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Analysis of Delay by Alternative Passing Opportunities on Two Lane Highways

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Abstract: *As of December 31, 2016, the total number of national highways in Korea is 13,948 km (about 12.9% of all roads), of which about 6,000 km (42.9% of the national highways) are two lane roads. Since 2000, many two lane roads have been extended as part of the interregional mobility policy, resulting in high standard and over-investment controversy for extended four-lane roads. Since then, the government has been asking for reasonable engineering grounds (e.g. demand base) for construction of new roads or already designed roads. In this situation, it is necessary to envision efficient operation improvement technique through low budget input rather than unconditionally expanding roadway by 4th lane. Therefore, in this study, we tried to provide the grounds for applying to the domestic market by referring to the various operating methods (overtaking opportunities) applied abroad in order to increase the capacity of two lane roads in Korea and to operate them safely and efficiently. The results of the field survey and the simulation of two lane roads were analyzed for the sections where the 100% overtaking prohibition section, the 100% overtaking section (1km), and the overtaking lane were installed. As a result, the two lane road with the overtaking lane has an effect of about 8.7% in terms of the traffic volume of 1,000 cars compared with the traffic lane, and the service level is also improved. This can be used as a reference for providing overtaking opportunities on two lane roads, and it is possible to elicit the overtaking period or the length of the overtaking interval through the detailed analysis of the overtaking rate.*
Keywords: *two-lane, passing, delay, PTSF, overtaking*

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I. Introduction

As of December 31, 2016, the total number of national highways in Korea is 13,948 km (about 12.9% of all roads), of which about 6,000 km (42.9% of the national highways) are two-laneroads [1]. Since 2000, many two lane roads have been extended as part of the interregional mobility policy, resulting in high standard and over-investment controversy for extended four-lane roads. Since then, the government has been asking for reasonable engineering grounds (e.g. demand base) for construction of new roads or already designed roads. In this situation, it is necessary to envision efficient operation improvement technique through low budget input rather than unconditionally expanding roadway by 4th lane.In Korea, the overtransmissible section, which is the only alternative to improve the service level of the two lane road, is limited. For example, if the existing overtaking possibility section is changed to the prohibition section, the overtaking section length is not allowed to be 200 m on the average, and the maximum allowable distance is no longer than 400 m. Even if the overtaking intermittent camera Considering that a passing vehicle accelerates at a speed of about 10 to 15 km/h and must pass, assuming that the vehicle is traveling at a limited speed, it is not preferable to install the overtaking section of the overspeed camera in the overtaking vehicle. It limits the chance of passing.

This is the main cause of lowering the service level of the two lane roads. In the United States, especially in the United States, where relatively geographical conditions are favorable, not to mention Europe where the geographical conditions are not favorable, there is a considerable effort to efficiently operate the two lane roads. For example, the recent introduction of 2 + 1 lane roads (Passing lane in the US NCHRP 3-55, 2 + 1 lane roads emerged in Europe) [2] as overtaking lanes and concession lanes . As a result, outside the country, there are various ways to operate two lane roads efficiently. In Korea, however, two lane roads have not been provided properly. It is necessary to compare and analyze the delay effect on various measures.

II. Literature Review

Harwood and John [3] compared and analyzed the effects of overtaking, short four-lane, long turnout, turnout, and two-way left-turn(TWLT). In addition, Harwood and John [4] analyzed the effect of transportation operation on overtaking lanes and suggested that it is a low-cost alternative to the extension by the fourth lanes.

