□ 論　　文 □

양방향 2차선 도로의 추월금지 모형개발 및 교통류특성 분석 연구

Development of no-overtaking Model and Analysis of fundamentals of traffic flow Characteristics on Two-Lane Highways

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ABSTRACT

본 논문의 목적은 2차선 지방지역도로에서 사용가능한 No-overtaking Model의 개발과 현장조사를 통한 우리나라 2차선 도로의 교통류 특성의 규명이었다. No-overtaking Model을 개발하기 위해서는 이미 개발된 바 있는 Slow moving Vehicle Model의 이론적 틀을 근거로 하되 중차량을 따라 피동적으로 주행하는 일련의 차량군에 또다른 중차량이 포함된 경우에 대해서도 분석이 가능하도록 개선했다.

경기도 일원에서 약 3개월동안 조사한 현장조사에서 나타난 우리나라 2차선도로의 교통류 특성은 첫째로, 2차선 교통류의 주요 MOE(Measures of Effectiveness)들은 교통량에 의해 비교적 정확하게 산정가능하다는 것과, 둘째로 우리나라의 주요 MOE값은 외국의 경우와 비교했을 때 대체로 유사한 결과를 보이나 평균속도의 경우 최소 5km/h 최대 15km/h 정도와 차이를 나타낸다는 것, 그리고 셋째로 차량군의 선두차량 85%의 경우 그 속도는 100.4km/h이고 추월에 필요한 반대편차선 차량과의 여유 거리는 754.8m이라는 것이었다.

향후 연구과제로는 중차량의 속도분포를 확률분포식으로 나타내는 경우의 지체시간, 추월율 등의 2차선교통류 MOE를 산출할 수 있는 Model을 개발하는 것이며 현재 5분교통량으로 표시된 교통량을 보다 많은 현장수집자료를 통해 1시간 단위의 교통량을 기준으로 하여 MOE를 산정해보는 것이다.

Background

Historically, rural roads in Korea have been built to either two or four lane standards. Although many two lane highways have been upgraded recently to high standards with approximately 1.5 m unpaved shoulders, these have been done without reviewing prior to the upgrading the specific effects resulting from these improvements on traffic flow parameters such as average platoon length, percent time delay, and overtaking rates. As far as research is concerned, there have been only limited attempts at deriving empirical speed-density-flow relations for two-lane traffic, and the generality of these developed relations remains in doubt. Moreover, unlike the multi-lane situation, traffic flow theorists have not yet developed a link between basic considerations of vehicle interactions on two-lane roads and macroscopic stream models. It is mainly due to the fact that driver perception of density and traffic impedance would differ significantly from multi-lane cases. It follows that, when platooning is a dominant stream characteristic, density alone may not be an adequate descriptor of the spatial nature of the traffic and its effect on stream speed.

In practice, not many people in Korea appear to take advantage of many newly developed practices such as passing lanes and because of this situation the relatively expensive method of widening two lane roads into four lane standard almost always has been taken as a rule. While the passing lane design procedure was developed due to highway budget constraint in the other countries, this idea have been ignored in Korea until very recently, mainly because only a sizeable road improvement was considered as the starting point for regional development. In this regard, road improvement has been advocated by many of citizen representatives.

In Korea, traffic characteristics for rural two-lane roads are as follows: First, traffic involves extremely high percentage of heavy vehicles. Second, geometrics include almost 100 % no-passing zones and very low design standards. Third, drivers are generally so impatient that it is not difficult to observe passing maneuvers even within no passing zones. Fourth, separate left turn lanes usually are not provided at at-grade intersections. Also, signalized intersections without warranted traffic volume frequently present problems such as an abnormally high number of traffic accidents.

