and evaluated by using AIMSUN version 6.1 and the results were then compared to the calculation of IHCM-1997 in terms of traffic performance analysis. The purpose of the report is to give insights in how traffic simulation models can be used for analyzing real world traffic problems. Inputs to the simulation study are data from the motorway control system (MCS) in the area.

The traffic simulation is developed based on the provided data from traffic flow and speed detectors in the study area. The peak-hour data is used to build the traffic simulation model. The calibration process in the software works by adjusting two main parameters in order to find the best model. The comparison of AIMSUN and IHCM-1997are conducted in the terms of flow, speed and density. All counted vehicles in this research were considered as LV (light vehicle)

The area of this research is on Underground Street freeway in Stockholm. The area is one of the intersections between E266-Street and E75-Street (Södralänken). The location is a 3-approach freeway which has 2-3 lane streets, as shown in figure 1

2 LITERATURE REVIEW

2.1 Network Model

The area used in this paper is a location close to the roads E266 and E75 (Södralänken) in Stockholm, Sweden. The location covers a three-approach intersection. A map of the covered area and an outline of the network model are shown in Figure 1. In Figure 1, the locations of the MCS detectors available in the area are shown as circles.

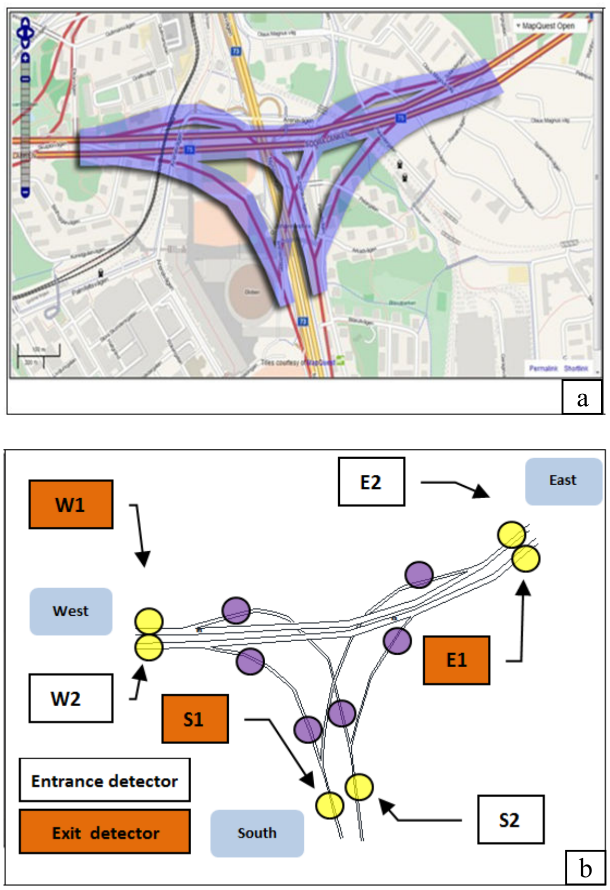

Figure 1. Map of the covered area (up), and outline of the network model with detector locations (down)

2.2 Geometry Data

The links in the network (see Figure 1) are two, three, or four lane links. For the link from west to east (E75), the number of lanes changes 3 times. At the beginning (from west) the road has 3 lanes, and at the diverging link the number of lanes is reduced to two. About a hundred meters before the merging lane, the number of lanes increases to three and then turns into a four-lane road. All links directly connected to east centroid have four lanes. All links that directly connect to the west centroid are three-lane roads and all links that directly connect to the south centroids are two lane roads. The majority of the road distance is covered in a tunnel. In main tunnel, the lane width is 3.75 m at the ramps of 4.5 m. The specific dimension for the road in the main tunnel is 0.75 m for left shoulder; 3.75 m for main lane and 1.75 m for the right shoulder. For the ramp part, the specific dimension is 2.5 m for left shoulder; 4.5 m for main lane and 1 m for right shoulder. Along the roads, there are no pedestrian crossing facilities, bus stop, or reserved lanes for public transport. The speed limit is 70 km/h. The AIMSUN network was built using the available Graphical User Interface (GUI).

2.3 Traffic Demand Data

The traffic demand used as the input to the simulation models is the data from the motorway control system (MCS) in the area. Two hours of clock time is simulated, corresponding to the peak hours in the area. A one-day data is used. Each detector gives the number of vehicles and the average spot speed for one-minute intervals, not including information about the type of vehicle counted, which was modeled as a car. For analysis purposes, the one-minute interval data of vehicle counts and speeds are aggregated into matrices covering 5-minutes intervals. The detector readings at the entrance, and at unnumbered detectors in Figure 1, are used to define the OD matrix data.

