Analysis of the Effects for Travel Speed on Arterial Roads by Unsignalized Intersections Access

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Road Division, Road Traffic Department
Researcher (Ph.D. in Engineering) AOYAMA Eri Head MATSUMOTO Kōji Senior Researcher KAWAMOTO Naoyuki
Guest Research engineer SHIGETA Kengo

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1. Introduction

In the road network in Japan, the travel speed on ordinary roads remains at a low level and there are few roads that ensure an intermediate speed based on the difference with the travel speed on expressways, and thus appropriate hierarchical road network has not been achieved. The travel speed on ordinary roads is obviously affected by medians, unsignalized intersections access, the spacing between signalized intersections, and other factors, and NILIM aims to present a guide for road structure requirements to achieve a target travel speed.

Our analysis focuses on unsignalized intersections access as an influence on travel speed on ordinary roads; we firstly gained an understanding of the actual effects that entering and exiting vehicles on an arterial road with two lanes on each side have on vehicles directly behind them, and then examined their influence on entire sections using traffic simulations based on these results (fig. 1).

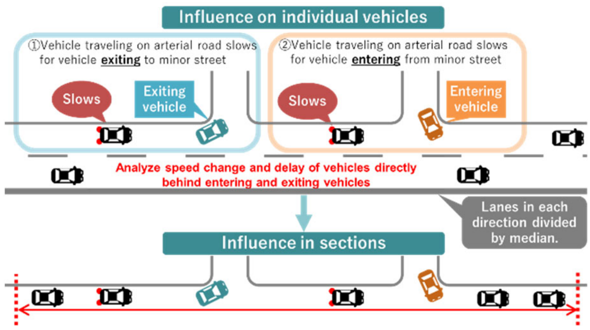

Fig. 1. Image of analysis target

2. Effect of entering and exiting vehicles on vehicles traveling on arterial roads

(1) Investigation outline

We installed video cameras so that they can shoot entry and exit sections and the areas upstream and downstream of them in four locations connected to National Highway 21 and two locations connected to National Highway 274 with unsignalized intersections. Each point had two lanes in each direction, divided by a median, and entry and exit behavior was limited to left-turn exits and entries.

(2) Analysis of speed changes of individual traveling vehicles

From the vehicles traveling on the arterial road, we extracted any vehicle where an entry or exit occurred within the section approximately 150 m ahead with that vehicle as the vehicle directly behind an entry or exit and acquired its speed immediately near the entry or exit, at three points upstream, and at one point downstream. The distribution of the change in speeds for each vehicle directly behind an entry or exit is shown in figure 2, using one of the investigated unsignalized intersections as an example. Here, "exit" indicates an vehicle directly behind an exiting vehicle and "entry" indicates a vehicle directly behind an entering vehicle. For both exits and entries, vehicles travel at a speed close to the free flow speed until 100 m upstream, but a decrease in speed is observed from 50 m upstream to the entry or exit point (0 m), and recovery to close to the free flow speed is observed at the point 150 m downstream. Exits tend to have a greater decrease in speed, but this demonstrated the possibility that vehicles traveling on arterial roads may suffer delays due to entries, as well as exits.

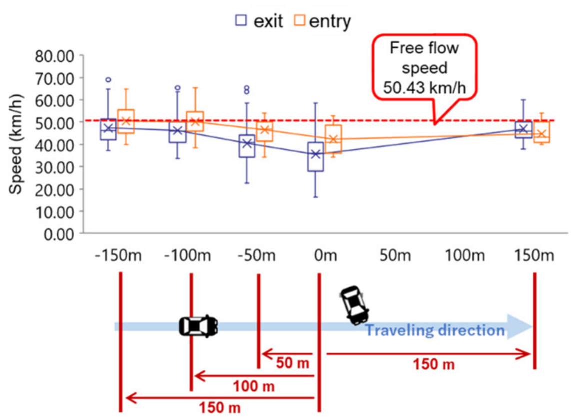

Fig. 2. Change in speed in vehicles directly behind entering and exiting vehicles

Next, we considered the delay in a vehicle traveling on the arterial road due to an exiting or entering vehicle to be the difference between the actual travel time of the vehicle directly behind an exit or entry and the free flow travel time, and computed it as 0 when the actual travel time was shorter. The delay at each unsignalized intersection is shown in table 1, aggregated by the exit or entry behavior of the car in front. It was confirmed that delay arose for both exits and entries. On the other hand, the delay varies depending on the point, and it appears necessary to examine differences due to the point and differences due to the route.