Primarily, in this research various traffic flow parameters were empirically analyzed based on the field data. Subsequently, an attempt was made to develop the most relevant traffic flow analysis methodology applicable to rural two lane roads in Korea. In doing this, literature reviews on two-lane rural roads were also made. Through the literature reviews, it was found that macroscopic models as well as microscopic models have been developed extensively for rural two-lane roads. For example, macroscopic models include shock wave theory and car-following theory and microscopic models include probability and queueing theory. Microscopic models conceptually deal with probabilistic nature of an individual vehicle, particularly about how it is operating when overtaking slower vehicles on a two-lane, two-way road. The modeling process requires lots of empirically determined traffic characteristics and simplified assumptions. It is to be noted that the difficulty associated with modeling process led to the following conclusion by John R. Lean.

From the literature review of microscopic and macroscopic models, it was clear that there was, as yet, no completely satisfactory theoretical model of two-lane road traffic operations, even for steady-state equilibrium conditions. Moreover, given the analytical complexities that arise when severe assumptions are made, it would be unrealistic to anticipate future development of a comprehensive microscopic model which gives explicit consideration to all factors affecting flow performance.

Study Area Description

The two-lane roads studied for defining traffic characteristics are located in Changhowon, Ich n-Gun,Ky nggi-Do, which is central part of Korean peninsula. As the primary objective of this research was to develop traffic parameters for two-lane road and these were believed to depend upon fundamental characteristics of overtaking, in the early stage of this research, much attention was directed at the in-depth analysis of overtaking mechanism. Later on it was realized that korean two-lane roads are usually made of 100 % no-passing zones, so that spending too much time on analyzing mathematically the overtaking mechanism was considered useless. Naturally, it was decided that the model for this research should be a no-overtaking model. The field data were collected along relatively long and geometrically favorable section of a two-lane road, so that only traffic flow parameters would influence the quality of traffic flow.

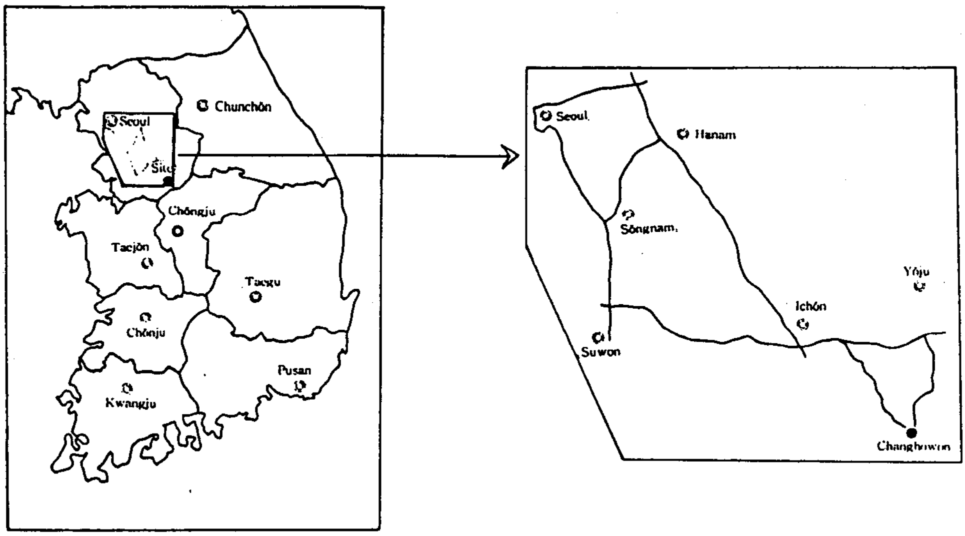

Figure 1. Location of the field site

The approximate geometric characteristics and traffic characteristics of the study area are summarized in Table 1 and Table 2, respectively.

Table 1. Geometric characteristics of the field site

Lane Width	3m
Shoulder Width	1m
Grade	0%
% No-Passing Zone	0%
Total Length	1,200m
Directional Distribution	50/50

Typical cross section consists of 3.0 m lanes and 1.0 m paved shoulder. As shown in Table 2, the average daily traffic (ADT) is relatively high to warrant upgrading to four lanes in the near future.