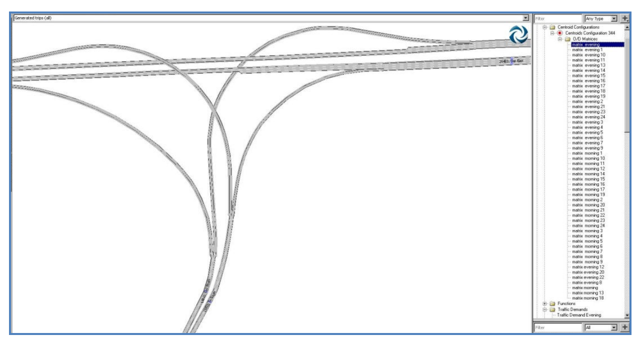

Figure 2. Graphical User Interface of AIMSUN

2.4 Vehicle Properties

For the AIMSUN model, the vehicle properties are cars with length of 4 meters (mean), minimum distance vehicle of 1 meter (mean), desired speed of 100 km/h, and normal deceleration of 4 m/s^2. These are given as parameters in the AIMSUN model.

2.4.1 AIMSUN

AIMSUN is a widely used commercial transport modeling software, developed and marketed by TSS-Transport Simulation Systems based in Barcelona, Spain. The input data required by AIMSUN Dynamic simulators are a simulation scenario, and a set of simulation parameters that defines the experiment. Based on AIMSUN Manual (TSS-Transport Simulation Systems, 2010), the scenario is composed by four types of data such as: *Network descriptions; Traffic control plans; Traffic demand data; Public transport plans.* Traffic modelling in AIMSUN involves four components to run. Those components are *traffic demand data, traffic generation, vehicle entrance process, vehicle attributes and vehicle modelling parameters.*

2.4.2 Model Calibration

Before the models can be evaluated, they need to be calibrated. In this section, the calibration process is described, which consists of parameter values with a subset of the available parameters in the car-following models adjusted in order to find a most suitable measures between the model output and the observed speeds from the MCS detectors. The fit measure used is defined as

$$RMSE = \sqrt{\frac{1}{D}\frac{1}{R}\sum_{t=1}^{R}\sum_{d=1}^{D}(x_{td} - \bar{x}_{td})^2}$$

Where:

x_{td} = Model estimation of speed at detector d and t:th time,

$\bar{x}_{td}$ = Observation data of speed at detector d and t:th time,

R = Number of $t$ime intervals (5-minute intervals),

D = Number of detectors (6).

The RMSE value is computed based on the speed on the exit and entrance detectors in south (S1 and S2), east (E1 and E2), west (W1 and W2) and the simulation output for 24 time intervals on those corresponding detectors. The calibration is made independently. Based on the initial experiments regarding the sensitivity to the output, the calibration is limited to the parameters with desired speed and speed acceptance in the AIMSUN model. The calibration of the AIMSUN in this research used morning-speed data to find optimal value for the set of parameters used in this model. Those two parameters are *speed acceptance* and *maximum desired speed.* Other parameters are considered not to affect the speed on the network significantly. 150 experiments have been done for 150 combination sets of those two parameters. The model output speed came from set of parameters *maximum desired speed = 100 km/h* and *speed acceptance* = 1.1. A validation process has been done against evening-peak-hour flow data byre-running the experiment using evening-peak-hour demand data as input.

2.4.3 IHCM-1997

In this manual, Freeway is defined as a road for through traffic with full control driveway—same meaning with toll way in Indonesia. The segment in the freeway is defined as a piece of freeway in between and not affected by intersection to the connecting line (in or out) and it must have similar geometric planning characteristic and flow. Significant change in road characteristic will automatically be the segment border, even if there is no intersection before or after it. Segment border should be determined if there is an important characteristic change, even if the segment is shorter. IHCM (1997) explained about the characteristic of freeway. Other parts of freeway adjustment factors are including *Geometric, Flow Composition, Flow Separation, Free Flow Speed, Capacity, Degree of Saturation, and Average Speed*. IHCM 1997 uses travel speed as main criterion to determine the performance of the freeway. After obtaining the degree of saturation in previous step, a user have to find the real speed in traffic situation by using graphic of saturation degree and free flow speed. The graphic is shown in the following picture. The manual also contains the *Speed-Flow-Density relationship.*

Based on the calculation using equation in IHCM-1997, the capacity and free flow speed of the six points (segment) of observation spot are calculated. Detector W1 & W2 have capacity of 7107 pcu/h, E1 & E2 have capacity of 9476 pcu/h, detector S1 & S2 have capacity of 4738 pcu/h. The free flow speed on segment S1 & S2 are 90 km/h, and the rest of detectors has free flow speed of 93 km/h. Based on the calculation by using equation in IHCM-1997, the degree of saturation (DS) of the six points (segment) of observation spot are calculated. It should be noted that the flow available in this report is in 5-minute interval and the capacity is in an hour interval. This report is using graphic method to find out the average speed according to its Degree of Saturation. Graphic of average speed is used to find the average speed after the DS and the free flow speed are found. By using the flow (pcu/hour) and average speed from the previous steps, the density of the segment/detector can be found.

