IMPACTS OF LOCATIONS AND HEAVY VEHICLE PERCENTAGE ON LANE UTILIZATION RATE ON EXPRESSWAY

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1. Introduction

On expressway, lane utilization rate (LUR) plays an important role as it influences expressway performances like breakdown probability which has already been confirmed by some existing studies[1), 2)]. However, impacts of traffic conditions and geometry on LUR have not been thoroughly investigated based on empirical data. Especially how traffic conditions such as heavy vehicle percentage, geometry or distance to diverge section impact on LUR still remains unclear.

This paper is a preliminary study to investigate the impacts of the distance to diverge section, heavy vehicle percentage on LUR under uncongested traffic flow.

2. Site descriptions

The two-lane section from Otowa-Gamagori IC (282.3KP) to Toyota JCT (304KP) in the westbound of Tomei Expressway in Japan is chosen as the test bed. Its layout, lane configuration and detector locations are shown in Fig.1. At this test bed, three diverge sections exist: diverge sections of Toyota JCT (D1), Okazaki IC (D2) and Miai Parking Area (D3). 5-min aggregated data from 10 detectors is used. The data covers the period from January to March, 2009. All the detectors are located at the 2-lane section from 284.15KP to 302.15KP as shown in Fig. 1.

3. Methodology

The first step in handling the data is to remove missing or error values from detector data. Furthermore, the data which include traffic accidents, road maintenance and other abnormal conditions is excluded as well. Then data at uncongested flow condition is distinguished from those at congested flow condition by adopting a critical speed threshold based on the Q-V curve of each detector location. Uncongested flow data is divided into three traffic flow levels; less than 100veh/5-min/2-lane (Q1), between 100 and 200 veh/5-min/2-lane (Q2), and over 200 veh/5-min/2-lane (Q3). Combined data from Q1 to Q3 is denoted as Q_{total}.

4. Results and discussions

4.1 Impacts of locations

1) Change of shoulder lane utilization rate (SLUR) by locations

Fig.2 shows the SLUR at different locations under three traffic flow levels. The blue boxes stand for the SLUR of nearest detector locations before diverge sections. The gray boxes represent the other detectors in basic sections.

At first, SLURs at the detectors nearest to the diverge section were compared to those at adjacent upstream detectors as shown in Table 1. The former was significantly higher the latter at D1 and D2, while the former was significantly lower at D3 at 95% confidence

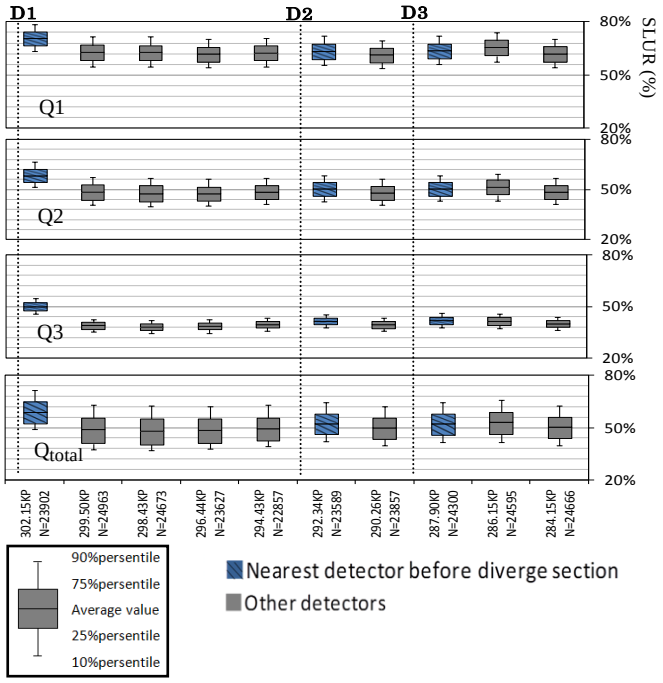

Fig.2 SLUR at different locations under each flow level

Table 1 t-test results of SLURs at the nearest detectors before each diverge section and those at their adjacent upstream detectors

Diverge section	KP of detectors		t-value			
	Downstream	Upstream	Q1	Q2	Q3	Q_{total}
Toyota JCT(D1)	302.15	299.5	63.86	141.9	200.7	121.74
Okazaki IC(D2)	292.34	290.26	17.40	34.48	23.53	30.52
Miai PA(D3)	287.90	286.15	-13.5	-8.72	4.21	-7.42