Table 2. Traffic characteristics of the field site

Hourly Volume	155(vehicles/hour)						
Average Speed	84.18(km/hour)						
Vehicle Size	Length(m)	0≤L[1)]<5.8	5.8≤L<9.1	9.1≤L<12.2	12.2≤L<15.2	15.2≤L<18.3	18.3<L
Classification	Percent	59.15	21.74	11.99	5.64	0.76	0.72

1) L : Vehicle Length

[Report #1 Sequential Data]

Hi-Star ID : 3350	Begin : 11/10/95 14:00	End : 11/10/95 17:00
Route : Changhowon	Lane : J	Hours : 3.00 hrs
Loc/Sta : Changhowon	Oper : Kim	UC : 0
City : Ich n-Gun	Posted : kph	Raw Count : 515
County : Ky ngki-Do	AADT Factor : 1.00	AADT Count : 4120

Vehicle	Day	Date	Arrival Time	Delay	Headway (secs)	Spacing (mtrs)	Speed	Length
1	Fri	11/10/95	14:00:05	0	NA	NA	87	4.6
2	Fri	11/10/95	14:00:16	0	11	266	113	8.5
3	Fri	11/10/95	14:00:24	0	8	250	82	4.6
4	Fri	11/10/95	14:00:27	0	3	68	93	4.6
5	Fri	11/10/95	14:00:36	0	9	233	87	4.3
6	Fri	11/10/95	14:01:24	0	48	1159	95	5.8
7	Fri	11/10/95	14:01:34	0	10	264	90	4.9
8	Fri	11/10/95	14:02:08	0	34	851	111	9.4
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Figure 2. Configuration of output from the traffic data recorder

Study Methodology

The highway alignment data were assembled based on as-built engineering maps provided by the Seoul Regional District Office which is one of lower level organizations in the Ministry of Construction and Transport. In addition, geometric data such as sight distance, terrain type, land use pattern, and lateral clearance were obtained manually.

Traffic data included existing (year 1995) and design hourly volume from the final report prepared with the as-built engineering maps. Space mean speed studies were conducted using traffic data recorder developed in the U.S.

Traffic composition also was collected by the data recorder. Figure 2 illustrates the configuration of output from the traffic data recorder.

The Model

The model developed in this research is based on the prevalent condition of no-overtaking in two-lane roads in Korea and we call it the no-overtaking model.

The no-overtaking model consider the performance of a single stream of vehicles where overtaking is prohibited. As this involves only platoon catch-up, with no interactions between opposing streams, it can be modeled much more rigorously than the limited overtaking case.

Prior to developing the no-overtaking model in this research, literature review was made and SMV (Slow Moving Vehicle) model developed by John Morrall in the University of Calgary appeared to be applicable to Korean condition, particularly at the situation where majority of two-lane highways were with no-passing barrier strips. Nevertheless, The SMV model only accounted for a single number of slow moving vehicle. A more realistic case where two or more of slow moving vehicles were traveling together in the same platoon could not be explained realistically. In this research this shortcoming of the SMV model was removed partly by embedding two different slow moving vehicles into the model structure.

As a consequence, more realistic simulations where a truck and a bus, or 200 lb/hp and 300 lb/hp heavy vehicles are travelling together could be analyzed in a reasonable manner.

The Structure of Model

The structure of no-overtaking model is as follows:

If volume for one time unit is Q, the probability of x vehicles pass the starting point P for time interval t is by Poisson distribution explained as:

$$P_t(x) = e^{-Qt}\frac{(Qt)^x}{x!}$$

Hence, the probability density function of the waiting time for one vehicle passing the starting point is as follows:

$$f(t) = Qe^{-Qt} \qquad (0 \leq t < \infty)$$

Also, the mean and the variance are 1/Q and $1/Q^2$, respectively. The probability density function of the waiting time for k vehicles passing the point is:

$$f(t) = \frac{Q(Qt)^{k-1}}{(k-1)!} e^{-Qt} \qquad (0 \le t < \infty)$$

The mean and the variance are k/Q and k/Q^2, respectively.

Hence, it is assumed that vehicles pass the point for each 1/Q time unit. Also the following assumptions are used in this model.