3 RESULT AND DISCUSSION

For morning data/demand in the term of flow, most of speed and density are normally distributed data except for some points such as: observation-speed (W2), observation-density (W2), IHCM-speed (W2) and IHCM-speed (S1). For evening data, there are 6 points of data which appears to be not normally distributed. Those points are: observation-speed (W2 & S2), IHCM-speed (W1, E2, E1, S2)

3.1 AIMSUN vs Observation

Recapitulation of t-test and sign test using morning data shows that in terms of flow on all detectors, the AIMSUN are not significantly different compared to observation data. While in a similar test conducted using evening data, it shows that in terms of flow on almost all detectors (except W1), the AIMSUN also gives similar results with the observation. In terms of density, almost all detectors (except S2) the AIMSUN are not significantly different with the observation data.

Table 1. The recapitulation different average between AIMSUN and observation data (morning)

Observation vs AIMSUN		Detector (%)					
		W1	W2	E1	E2	S1	S2
Different average	Flow	15.7	3.0	20.1	4.2	16.6	3.9
	Speed	65.3	55.1	12.9	88.8	21.7	18.8
	Density	39.9	34.8	33.8	43.5	23.4	24.3

Table 2 The recapitulation different average between AIMSUN and observation data (evening)

Observation vs AIMSUN		Detector (%)					
		W1	W2	E1	E2	S1	S2
Different average	Flow	25.4	12.9	23.0	2.8	28.8	4.5
	Speed	7.1	15.6	2.4	3.8	12.5	5.3
	Density	25.7	18.9	23.6	5.8	36.8	7.3

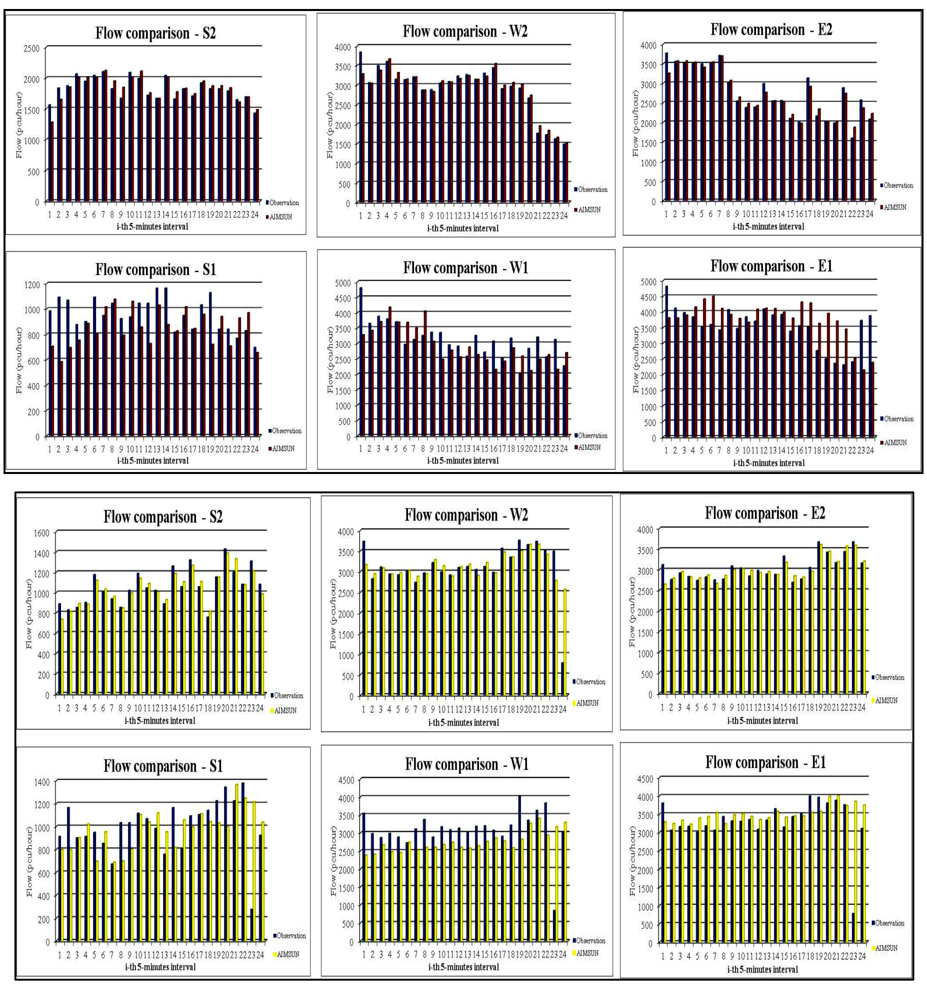

Figure 3. Comparison of flow data between observation and AIMSUN in each segment at morning (up) and evening (down)

3.2 IHCM-1997 vs Observation

Recapitulation of t-test and sign test using morning data shows that in terms of speed and density on all detectors, the IHCM-1997 is significantly different compared to the observation data.

