APPLICATION OF VEHICLE SPECIFIC POWER MODEL TO MICRO TRAFFIC SIMULATION

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1. INTRODUCTION

Recently, a proposal of method is required to accurately estimate fuel consumption of vehicle in consideration of its improvement by automobile technologies, difference of various vehicle types and precise running situation: acceleration and deceleration. On the other hand, the Vehicle Specific Power(VSP) is a possibility to precisely estimate it more than the existing method in consideration of running resistance. However, the parameter of VSP is necessary to be calibrated for showing unique characteristic of each vehicle. Therefore, coast-down test is carried out by vehicles which are mainstream in Japan. Furthermore, if VSP is applied into micro traffic simulation model, policy evaluation could efficiently be conducted without actual measurement of fuel consumption and value of VSP. The objective of this study is to apply VSP model in micro traffic simulation. In comparison of VSP of actual running test data and simulation data, its applicability is verified.

2. REVIEW OF EXISTING RESEARCH

Fukumuro et al. (2016) conducted the coast-down test using a fuel consumption measuring device. As a result, the relationship between VSP model and fuel consumption with high accuracy is revealed. Suzuki (2016) estimated parameters of VSP model for several types of vehicles. As a result, increasing of vehicle weight is revealed to have relationship with increasing of value of VSP.

3. METHODOLOGY

3.1 Outline of VSP

VSP is the index for expressing energy consumption of vehicle added running resistance which is rolling resistance and air resistance, accelerate resistance, gradient resistance. VSP is calculated using at running vehicle data which is vehicle speed and acceleration, road gradient data. In this study, VSP is employed on the basis of the MOVES2010 model of EPA of the United States of America. The formula of VSP is shown to Eq. (1).

$$VSP=\left(\frac{A}{M}\right)\cdot v+\left(\frac{B}{M}\right)\cdot v^2+\left(\frac{C}{M}\right)\cdot v^3 +(a+g\cdot\sin\theta)\cdot v \qquad (1)$$

Where *VSP* is the Vehicle Specific Power (kW/t), *A*, *B*, and *C* are the running resistance characteristic parameters in units of (kW-s/m), (kW-s^2/m^2), (kW-s^3/m^3), respectively. *M* is vehicle weight (metric tons), *g* is gravitational acceleration (9.8 m/s^2), *v* is the vehicle speed in (m/s), *a* is the acceleration in (m/s^2), and θ is the road gradient (angle). Moreover, the formula of Running resistance characteristic parameters estimation are shown Eq. (2), Eq. (3), Eq. (4) respectively.

$$A=\frac{A_tPF}{50}\times\left(GTRL_{@50mph}\right) \qquad (2)$$

$$B=\frac{B_tPF}{50^2}\times\left(GTRL_{@50mph}\right) \qquad (3)$$

$$C=\frac{C_tPF}{50^3}\times\left(GTRL_{@50mph}\right) \qquad (4)$$

Where A_tPF, B_tPF, and C_tPF are coefficients calculated by vehicle tire size. In this study, coefficients were applied of A_tPF=0.71, B_tPF=0.40, and C_tPF=-0.11. Furthermore, the formula of $GTRL_{@50mph}$ is shown to Eq. (5).

$$GTRL_{@50mph}=\frac{\left(\frac{0.5\times ETW}{32.2}\right)\times\left(V_1^2-V_2^2\right)}{550\times ET} \qquad (5)$$

Where, ETW is the vehicle weight (lb), ET is the run of coasting time from the initial vehicle speed to the final vehicle speed (sec), V_1 is the initial vehicle speed calculated from mph (ft/sec), V_2 is the final vehicle speed calculated from mph (ft/sec).

3.2 OUTLINE OF EXPERIMENTAL

(1) Selection of Vehicle Type

In this study, select vehicle is Toyota Vitz (14.04 model) as a based on the existing research.

(2) Coast-down Test

Coast-down test was carried out on November 27, 2016. Fuel consumption measuring device and GPS receiver were installed on selected vehicle. Coast-down test was measured the coasting running time lowered speed by coasting from 60 mph to 40 mph on a flat road.

(3) Actual Running Test

Actual running test was carried out on November 28 and 29, 2016. Selected test route is shown in Fig. 1, the line chart of height of test route is shown in Fig. 2.

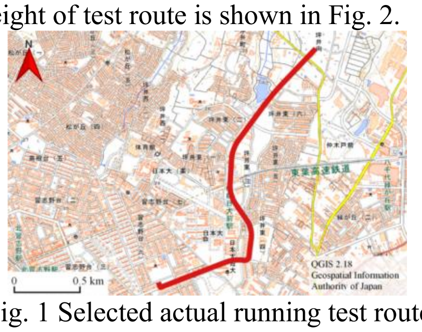

Fig. 1 Selected actual running test route

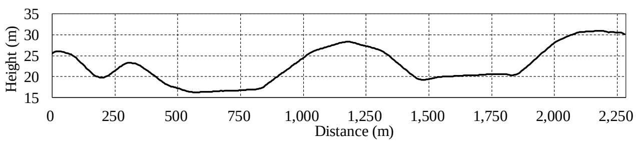

Fig. 2 Height of selected actual running test route

3.3 Outline of Traffic Simulation

In this study, the VISSIM of PTV AG was employed as micro traffic simulation. VISSIM is able to analyze precise vehicle maneuver with car-following model, lane

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configuration, traffic signals, etc. Therefore, micro traffic simulation is used as a tool to measure of evaluate of various alternatives plan.