Table 1. Mean delay

Point no.	Exiting (sec)	Entering (sec)	Overall: exiting and entering (sec)
1 (Nat. Hwy 21)	2.19 (110)	1.44 (4)	2.16 (114)
2 (Nat. Hwy 21)	3.27 (100)	2.01 (15)	3.10 (115)
3 (Nat. Hwy 21)	2.18 (56)	1.33 (7)	2.09 (63)
4 (Nat. Hwy 21)	1.89 (194)	1.17 (49)	1.74 (243)
5 (Nat. Hwy 274)	1.79 (60)	1.48 (14)	1.73 (74)
6 (Nat. Hwy 274)	0.95 (357)	1.19 (28)	0.97 (385)

Parentheses indicate number of samples

(3) Analysis of influence in sections

We examined the influence from exiting and entering vehicles in a given section of an arterial road using traffic simulations. As the three points connected to National Highway 21 where we conducted the survey are on the same route and proximate, we set up a road section as in figure 3 in a simulation using the positional relationships and observed results of these points. We thought that the arterial road traffic volume, exiting and entering traffic volume, and number of unsignalized intersections would have an effect and conducted simulations changing these conditions.

We found the delay and travel speed for all vehicles traveling on the arterial road and converted them into values per vehicle. In addition to the vehicles traveling on the entire arterial road in the section under analysis, we included in the analysis the effects exerted on exiting and entering vehicles by other exiting and entering vehicles in arterial road sections that the vehicles traveled on.

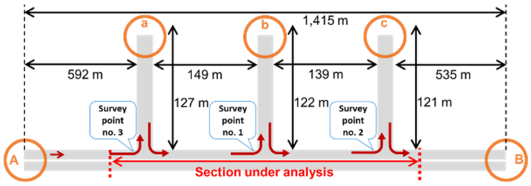

Fig. 3. Road section image

First, figure 4 shows the delay and travel speed when the arterial road traffic volume was changed. When converted to a delay per vehicle, the results were less than 2 seconds even with the highest traffic volume and were smaller than the observed delay when looking only at vehicles directly behind exits and entries as shown in table 1 (approx. 2–3 seconds). In addition, the delay increased and the mean travel speed decreased with an increase in traffic volume. The same also applied when the exiting and entering traffic volume was changed.

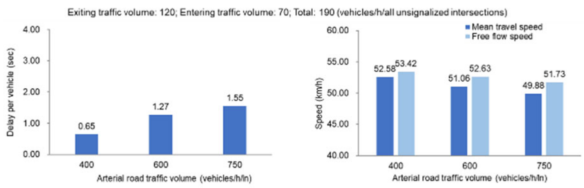

Fig. 4. Arterial road traffic volume and delay and travel speed

Next, figure 5 shows the delay and travel speed when the number of unsignalized intersections was changed. The total exiting and entering traffic volume was not changed, notwithstanding the change in the number of unsignalized intersections, but the delay per vehicle decreased and the travel speed increased with a decrease in the number of unsignalized intersections. It means an increased exiting and entering traffic volume per unsignalized intersection when the number of unsignalized intersections decreases and a longer time for entering vehicles to enter, as they do not have the right of way. Because of this, reducing the number of unsignalized intersections may contribute to improving travel speeds on arterial roads, but may have adverse effects on the road sections outside of arterial roads.

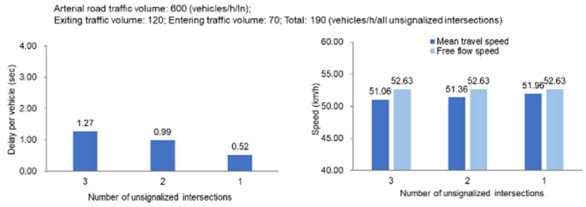

Fig. 5. Number of unsignalized intersections and delay and travel speed

3. Conclusion

We found that vehicles entering and exiting at unsignalized intersections connected to arterial roads may reduce the speed of vehicles traveling on the arterial road directly behind them and also lead to the occurrence of delay and decreases in travel speed in a certain section. It appears necessary to examine the factors causing decreases in arterial road travel speed, including signalized intersections, and to expand the examination to the network including roads connecting to arterial roads.

☞See here for detailed information

1) Effect for Travel Speed on Arterial Roads by Unsignalized Intersections Access, Proceedings of the 66th Infrastructure Planning Conference