This study applied the TWOPAS model to compare and analyze overtaken roads with and without overtaking in terms of road effect and validated they using data observed on the two lane road with overtaking lanes. As a result, it was found that the effect of overtaking was correlated with the length of traffic volume and overtaking distance. Potts and Harwood [5] analyzed the applicability and potential effects of overtaking lanes in US Missouri two lane roads, the analysis of service level and safety effects of existing overtaking lanes, overtaking and related standards, road design (PTSF) decreased by 10 ~ 31% compared to two lane road with no overtaking lane, and the frequency of accidents (Number of accidents/mile/year) decreased by 12 ~ 24%.The Measure of Effectiveness (MOE), which indicates the level of service (LOS) of two lane roads, is related to the lag in the US Road Facilities Manual (USHCM) [6,7] and Korea Road Capacity Manual [8,9]. In USHCM in 1985, MOE called Percent Time Delay (PTD) was used. In 2000 USHCM, Percent Time Spent Following (PTSF) was used. In addition, the average travel speed (ATS) was used as an auxiliary service level criterion in CLASS I two lane roads of high standard. First, the PTSF means the average travel time ratio of vehicles that are delayed by the low-speed leading vehicle on two lane road. The PTD is basically similar to the PTSF, but the PTSF is a concept representing the lag. Whereas the PTD is a measure of effectiveness as a measure of the ratio of traffic to traffic that forms a group of vehicles versus the total traffic passing through this point relative to a particular point to be analyzed.The USHCM also calculated the PTD from the field survey data for the PTSF calculation and established the PTSF calculation formula by the regression equation. Total Delay Rate (TDR) is the MOE used in 2001 KHCM, which is the index of the difference between the desired travel time and the actual travel time. The current version of KHCM in 2001 shows that the calculation is based on traffic volume. Table 1 compares the MOE, which shows the degree of delay of the two lane roads.

Table 1. MOEsin relationwith delay in two lane roads

Measure of Effectiveness(MOE) in relation with delay		
Percent Time Spent Following(PTSF)	Percent Time Delay(PTD)	Total Delay Rate(TDR)
$PTSF = 100[1 - e^{-0.000879 V_P}] + f_{d/np}$	$PTD = \frac{V_{platoon}}{V_{total}} \times 100$	$TDR = 100 \times \frac{\sum_{i=1}^{n} (\frac{TT_{ai} - TT_d}{TT_{ai}})}{n}$
where, V_P = traffic volume(vph) $f_{d/np}$=change of PTSF according to the rate of overtaking-prohibited section	where, PTD = Percent time delay(%) $V_{platoon}$ = Platooned traffic volume V_{total} = Total traffic volume	where, TDR = Total delay rate(%) TT_{ai} = Actual travel time TT_d = Desired travel time n= Traffic volume(number of cars)
(USHCM, 2000)	(D.W.Harwood and A.D. John, 1985·1986)	(Moct, 201)

In addition to the above-mentioned delay related effect scale, there is an effect scale of overtaking rate for measuring the overtaking effect of two lane road. It is represented by the number of times of passing per unit distance, unit time, and usually expressed as "times/1 hour/1km".

III. Analysis Methodology And Field Survey

3.1 Establishment of analytical methodology

3. 2 Selection of analysis scale

The PTSF was selected as an index to explain the delay of the two lane road by reviewing the effectiveness measures proposed by USHCM 2000 and KHCM 2001. The reason for this is that the PTD is basically similar to the PTSF calculation formula, and the TDR, which is used as the MOE in two lane road of the domestic road capacity manual, is not easy to set the desired travel time for individual vehicles. It is not easy to directly compare the results.

3.2 Selection of the analysis target area and field survey

In this study, data collection and analysis were performed on the sites with the similar geometry to those of the study subject by dividing them into the sections for which overtaking was prohibited, some overtaking sections, and overtaking sections.

Simulation TWOPAS was selected as a suitable program for the simulation and the input values were derived using the results of the field survey. TWOPAS is used as a tool for the TAM (Traffic Analysis Module) among five analysis modules in the IHSDM (Interactive Highway Safety Design Module) program developed by the US Federal Road Administration. TWOPAS is a typical road traffic flow analysis program that performs simulation by inputting geometry and traffic data, and derives PTSF, traffic volume, speed, and delay related effect scale as the result.Comparison of lagging by means of providing overtaking opportunities on two lane roadsThe results of the simulation were compared with each other and the results were compared with those of the pre- entry and post - entry PTSF.