While in a similar test conducted using evening data, similar results occurred and it shows that the IHCM-1997 is significantly different compared to the observation data in terms of speed and density.

Table 3. The recapitulation of different average between IHCM-1997 and observation data (morning)

Observation vs IHCM-1997		W1	W2	E1	E2	S1	S2
Different average	Speed	143.5	69.5	29.1	163.9	22.9	26.2
	Density	57.3	22.9	22.1	58.7	18.6	20.7

Note: "Detector (%)" is printed above the detector columns (W1–S2) in the original header.

Table 4. The recapitulation of different average between IHCM-1997 and observation data (evening)

Observation vs IHCM-1997		W1	W2	E1	E2	S1	S2
Different average	Speed	18.8	33.2	28.57	20.4	23.7	29.1
	Density	15.6	24.9	22.1	12.3	19.1	28.8

Note: "Detector (%)" is printed above the detector columns (W1–S2) in the original header.

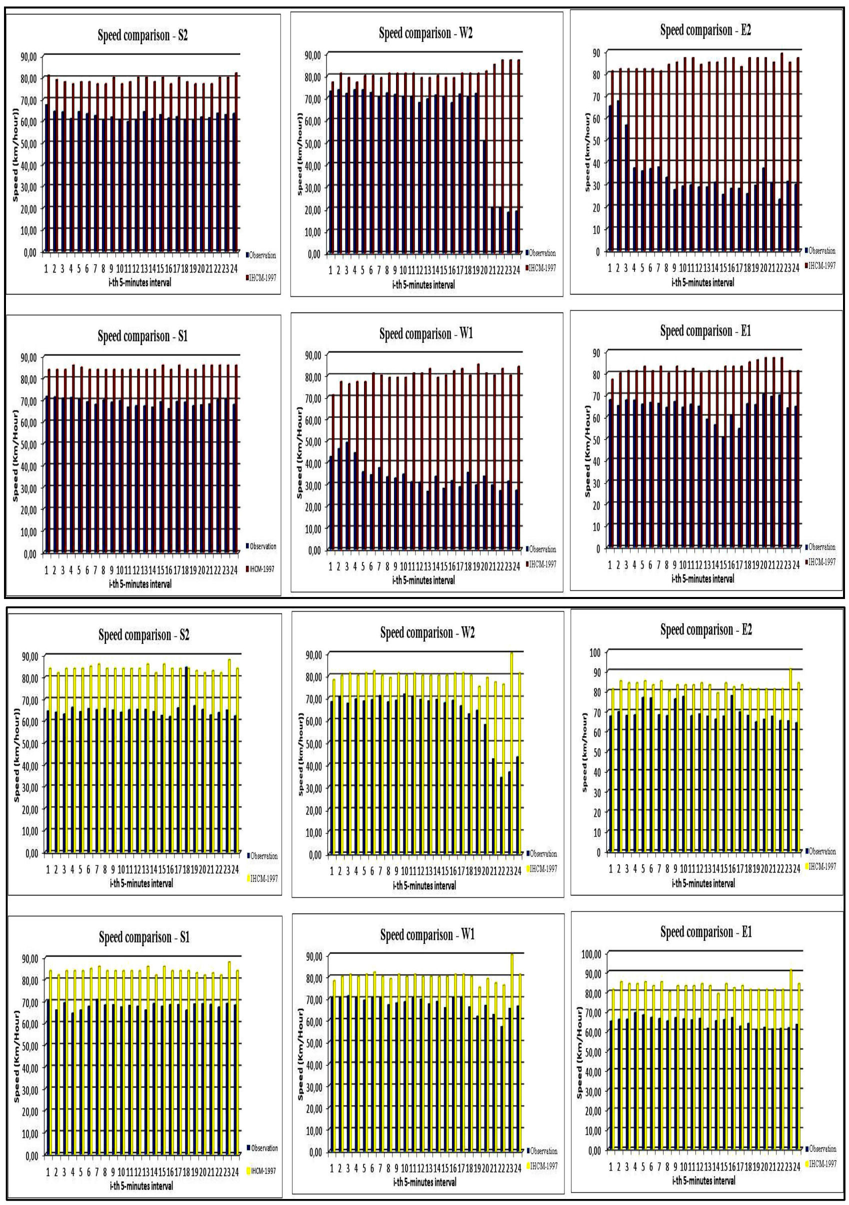

Figure 4. Comparison of speed data between observation and IHCM-1997 in each segment at morning (up) and evening (down)

3.3 AIMSUN vs IHCM-1997

Recapitulation of t-test and sign test using morning data shows that interms of flow on all detectors, the AIMSUN is not significantly different compared to IHCM-1997 data.