3.4 Method of Analysis

(1) Actual Running Test

Actual running data is collected at 0.02 second interval. For that reason, the collected data is aggregated into 0.1 second with same of micro traffic simulation. This study used to height of actual running route which is based on the mesh numerical elevation data 5m in Digital elevation model(DEM) acquired from the Geospatial Information Authority of Japan. Therefore, gradient of actually running route is used to calculate VSP.

(2) Traffic Simulation

Micro traffic simulation input data is based on actual running data which is vehicle weight, vehicle acceleration, etc. Micro traffic simulation route is created based on the mesh numerical elevation data 5 m of the acquired DEM as in the case of the actual running data. Therefore, gradient of actually running route is used to calculate VSP.

4. RESULTS

(1) Resistance Parameter Used for VSP

The average value of the running resistance characteristic parameters from coast down test are calculated into three parameters: A=0.1743 kW-s/m, B=0.0020 kW-s^2/m^2, C=-1.080×10^{-5} kW-s^3/m^3.

(2) Application of Traffic Simulation

The line chart of vehicle speed and running time is shown in Fig. 4, the line chart of acceleration and deceleration and running time is shown in Fig. 5.

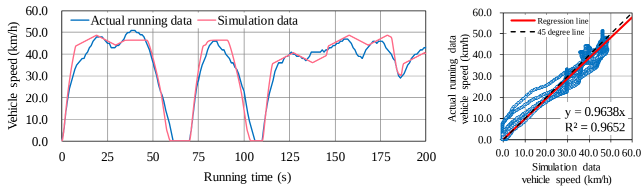

Fig. 4 Line chart and correlation diagram of vehicle speed and running time

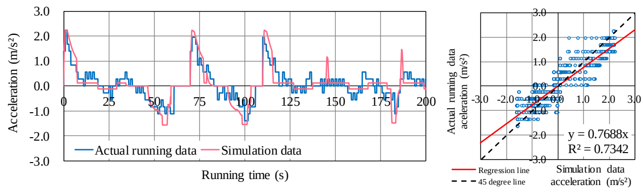

Fig. 5 Line chart and correlation diagram of acceleration and running time

The correlation coefficient between actual running data and simulation data were 0.97 in the case of the vehicle speed, 0.73 in the case of acceleration and deceleration. Those results were extremely strong correlation. Next to, the frequency distribution diagram calculated by VSP of actual running data and traffic simulation data is shown in Fig. 6.

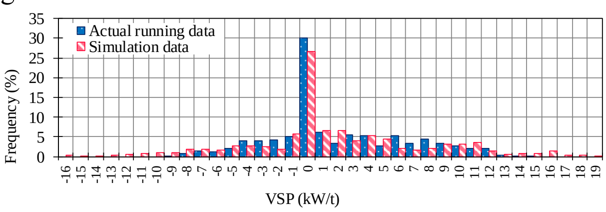

Fig. 6 Frequency distribution diagram of VSP of each result

In Fig. 6, The frequency distribution of actual running data and simulation data are extremely similar. However, the frequency distribution of VSP of simulation data is more spread than actual running data. The frequency distribution of actual running data and simulation data are slightly biased overall in direction on the right side. VSP is acquired correct result which is biased in positive direction due to running resistance and gradient. In addition, correlation diagram of VSP of actual running data result and traffic simulation data result is shown in Fig. 7.

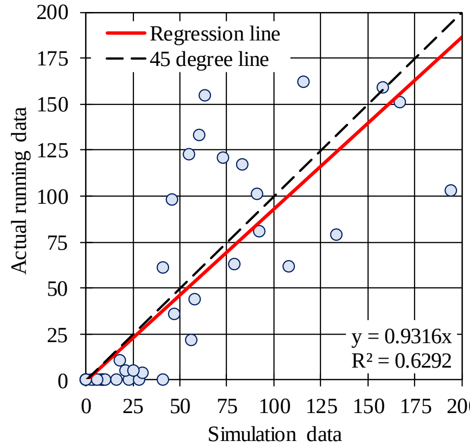

Fig. 7 Correlation diagram of VSP of each result

In Fig. 7, The correlation analysis was estimated of VSP excluding the frequency 0 which was received with large influence of the frequency distribution of actual running data and simulation data. As a result, correlation coefficient was estimated 0.63. Although the correlation between the speed and the acceleration were high in actual running data and simulation data, the correlation of VSP became lower. As a cause of low correlation, vehicle in simulation made suddenly acceleration and deceleration, in simulation with the certain condition. Therefore, car following model is need to be reconsidered to adjust acceleration and deceleration of driving like real human.

5. CONCLUSION

This study attempted to reproduce the VSP model by micro traffic simulation. As a result, it was possible to reproduce. However, acceleration and deceleration are needed to be reproduced for tracing the actual running data in more detail. The traffic simulation software used in this study was designed to be able to apply gradient, it is necessary to verify whether vehicle speed, acceleration and deceleration at gradient can be reproduced or not in comparison with these value at actual gradient.

REFERENCES

Fukumuro, K., Ishizaka, T., and Fukuda, A.: Analysis on Relationship of Estimated VSP from Coast-down Test and Fuel Consumption, Japan Society of Traffic Engineers Thesis 2(2), 2016, pp. A_199-A_204.

Suzuki, Y.: Application of VSP Model for Several Types of Vehicles to Estimate Fuel Consumption, Nihon University College of Science and Technology Transportation Systems Engineering Graduation Thesis, 2016, pp.85-86.

U.S. Environmental Protection Agency: MOVES2010 Highway Vehicle Protection and Activity Data, EPA-420-R-100-26, November 2010.

PTV: PTV Vision VISSIM 5.40 – User Manual, 2012.