3.2 Field Survey

To conduct this study, we conducted a field survey on the 88 Olympic Expressway with concession lanes.

1. Target area: Gyeonggi-Dong Goryeong Intermediate area of IC area (currently operated as a concession lane, as an overtaking lane at the time of the survey)
2. Traffic volume, speed, headway interval before and after the passing vehicle
3. For 165 minutes total, select three sites and search by video (traffic flow investigation) and sound recorder (car license plate survey)
4. Data reduction: Excluding non-matching materials
5. 15-minute traffic flow rate is mainly analyzed on continuous roads, but 5-minute traffic flow rate is used for more detailed analysis

IV. Analysis Results

4.1 Deriving simulation input values

For the simulation, the field survey data were analyzed to set the vehicle group rate (Percent Following), the input value for the desired speed, and the target geometry. First, the vehicle group ratio is the same as PTD and PTSF, which is the ratio of the total traffic volume to the following traffic volume. In TWOPAS, the vehicle group ratio = 100 (1-exp (-0.0176 * flow). Through the field survey, the car group ratio prediction model is derived as shown in Fig. The desired speed was set at the average speed of the car type (passenger, truck) and single car, and it was derived from the field survey as shown in Table 2.

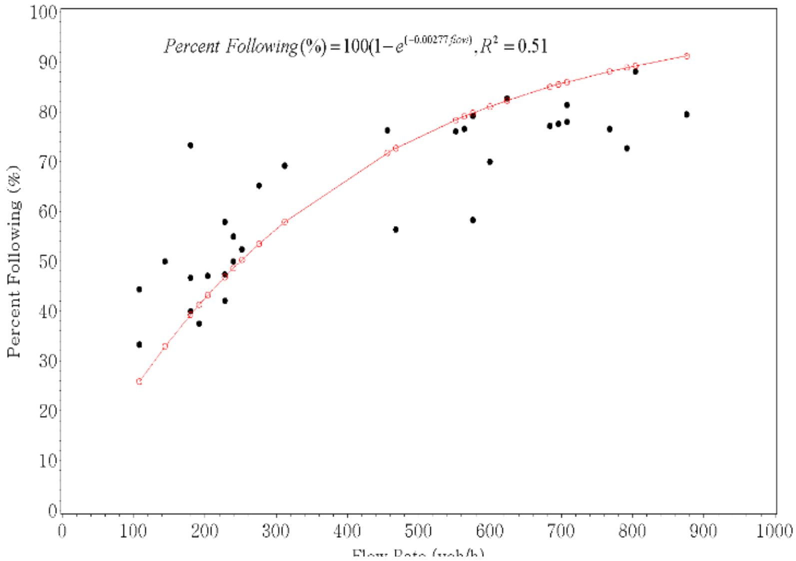

Fig.1. Percent Following by flow rate

Table 2. Selection of traffic flow input value for simulation

Volume for Simulation			Desired Speed(km/h)/Std.		Platoon Percent of volume[3)]
Volume (veh/h/direction)	Passenger car(%)[1)]	Truck(%)[2)]	Passenger car	Truck	
100	90	10	85.5/11 (※TWOPAS 99.0/8.0)	80.9/7.6 (※TWOPAS 95.7/6.4)	24.2
300					56.4
500					75.0
700					85.6
900					91.7
1,000					93.7

1) Passenger car and bus, 2) Truck and semi-trailer,
3) Using the model from field survey: platoon percent of volume = 1-exp(-0.00277*volume)

The section length of the simulation target section is set to 5 km each, and the section is selected as the overtaking section, the overtaking section, and the overtaking section (see Table 3).