- Traffic volume is Q for each time unit.
- The average vehicle length is L.
- The starting point is P, the ending point is R, and the distance between the two points is d.
- A slow moving vehicle S passes point P with speed v and another slow moving vehicle T passes the point with speed w after time unit b. Also, the speed v is within the range of QL<v<w, and as many as (k-1) vehicles are existing between points S and T.
- $\frac{bv}{w-v} - \frac{kL}{w-v} < \frac{d}{v}$
- The speed for other vehicles is v_f and it is assumed that $w < v_f$.

The Algorithm

Then the following procedures have to be considered to solve the delay resulted from two slow moving vehicles S and T.

Step 1) The time of passing point P by vehicle S is 0.

Step 2) Vehicle y passes the starting point P after time unit t. If as many as (m-1) vehicles are moving between points S and y, and let the time when vehicle y is to be influenced by vehicle S be t_c and if t < b,

$$(t_c - t)v_f = t_c v - mL$$

Hence,

$$t_c = \frac{tv_f - mL}{v_f - v}$$

The actual time for vehicle y to move from point P to point R is:

$$t_y = \frac{d - t_c v}{v} + \frac{t_c v}{v_f}$$

The travel time spent by a free-moving vehicle is:

$$t_{y0} = \frac{d}{v_f}$$

Accordingly, the delay experienced is:

$$D_{t,m}(y) = t_y - t_{y0} = d\left(\frac{1}{v} - \frac{1}{v_f}\right) - t + \frac{mL}{v_f}$$

Step 3) If vehicle T is influenced by vehicle S at time t_1 :

$$w(t_1 - b) = vt_1 - kL$$

Hence,

$$t_1 = \frac{bw - kL}{w - v}$$

The time required for vehicle T to move from point P to R is:

$$t_T = \frac{d - t_1 v}{v} + \frac{t_1 v}{w}$$

For a free-moving vehicle, the required time is:

$$t_{T0} = \frac{d}{w}$$

Hence, the delay is:

$$D_t(T) = d\left(\frac{1}{v} - \frac{1}{w}\right) - b + \frac{kL}{w}$$

Step 4) If vehicle x begins to be influenced by vehicle T at the moment when the vehicle traveling behind of vehicle T, which passed the starting point at time a, begins to be influenced by vehicle S:

$$v_f(t_1 - a) = w(t_1 - b) - nL$$

Therefore,

$$a = \frac{(v_f - w)t_1 + bw + nL}{v_f}$$

Step 5) Vehicle x started at time b<t≤a and travels as many as n vehicles behind of the vehicle T. Let time t_2 be the moment when vehicle x begins to be influenced by vehicle T:

$$v_f(t_2 - t) = w(t_2 - b) - nL$$

Therefore,

$$t_2 = \frac{tv_f - bw - nL}{v_f - w}$$

Total time for vehicle x to travel from point P to point R is composed of $w(t_2 - b)$ with speed v_f, $w(t_1 - t_2) + kL$ with speed w, and $d - w(t_1 - b) - kL$ with speed v. As a result, delay can be calculated as:

$$D_{t,n}(x) = d\left(\frac{1}{v} - \frac{1}{v_f}\right) - t + \frac{nL}{v_f} + \frac{kL}{w}$$

Step 6) Vehicle x started at time of $a (a<t)$ and is traveling as many as n vehicles behind of vehicle T. In this case, vehicle x begins to be influenced by vehicles T and S at the same moment. Let this moment be t_3. Then this results:

$$v_f(t_3 - t) = w(t_1 - b) + v(t_3 - t_1) - nL$$

Hence,

$$t_3 = \frac{tv_f - (k+n)L}{v_f - v}$$

The actual time for vehicle x to travel from point P to point R is composed of $w(t_1 - b) + v(t_3 - t_1)$ by speed v_f, kL by speed w, and $d - w(t_1 - b) - v(t_3 - t_1) - kL$ by speed v. Therefore, delay is:

$$D_{t,n}(x) = d\left(\frac{1}{v} - \frac{1}{v_f}\right) - t + \frac{nL}{v_f} + \frac{kL}{w}$$