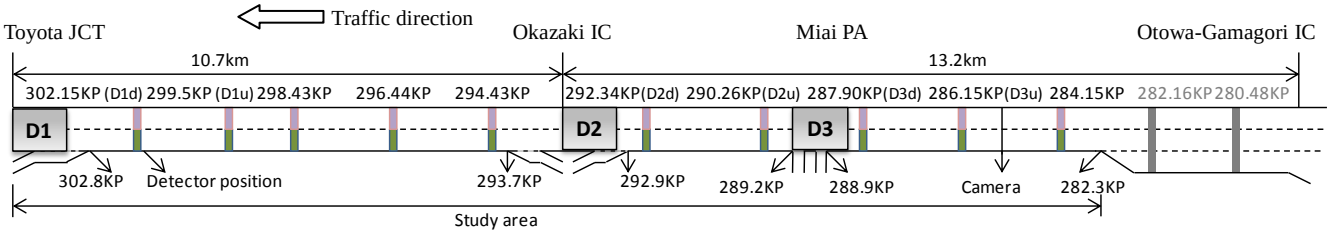

Fig.1 Layout of study site

Table 2 Diverge rate for each diverge section

Diverge section	D1	D2	D3
Diverge rate (%)	52.4	8.75	9.74

interval. As all the diverge sections have diverge lanes at left-hand side, drivers who intend to diverge would prefer to shoulder lane. As a result, SLUR was increased at D1 and D2. The reason why the opposite result is obtained at D3 may be because of the existence of a speed enforcement camera at 286.15KP. Before passing this camera, all the drivers who are traveling with high speed tend to slow down. Vehicles on the median lane may also slow down and intend to shift to the shoulder lane. As a result, the SLUR gets higher.

Comparing the SLURs at different diverge sections, it is found that the SLUR at adjacent upstream detector of D1 (302.15KP) is higher than the other two, while these at the other two detectors (292.34KP and 287.90KP) are almost in the same level. One of the possible reasons is that high diverge demand causes that more drivers change to the shoulder lane to diverge. Table 2 shows the diverge rate at each diverge section (diverge flow/mainline traffic flow at upstream detectors*100%). Diverge flows are calculated from different data sources: detector data at the junction for D1, ticket and ETC gate information for D2 and two-days survey data in Oct. 2007 for D3. The diverge rate of D1 and D2 are the average of all the analysis period while that of D3 is the average of the survey period.

It is found that diverge rate of D1 is 52.4%, which is 5 times more than the diverge rates of other two diverge sections. It can be considered that high diverge rate have a positive correlation with the SLUR upstream of the diverge section. The quantitative relationships of the diverge rate and SLUR should be analyzed.

2) Variation of SLUR

The variation of the SLUR under high demand level Q3 is smaller than the one under low traffic volume Q1. Under Q3, headways become small so that vehicles cannot change lanes freely. Thus lane changing behaviors are restricted and then the SLUR will have a small fluctuation.

4.2 Impacts of heavy vehicle (HV) percentage

Fig. 3 shows SLURs under different HV percentages at 284.15KP. As the results of all the detectors have the same tendency, the data at 284.15KP was chosen as an example. The result of Qtotal in Fig. 3 indicates that the SLUR has an increasing tendency when HV percentage is over 30%.

T-values (at a confidence level of 95%) of every two adjacent groups of HVs under three traffic levels are shown in the Table 3. There are no significant difference in SLUR between group 1(0-10%) and group 2(10-20%); however, the SLURs of the rest groups have significant differences between every adjacent groups. It can be concluded that when the HV percentage is over 20%, the SLUR will increase with the increase of HV percentage. When the HV percentage is over 30%, the impacts on the SLUR caused by HV become clearer.

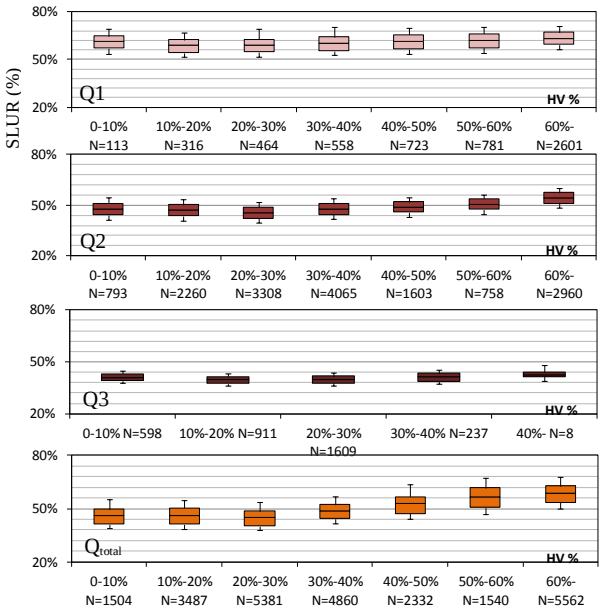

Fig.3 SLUR regarding different HV% at 284.15KP

Table 3 t-values of SLUR comparison between different HV groups

HV (%)	0-10 with 10-20	10-20 with 20-30	20-30 with 30-40	30-40 with 40-50	40-50 with 50-60	50-60 with 60-
Q1	3.89	-0.94	-2.29	-1.70	1.06	-4.43
Q2	3.20	11.45	-18.55	-9.73	-8.59	-19.32
Q3	10.06	-2.38	-7.06	-1.14	-	-
Q_{total}	-0.42	7.63	-28.39	-21.27	-13.85	-9.54

Since the heavy vehicles have speed limit equipments, they prefer to travel on the shoulder lane in most of their travel time. Therefore, the SLUR increases with the increase of HV percentage.

5. Conclusion

The SLURs at the detectors located nearest to the diverge section were significantly higher compared to their adjacent upstream detectors. The HV percentage over 20% will impact on the SLUR.

6. Future work

Effect of diverge demand should be found out quantitatively. Since the data in this paper was only from three months at a limited section, much data and more sections should be analyzed to derive quantitative relationships.

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