Table 3. Set the target sites for the simulation

Section type for simulation	Description	Remarks
Non-overtaking(Basic) section	100% non-overtaking section	
Overtaking section	Center line Two-way overtaking section for 2~3km	
Passing lane section	Installed another lane(auxiliary lane) for 2-3km section	

4.2 Comparison of Operational Effectiveness
Simulation results

Simulation results through TWOPAS are shown in Table 4. It can be seen that as the traffic volume increases, the delay increases, and the delay decreases as the overtaking interval becomes longer than the overtaking interval and the overtaking interval. In this study, PTSF was selected as an effective measure to compare the degree of delay of two lane roads. The percentage of follow-up time in Table 4 is shown in Fig 2.

Table 4. Simulation results using TWOPAS

MOEs	Volume (vph) Section type	100	300	500	700	900	1000
percent time spent following	Non-overtaking section	35.7	68.4	80.9	85.2	89.9	91.6
	Overtaking section(1km)	29.5	65.5	79.2	84.1	89.5	91.2
	Passing lane section(1km)	25.6	56.7	70.2	76.2	81.7	83.6
Average Travel Speed (km/h)	Non-overtaking section	81	74	70	68	66	65
	Overtaking section (1km)	83	75	70	68	66	65
	Passing lane section (1km)	83	77	73	70	68	67
Total Delay1) (minutes/vehicle)	Non-overtaking section	0.11	0.42	0.7	0.81	0.95	0.98
	Overtaking section (1km)	0.04	0.37	0.66	0.78	0.93	0.97
	Passing lane section (1km)	0.01	0.29	0.54	0.65	0.82	0.85
Number of Passes2)	Non-overtaking section	0	0	0	0	0	0
	Overtaking section (1km)	21	39	42	44	21	23
	Passing lane section (1km)	28	185	515	714	1,220	1,356
Total Travel Time(veh-hrs)	Non-overtaking section	6.1	21.4	36.2	51.4	66.6	77.5
	Overtaking section (1km)	6	21.2	35.9	51	66.4	77.3
	Passing lane section (1km)	5.9	20.7	34.9	49.5	64.5	75.3

1) Total delay : The difference between the travel time under ideal conditions and the travel time derived from the simulation
2) Number of passes : In overtaking section, the number of overtaking times, the overtaking vehicle in the overtaking section

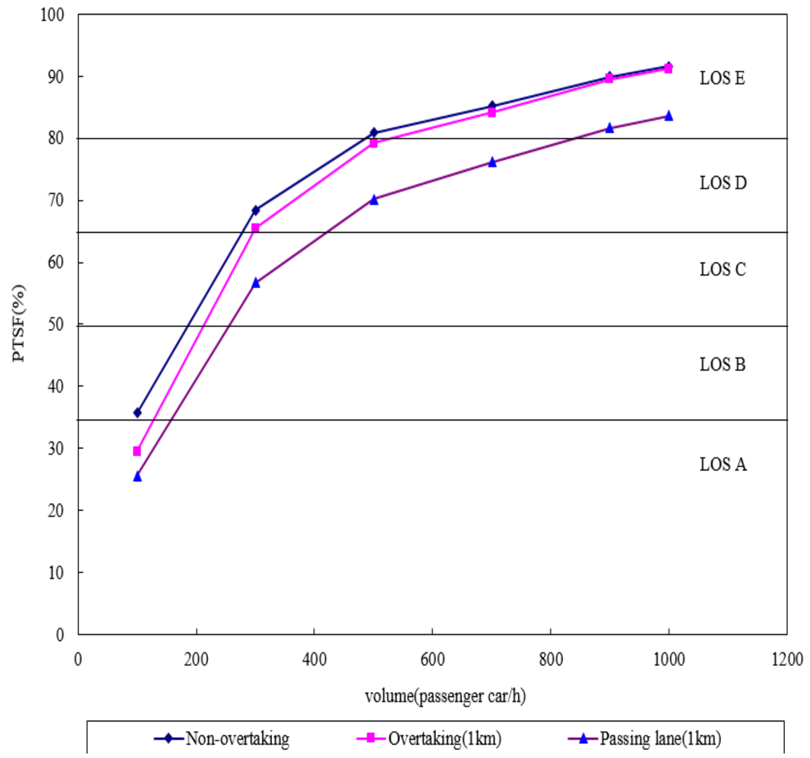

Fig.2.PTSF comparison by means of providing overtaking opportunities(CLASS I)