Step 7) There is delay occurring for a vehicle to pass point P from the time specified at step 6 to the time of:

$$t_3 = \frac{d}{v} + \frac{kL}{w} - b.$$

If so, $t = d\left(\frac{1}{v} - \frac{1}{v_f}\right) + \frac{v_f - v}{wv_f}kL + \frac{(k+n)L}{v_f} - b\left(1 - \frac{v}{v_f}\right)$ and the vehicles following vehicle T are as many as:

$$Q[d(\frac{1}{v}-\frac{1}{v_f})+\frac{v_f-v}{wv_f}kL+\frac{(k+n)L}{v_f}-b(2-\frac{v}{v_f})]$$

This equation represents the number of vehicles passing point P for the time interval of:

$$t-b=d(\frac{1}{v}-\frac{1}{v_f})+\frac{v_f-v}{wv_f}kL+\frac{(k+n)L}{v_f}-b(1-\frac{v}{v_f})-b$$

Step 8) Specifically, if the time unit is controlled so that Q=1, from steps 5 and 6, $(t-b)$ equals n. The total delay resulted from step 5 and step 6 is:

$$t_*=d(\frac{1}{v}-\frac{1}{v_f})+\frac{v_f-v}{wv_f}kL+\frac{(k+n)L}{v_f}-b(1-\frac{v}{v_f})$$

From this, the following equation is derived:

$$\sum_{t=b+1}^{t_*}[d(\frac{1}{v}-\frac{1}{v_f})-t+\frac{(t-b)L}{v_f}+\frac{kL}{w}]$$
$$=(t_*-b)[d(\frac{1}{v}-\frac{1}{v_f})-\frac{bL}{v_f}+\frac{kL}{w}-(t_*+b+1)\frac{v_f-L}{2v_f}]$$

Also, if vehicle are following uniformly between vehicle S and vehicle T, it follows from step 2 that $t=m$, $k=b$. The total delay resulted from step 2 is:

$$\sum_{t=1}^{b-1}[d(\frac{1}{v}-\frac{1}{v_f})-t+\frac{tL}{v_f}]$$
$$=(b-1)[d(\frac{1}{v}-\frac{1}{v_f})-\frac{v_f-L}{2v_f}b]$$

Then, the total delay for vehicle T is:

$$d(\frac{1}{v}-\frac{1}{w})-b+\frac{kL}{w}$$

Accordingly, the total delay for the total traffic volume can be stated as:

$$(t_*-b)\left[d(\frac{1}{v}-\frac{1}{v_f})-\frac{bL}{v_f}+\frac{kL}{w}-(t_*+b+1)\frac{v_f-L}{2v_f}\right]+(b-1)\left[d(\frac{1}{v}-\frac{1}{v_f})-\frac{v_f-L}{2v_f}b\right]+d(\frac{1}{v}-\frac{1}{w})-b+\frac{kL}{w}$$

Step 9) If delayed vehicles are uniformly distributed and passing point P, then the followings are true:

k = Qb from step 4.

m = Qt from step 2.

n = Q(t-b) from step 5 and step 6.

Hence, from step 2:

$$D_{t,m}(y)=d(\frac{1}{v}-\frac{1}{v_f})-\frac{m}{Q}+\frac{mL}{v_f}$$

As a result, the total delay resulted from step 2 is:

$$\sum_{m=1}^{Qb-1}\left[d(\frac{1}{v}-\frac{1}{v_f})-\frac{v_f-LQ}{Qv_f}m\right]$$
$$=(Qb-1)\left[d(\frac{1}{v}-\frac{1}{v_f})-\frac{(v_f-LQ)b}{2v_f}\right]$$