While in a similar test conducted using evening data, it shows that in terms of flow almost all detectors (except W1) the AIMSUN are not significantly different compared to IHCM-1997.

Table 5. The recapitulation of different average between IHCM-1997 and AIMSUN data (morning)

Observation vs IHCM-1997		Detector (%) W1	W2	E1	E2	S1	S2
Different average	Flow	15.7	3.0	20.1	4.2	16.6	3.9
	Speed	32.2	30.4	31.6	29.1	36.3	35.6
	Density	43.2	45.2	67.2	41.7	44.1	56.7

Table 6. The recapitulation of different average between IHCM-1997 and AIMSUN data (evening)

Observation vs IHCM-1997		Detector (%) W1	W2	E1	E2	S1	S2
Different average	Flow	25.4	12.9	23.0	2.75	28.8	4.5
	Speed	20.6	22.0	34.9	20.8	29.2	19.8
	Density	32.6	42.9	54.4	35.4	59.3	51.2

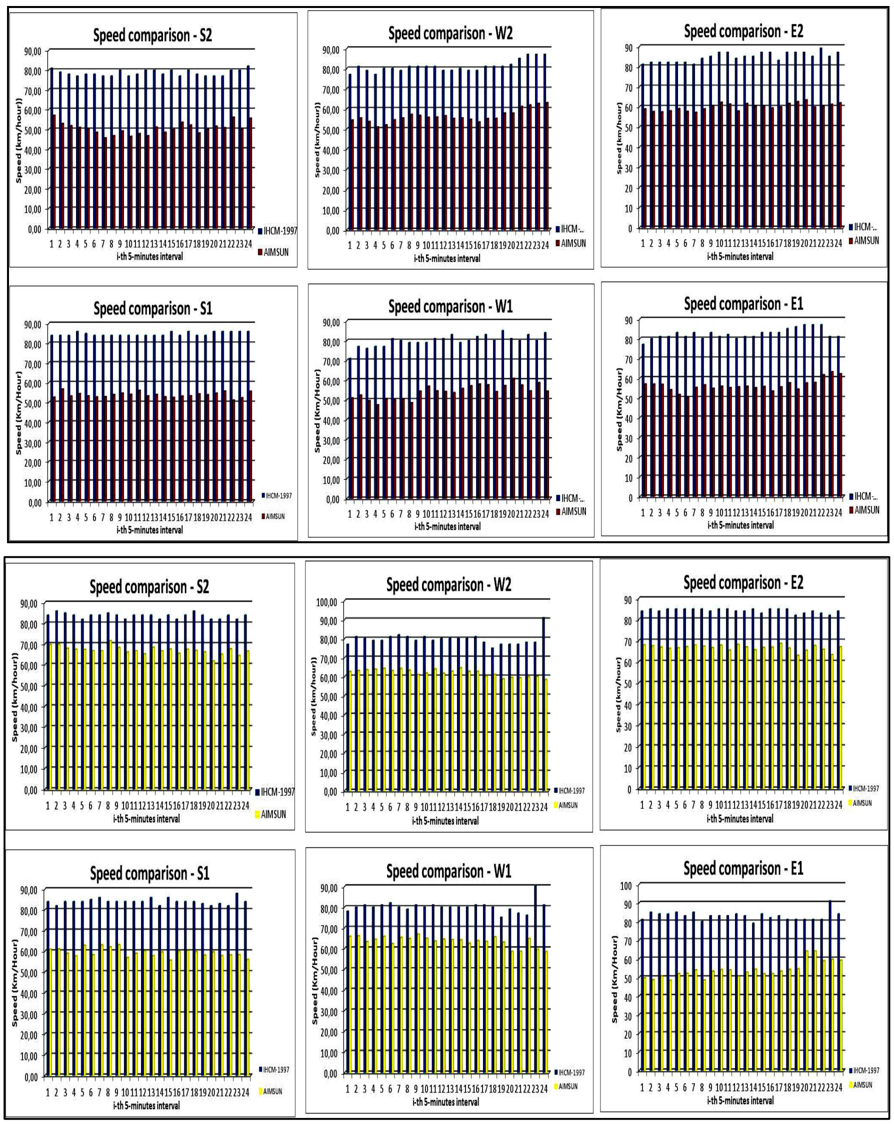

Figure 5. Comparison of speed data between IHCM-1997 and AIMSUN in each segment at morning (up) and evening (down)

3.4 Speed-Flow-Density Relationship

In terms of speed-flow-density relationship, AIMSUN and IHCM-1997 gave different result. The result is differentiated based on the time of event, morning and evening. The given graphs are resulted from the combination of all data from all detectors at once.