Compared with the service level of CLASS I proposed in the PTSF and USHCM (2000) derived from the simulation, the overtaking section shows a difference in level of service level compared to the overtaking section. In the case of 900 cars, LOS is located in the same E-class, but the PTSF of the interval is close to D and the PTSF of the overtaking interval is located at the upper end of the E-class. Table 5 compares the PTSF values shown in Fig. 2 and shows the improvement over the overtaking interval and the overtaking interval. As a result of the simulation, it was found that the overtaking interval has a minimum improvement of 8.7 ~ 28.3% compared to the overtaking interval.

Table 5. PTSF improvement rate by passing opportunities between before/after the passing lane

	Non-overtaking	Overtaking (1km)		Passing lane(1km)	
volume(vph)	PTSF_N(%)	PTSF_O(%)	Improvement rate(%)[1)]	PTSF_P(%)	Improvementrate(%)[2)]
100	35.7	29.5	17.4	25.6	28.3
300	68.4	65.5	4.2	56.7	17.1
500	80.9	79.2	2.1	70.2	13.2
700	85.2	84.1	1.3	76.2	10.6
900	89.9	89.5	0.4	81.7	9.1
1000	91.6	91.2	0.4	83.6	8.7
1)= ((PTSF_N-PTSF_O)/PTSF_N)*100 2)= ((PTSF_N-PTSF_P)/PTSF_N)*100					

Field survey results

Through the field survey, data such as traffic volume, speed, and headway interval were collected and analyzed in terms of delay. Table 6 shows the number of vehicles and the speed of the leading vehicle in the entire traffic flow. The traffic volume was 1215 units at 165 minutes and the vehicle group was 218 and 216 before and after the passing, respectively.

Table 6. No. of platoon and Ave. speed of leading vehicle in platoon between before/after the passing lane

contents	Before the passing lane		After the passing lane	
	No. of platoon	Ave. speed of leading vehicle in platoon	No. of platoon	Ave. speed of leading vehicle in platoon
Passenger car	143	83.6	180	94.4
Truck	64	80.2	31	88.05
Average speed	-	81.9	-	94.8
No. of leading vehicles	218	-	216	-

Figure 3 shows the result of calculating the PTSF before and after entering the traffic by traffic volume. Similar to the simulation results, USHCM LOS was compared with the CLASS I LOS standard in two lane road, and the PTSF was gradually increased rather than the simulated results.

