Survey on Saturated Traffic Flow Rate at Signalized Intersections and Estimation Method

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1. Introduction

In the planning of signalized intersections, it is important to set the traffic capacity appropriately from the viewpoint of traffic smoothness. This traffic capacity is calculated based on the saturated traffic flow rate (the maximum number of vehicles that can pass through each lane per hour at a green light). Normally, the traffic capacity is calculated based on the observed saturated traffic flow rate, but in cases where observation is difficult, such as in planning a new intersection, it is common to use, as the saturated traffic flow rate, the value estimated by multiplying the basic value (the saturated traffic flow rate assumed for ideal road and traffic conditions) by a correction rate based on various factors of road and traffic conditions such as lane width and longitudinal slope (the "estimated value"). However, since the basic value and correction rate used in the estimation were determined based on the results of observations made over more than 30 years ago, it is possible that they may deviate from the actual situation due to changes in vehicle performance, driver characteristics and awareness in recent years. In fact, in recent years, it has been reported that the observed saturated traffic flow rate has been on a declining trend. In this research, we surveyed the actual situation of the saturated traffic flow rate and conducted a basic analysis for the development of a new method to estimate the saturated traffic flow rate appropriately.

2. Fact-finding survey on saturated traffic flow rate

(1) Survey conditions

The fact-finding survey was conducted at 15 intersections in Tokyo from November to December 2019. The survey time was 6 hours and included peak traffic hours.

(2) Survey results

The saturated traffic flow rates observed in this research ("observed values") were 1,386 to 1,782 vehicles per hour of green light in through lanes, 1,382 to 1,595 vehicles per hour of green light in left-turn lanes, and 1,553 to 1,867 vehicles per hour of green light in right-turn lanes (**Fig. 1**). In the through lanes and left-turn lanes, the results were lower than the basic values (2,000 vehicles per hour of green light in through lanes and 1,800 vehicles per hour of green light in left-turn lanes and right-turn lanes) at all observation points. The observed values shown in **Fig. 1** are the results of intersections with relatively ideal road and traffic conditions, meaning that they do not contains any conditions that require correction.

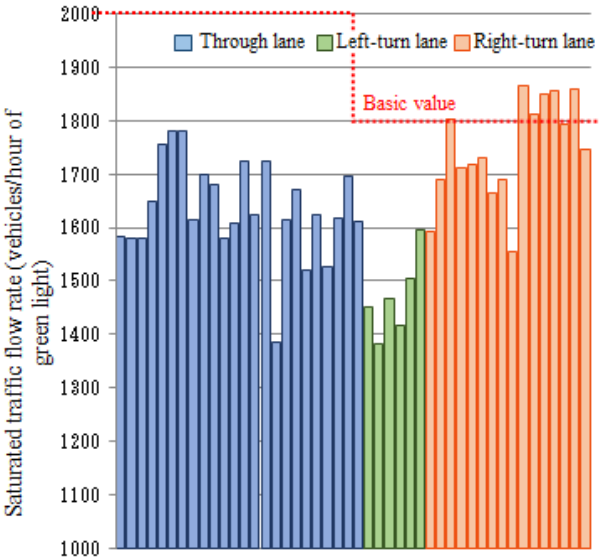

Fig.1 Observed value of saturated traffic flow rate

3. Basic analysis of methods for estimating saturated traffic flow rate

(1) Derivation of regression models based on survey results

The estimated value of saturated traffic flow rate is calculated by multiplying the basic value by a correction rate (all values are equal to or less than 1) based on various factors of road and traffic conditions, as shown in Equation (1).

$$S_A = S_B \times \alpha_W \times \alpha_G \times \alpha_T \times \alpha_B \times \alpha_{RT} \times \alpha_{LT} \quad (1)$$

[S_A: Estimated value of saturated traffic flow rate (vehicles/hour of green light),

S_B: Basic value of saturated traffic flow rate (vehicles/hour of green light),

α_W α_G α_T α_B α_{RT} α_{LT}: Each represents the rate of correction by lane width, longitudinal slope, heavy vehicle mixing rate, bus stop, right-turning vehicle mixing, and left-turning vehicle mixing, respectively]. On the other hand, as shown in **Fig. 1**, deviation from

the basic value was observed even under road and traffic conditions that did not require correction. Therefore, if we try to estimate the saturated traffic flow rate so that these actual conditions are reflected, it is necessary to consider a new estimation method. Accordingly, we focused on the relationship between saturated traffic flow rate and saturation speed, reaction time, and headway, and obtained Equation (2) in reference to previous studies, and derived the regression model shown in Equations (3) to (5) based on it.