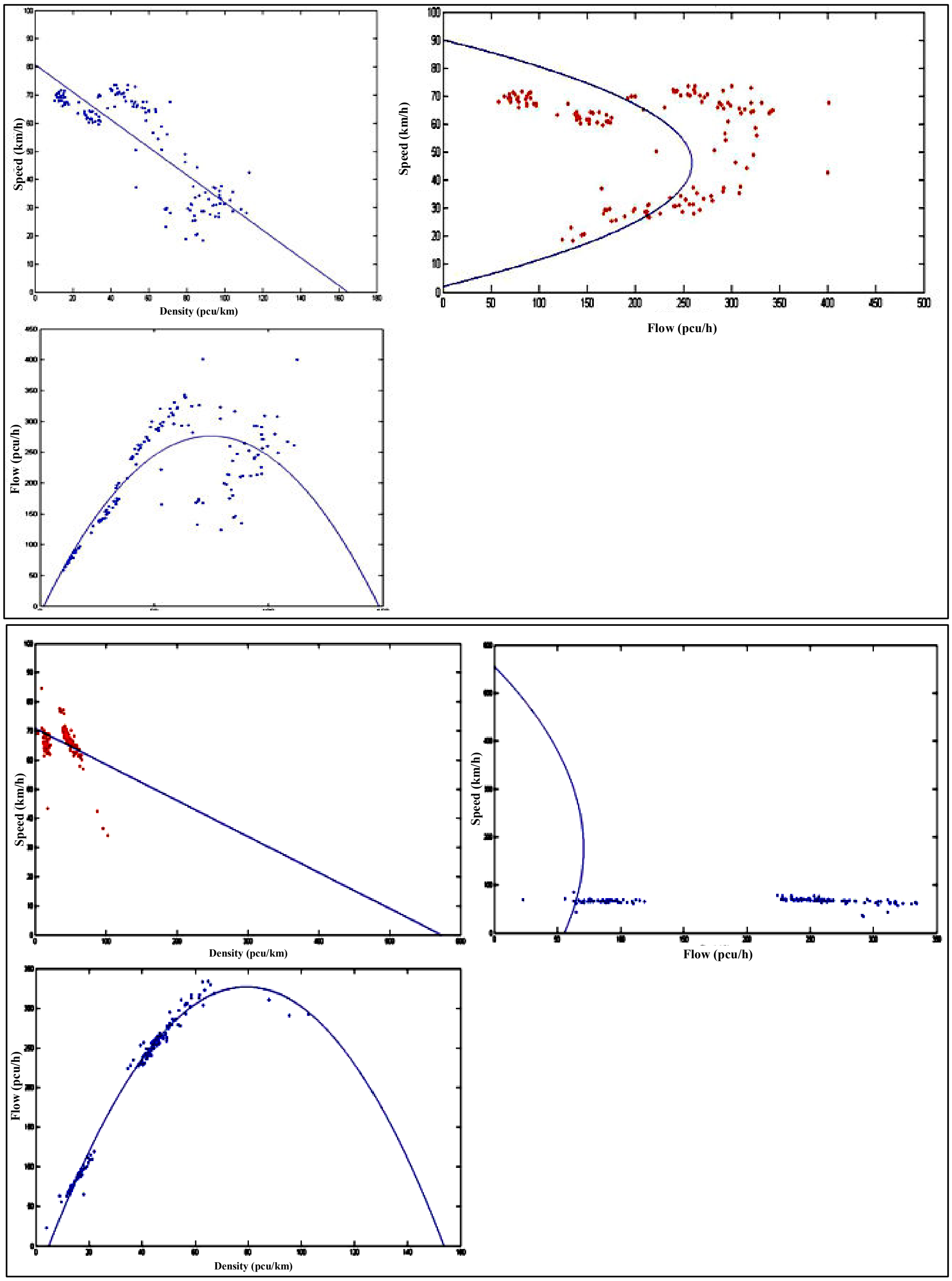

Figure 6. Speed-flow-density relationship of observation traffic at morning (up) and evening (down)