From step 5 and step 6, the following equation can be derived:

$$D_{t,n}(x)=d(\frac{1}{v}-\frac{1}{v_f})-t+\frac{nL}{v_f}+\frac{kL}{w}$$

Then the total delay resulted from step 5 and step 6 is :

$$t_*=d(\frac{1}{v}-\frac{1}{v_f})+\frac{v_f-v}{wv_f}kL+\frac{(k+n)L}{v_f}-b(1-\frac{v}{v_f})$$

and

$$\sum_{n=1}^{Q(t_*-b)}\left[d(\frac{1}{v}-\frac{1}{v_f})-b-\frac{(v_f-QL)n}{Qv_f}\right.$$

$$+\frac{bLQ}{w}\Big] = Q(t_{*}-b)\Big[d(\frac{1}{v}-\frac{1}{v_f})-b+\frac{bLQ}{w} -\frac{(v_f-LQ)(t_{*}-b)}{2v_f}-\frac{(v_f-LQ)}{2v_fQ}\Big]$$

The delay for vehicle T is:

$$d(\frac{1}{v}-\frac{1}{w})-b+\frac{bLQ}{w}$$

As a consequence, the total delay is:

$$(Qb-1)\Big[d(\frac{1}{v}-\frac{1}{v_f})-\frac{(v_f-LQ)b}{2v_f}\Big]+d(\frac{1}{v}-\frac{1}{w}) -b+\frac{bLQ}{W}+Q(t_{*}-b)\Big[d(\frac{1}{v}-\frac{1}{v_f})-b+bLQ -\frac{(v_f-LQ)(t_{*}-b)}{2v_f}-\frac{(v_f-LQ)}{2v_fQ}\Big]$$

where,

Q = volume for one time unit

b = time differences between two slow moving vehicles S and T

d = highway section length

v = speed of slow moving vehicle P

v_f = free flow speed

L = vehicle length

w = speed of slow moving vehicle T

t_* = time difference

All these variables can easily determined in the field and specified ay the user. Based on this algorithm, a more accurate result can be obtained, which enhances the practicality of the no-overtaking model developed in this research.

Field Study Results

1. Regression: Based on the field study results described previously, regression equations were derived for major traffic flow variables including number of platoons, size of platoons, percent time delay, and average speed. In the field study, a group of vehicles traveling with less than 4 seconds headway were considered as a platoon. The size of a platoon was simply the number of vehicles in a platoon and the percent time delay was the percentage of vehicles in platoons by total number of vehicles. Actually these traffic parameters were obtained by a computer software developed in this study and the field data are collected by a traffic data recorder developed in the U.S.

Additionally, 85 and 15 percentile values for headway, lead vehicle speed that is the speed of first vehicle in a platoon and this was idenfied by the computer program, and gap-accepted value were analyzed. The gap-accepted value is the distance from the starting point of a passing maneuver to the opposing vehicle location. The value was observed by the survey crew checking the above two locations using tentatively installed distance marks. The sampling period was 3 hours per weekday and total of 12 days surveying were made, which made total surveying period 36 hours in the fall of 1995.

Table 3 and 4 show the results.

2. Level Of Service Criteria: Additional attempt was made to select the most appropriate measure of effectiveness in defining the level of services in two-lane, two-way highways in Korea. Based on the field study result, it was found that percent time delay and average speed values were lower compared to the 1985 USHCM values. The average speed was automatically collected by the traffic data recorder

Table 3. Regression equations for each traffic flow MOE.

Independent variables	Number of platoons	Volume(v/5min)	Volume(v/5min)	Volume(v/5min)	Volume(v/5min)
Dependent variables	Size of platoons	Size of platoons	Number of platoons	Percent time delay	Average speed(km/h)
Regression equation	$0.113x^2 + 2.346x - 0.095$	$0.003x^2 + 0.155x - 0.067$	$0.022x^2 + 0.108x + 1.048$	$-0.211x^2 + 8.38x + 1.657$	$-0.022x^2 - 1.158x + 87.7$
R-squared	0.98	0.95	0.96	0.91	0.97

Table 4. 85 and 15 %-tiles Values for major traffic flow parameters.