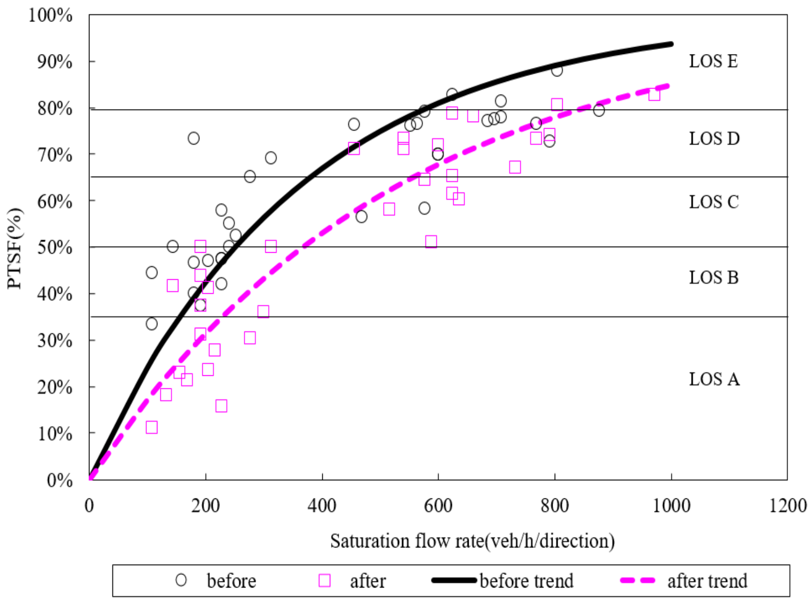

Fig.3.PTSF before/after the passing lane by traffic volume (CLASS I)

Table 7 shows the results of vehicle group analysis to compare the degree of delay before and after passing. Finally, PTSF was derived using the observed values in the field, and it can be seen that the PTSF was improved by about 12.2% after entering the market before passing by. That is, the section with overtaking lane is operated about 12% more efficiently than the section without overtaking lane. Vehicle group criterion is used in the range of 2 seconds to 5 seconds.

Table 7. PTSF comparison between before/after the passing lane

Before the passing lane		After the passing lane		Improvement effect of PTSF
Total volume	1,215	Total volume	1,215	12.2% =[(70-61)/70]*100
No. of platoon	218	No. of platoon	210	
max/min no. of vehicles in platoon	24/2	max/min no. of vehicles in platoon	21/2	
average no. of vehicles in platoon	4.9	average no. of vehicles in platoon	4.5	
Total volume of platoon	851	Total volume of platoon	747	
PTSF	70%	PTSF	61%	

Finally, the overtaking rate was calculated by comparing the vehicle order before entering with the overtaking vehicle and the order of the vehicle after passing through. The overtaking rate was regarded as an overtaking unconditionally regardless of the number of overturned vehicles. The results are shown in Table 8. In other words, 109 overtimes per hour were overtaken by the overtaking car. It is expected that this result will be used as a basis for calculation of the appropriate interval length by overtaking by deriving the overtaking rate in the future.

Table 8. Passing rate on passing lane section

No. of passing	Obs. time(min)	Length of section(m)	Passing rate(no./h/km)
308	165	1030	108.7 ≒ 109

V. Conclusion

Two lane road, basic overt, over table area, and additional lane were simulated and compared with various effect scales indicating the degree of lag. The results of this study show that two lane road with the overtaken section has about 8.7% of the 1,000 traffic volume compared to the overtaken section and the service level is also improved. This can be used as a reference for providing overtaking opportunities on two lane roads, and it is possible to elicit the overtaking period or the length of the overtaking interval through the detailed analysis of the overtaking rate.

References

[1]. Ministry of Land, Infrastructure and Transport, 2016, Manual on road works of department of road.

[2]. Transportation Research Board, 1996, Capacity and Quality of Service of Two-Lane Highways, Interim Report of NCHRP Project 3-55 (3). Midwest Research Institute.

[3]. D.W. Harwood and A.D. John, Passing Lanes and Other Operational Improvements on Two-lane Highways, FHWA-RD-85-028, FHWA, 1985.

[4]. D.W. Harwood and A.D. John, Operational Effectiveness of Passing Lanes on Two-lane Highways, FHWA-RD-86-195, FHWA, 1986.

[5]. I.B. Potts and D.W. Harwood, Benefits and Design / Location Criteria for Passing Lanes, RDT 04-008, Missouri Department of Transportation, MO, 2004.

[6]. Transportation Research Board, 1985, Highway Capacity Manual, Special Report 209.

[7]. Transportation Research Board, 2000, Highway Capacity Manual, Special Report 209.

[8]. Ministry of Construction, 1992, Road Capacity Handbook, Korean Transportation Society

[9]. Ministry of Construction and Transportation, 2001, Road Capacity Handbook, Korean Transportation Society

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