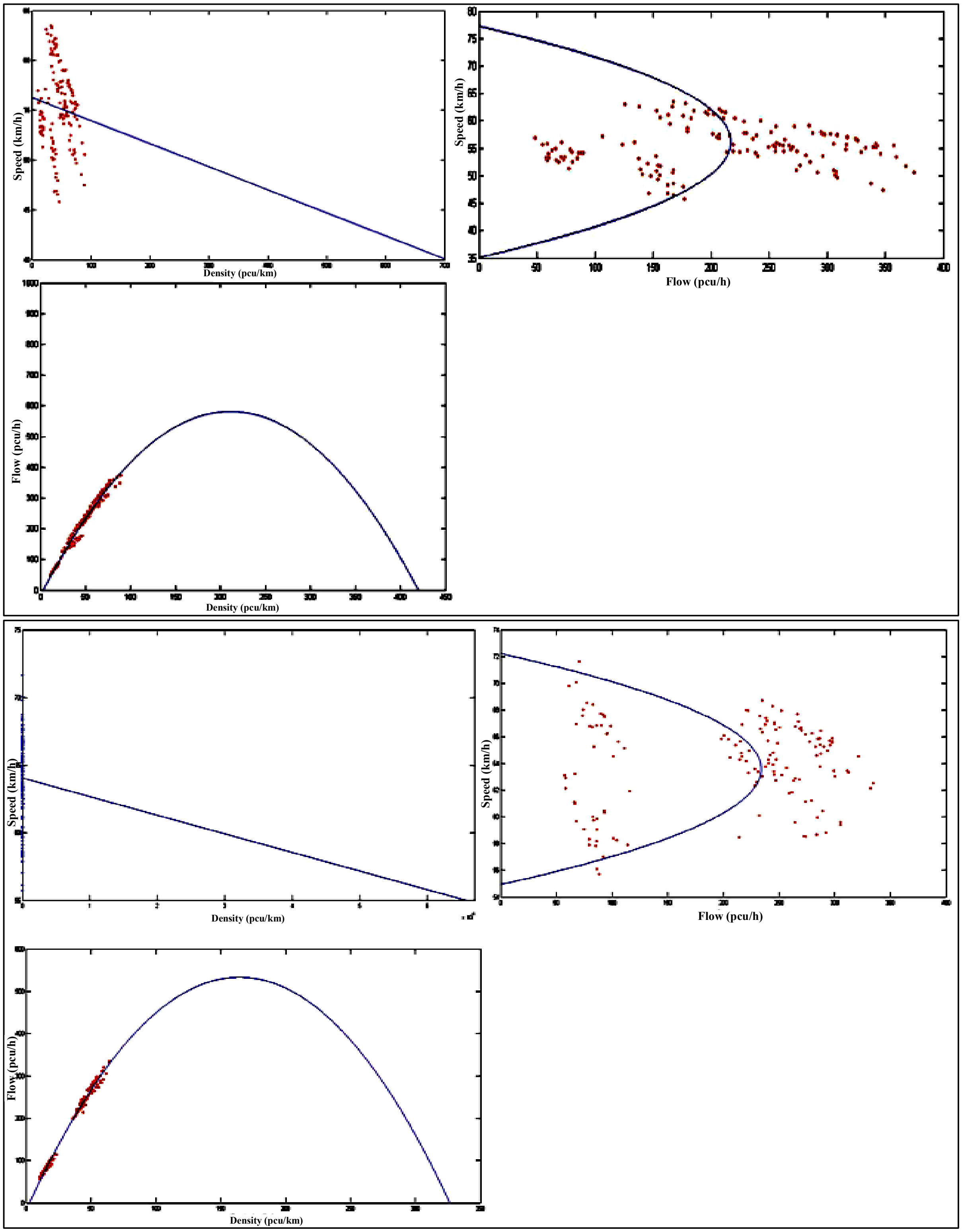

Figure 7. Speed-flow-density relationship of AIMSUN result at morning (up) and evening (down)