	Headways(sec)	Lead vehicle speed(km/h)	gap - accepted(m)
85 %-tile	33.08	100.39	754.8
15 %-tile	16.78	16.40	375.4

Table 5. Suggested Level of Service Criteria Compared to USHCM at 0% No-passing Zone

LOS[1]	Percent Time Delay		Volume (veh/min/direction)		Speed (km/h)	
	Suggested	USHCM[2]	Suggested	USHCM	Suggested	USHCM
A	0~30	0~30	3.73	3.5	83.08	93.34
B	30~45	30~45	6.12	6.3	79.79	88.51
C	45~60	45~60	9	10.03	75.49	83.68
D	60~75	60~75	13.03	14.93	68.86	80.47
E	75~100	75~100	19.00	23.33 57.76	57.76	72.42
F	100	100	—	—	—	—

1) LOS : Level of Service 2) Special Report 209, 1994

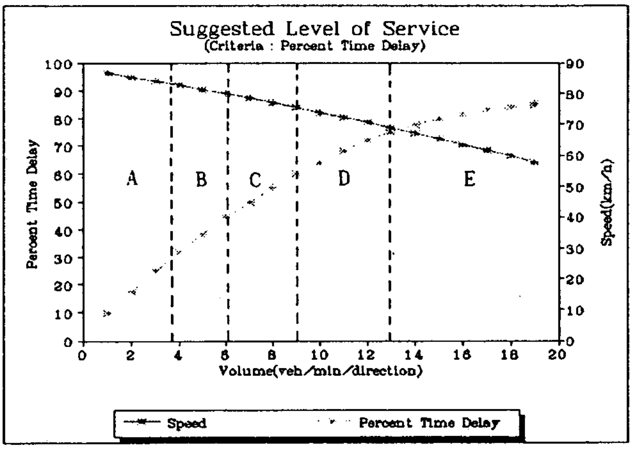

Figure 3. Suggested Level of Service Criteria applicable to Korean Two-lane Highways

and summarized based on 1 minute interval, which was needed as a consistent relationship between average speed and volume could be obtained only after 1 minute interval was applied. Also the observed volume ranges were relatively narrow. Based on the new relationship between average speed and volume established in this study, a new level of service criterion was developed and shown in Figure 3.

3. Relationships between major traffic flow parameters observed in the field study: The major relationships considered relevant to two-lane traffic flow were analyzed mostly by plotting the observed data. In this procedure traffic volumes, ranging typically 150-200 vehicles per hour in this study, were based on five minute volume, as the analysis based on hourly volume did not show any consistent pattern. Accordingly, it is to be noted that the use of these relationships should be confined to comparable volume ranges and geometrically similar places.

As far as delay is concerned, not much difference was shown between the study results and the USHCM values. But average speed involved 5 km/h minimum difference and approximately 15 km/h maximum difference. This difference seemed to be generated mainly due to unfavorable geometric conditions, relatively narrow shoulder width, in particular.