$$S = 3600/(t_x + 3.6 \times h_j/V_S) \quad (2)$$

[S: Saturated traffic flow rate (vehicles/hour of green light), t_x: Reaction time (sec), h_j: Headway (m), V_S: Saturation speed (km/h)]

$$S_T = 3600/(1.35 + 3.6 \times 7.0/V_S) \quad (3)$$

$$S_L = 3600/(1.20 + 3.6 \times 7.0/V_S) \quad (4)$$

$$S_R = 3600/(1.04 + 3.6 \times 6.0/V_S) \quad (5)$$

[S_T: Saturated traffic flow rate of through lane (vehicles/hour of green light)
S_L: Saturated traffic flow rate of left-turn lane (vehicles/hour of green light)
S_R: Saturated traffic flow rate of right-turn lane (vehicles/hour of green light)]

(2) Evaluation of the estimation method of saturated traffic flow rate

Figures 2-4 show the relationship between the observed values and the estimated values (saturated traffic flow rate calculated by Equations (3) to (5) and the saturated traffic flow rate by the conventional estimation method). The estimated values calculated by Equations (3) to (5) are relatively accurate.

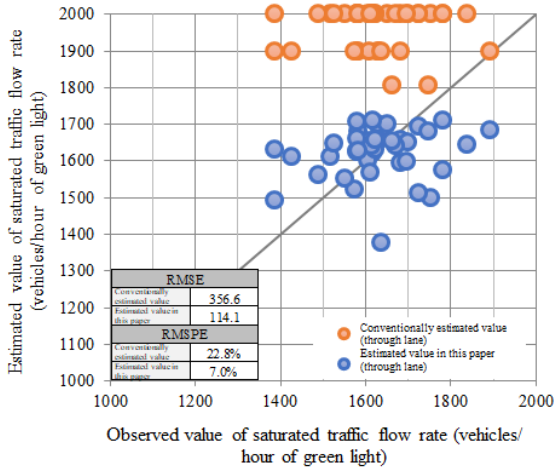

Fig. 2 Observed and estimated values (through lane)

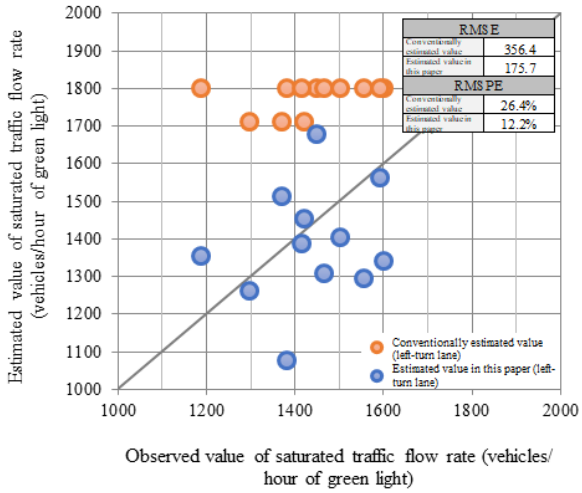

Fig. 3 Observed and estimated values (left-turn lane)

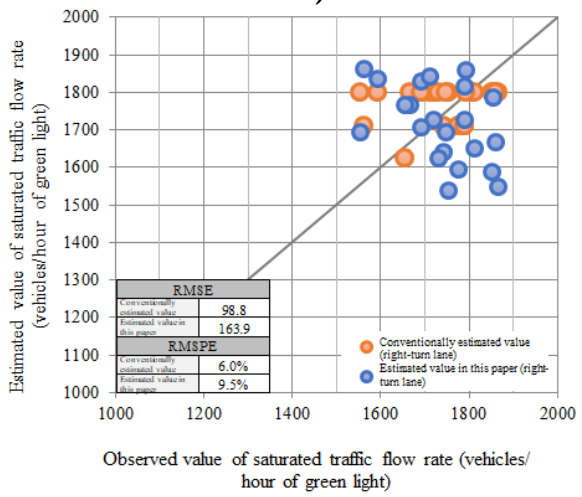

Fig. 4 Observed and estimated values (right-turn lane)

5. Conclusion

In this research, a fact-finding survey on saturated traffic flow rate was conducted and it was confirmed that all observed values were lower than the estimated values in the through lane and left-turn lane. Then, by focusing on saturation speed and other factors that are thought to affect the saturated traffic flow rate, we confirmed the possibility that a more accurate estimation could be obtained using a new equation that better accounted for these factors. In the future, based on this research, it would be necessary to conduct research from various perspectives, taking into account the workability in practice.

☞See the following for details.

1) Survey of saturated traffic flow rate at signalized intersections and basic study of influence factors, Collection of Presentations in the 62nd Conference of the Committee of Infrastructure Planning and Management