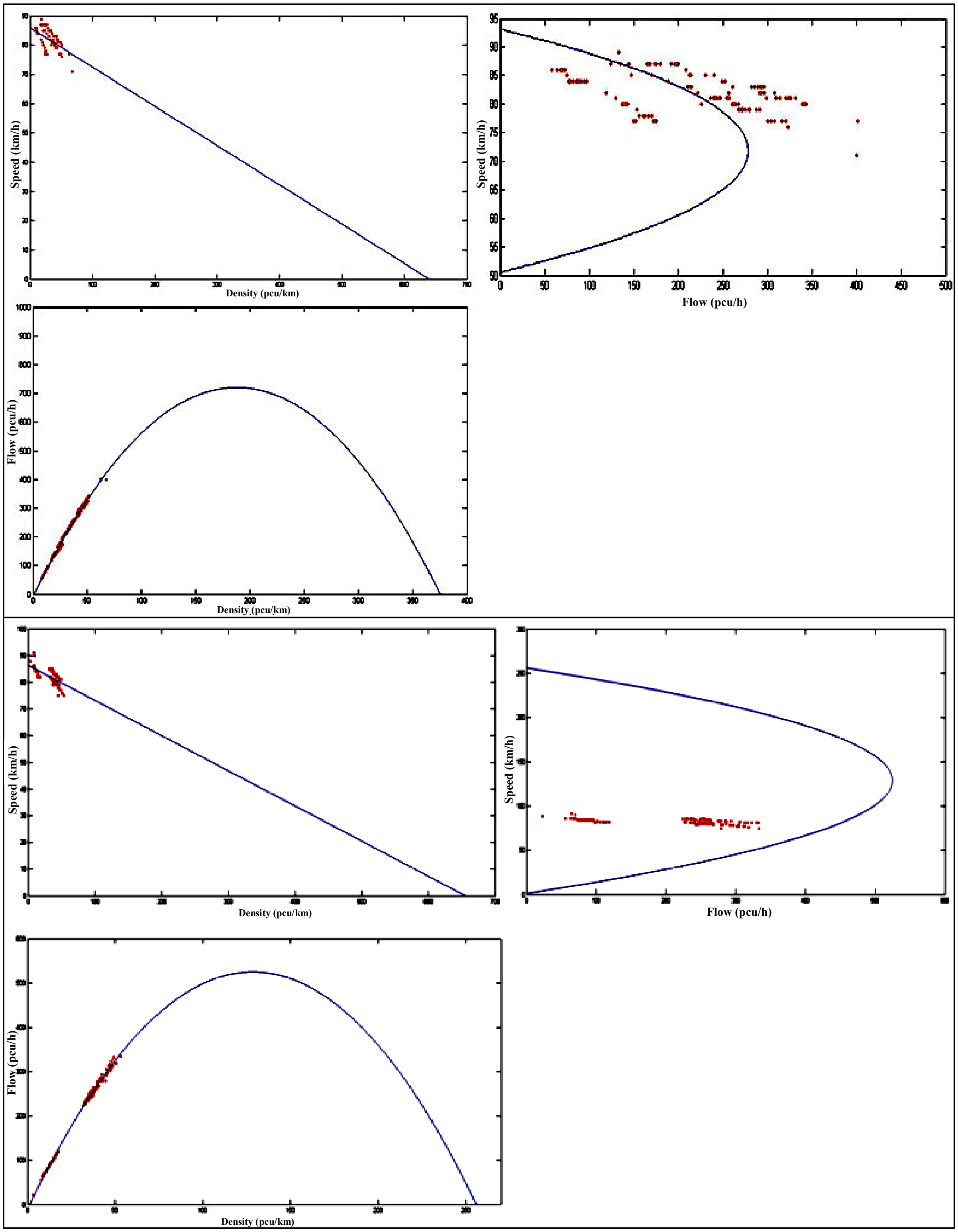

Figure 8. Speed-flow-density relationship of IHCM-1997 result at morning (up) and evening (down)

4 CONCLUSION

4.1 Conclusion

The best set of parameters, based on RMSE value, is on 1.1 for Speed Acceptance and 100 km/h for Maximum Desired Speed with RMSE value at this level of 19.394. In comparison between AIMSUN and morning/evening observation data, AIMSUN gave similar results in almost all detectors in terms of flow. While in terms of speed and density, AIMSUN gave significantly different results. It should be noted that the difference between the AIMSUN results and observation may occur since the model is calibrated in only two parameters.IHCM-1997 gave significantly different results compared to the observation data. This condition may occur since the calculation of speed in IHCM-1997 was based on the traffic behavior in Indonesia while the study object area is in Sweden. The speed resulted by IHCM-1997 is 75.87% higher than the overall observation. The results show that IHCM-1997 gave higher speed than AIMSUN in all detectors at morning and evening peak-hour. It can be concluded that the significant difference between AIMSUN, IHCM-1997 and observation was laid on the speed calculation. AIMSUN gave better results than IHCM-1997 in terms of speed. It can also be implied that in terms of behavior of taking speed, Indonesian drivers tend to take higher speeds than Sweden driver since the speed determination in IHCM-1997 was based on the empirical study of speed behavior characteristics in Indonesia.

The AIMSUN calibration in this research only involved two parameters. Therefore, it would be better if further research involves more than two parameters as available in the AIMSUN software package. Model simulation in AIMSUN is also available in meso-simulation, therefore, it would be interesting if there is research which can compare this software performance to another meso-simulation software such as EMME in a bigger research area. All vehicles counted by the detectors in the research area are considered as passenger cars since the output from detectors did not detect the type of vehicles. As the consequence, the flow detected by the detector cannot represent the real condition of the flow. It is highly recommended for further related or similar researches to distinguish the type of the vehicles in the analysis. It was understandable that IHCM-1997 does not give better results in this case of research and thus this manual should be improved or maybe renewed in order to accommodate the contemporary behavior or characteristic of traffic in Indonesia, considering that the characteristic should have been changed after 15 years.

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