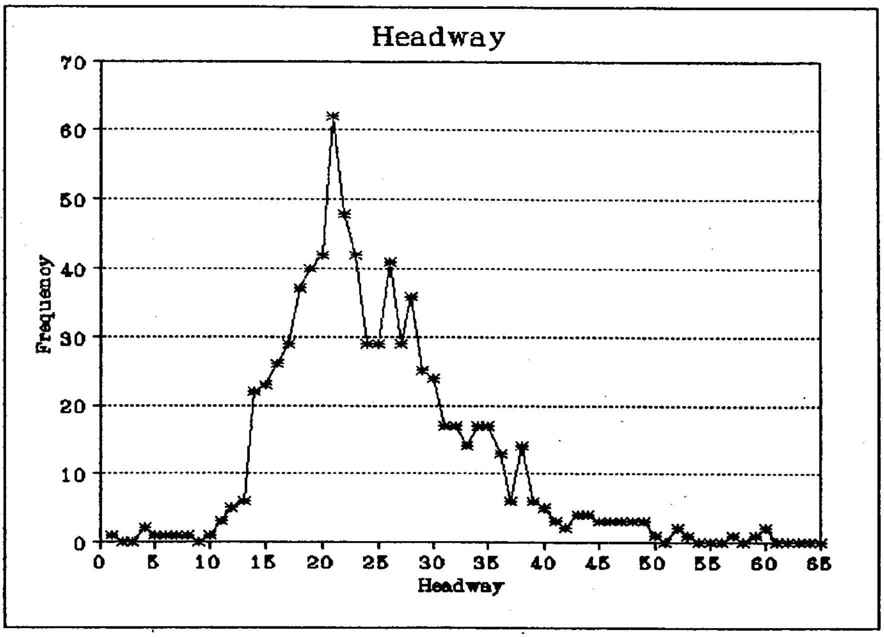

Figure 4. Distribution of Headways

15% - tile = 16.78(sec)
85% - tile = 33.08(sec)

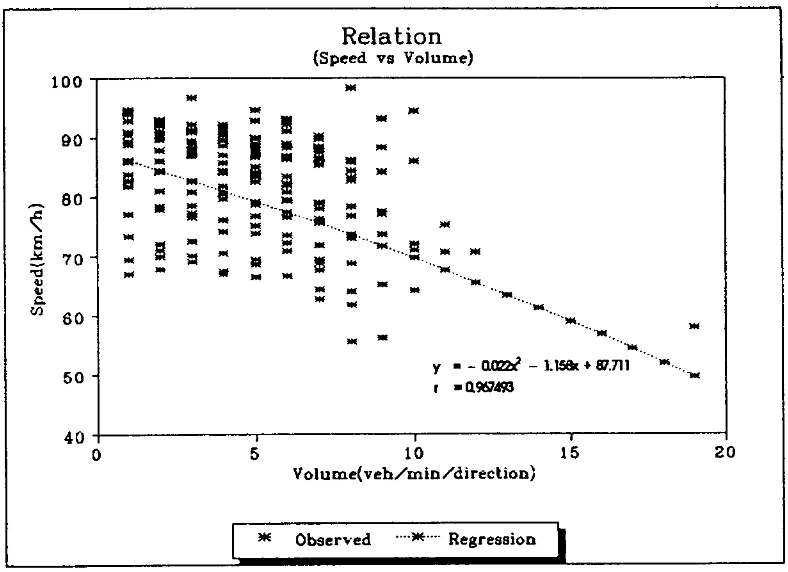

Figure 5. Relationship between Speed and Volume

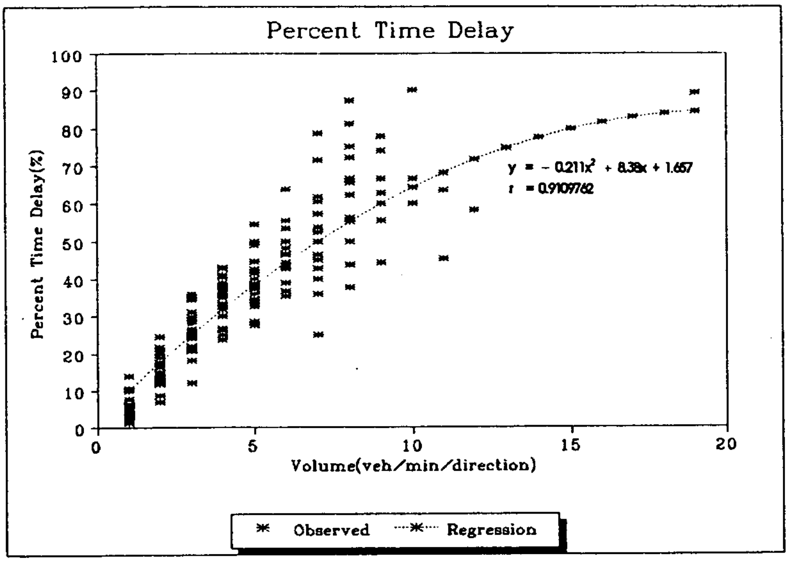

Figure 6. Relation of Percent Time Delay versus Volume

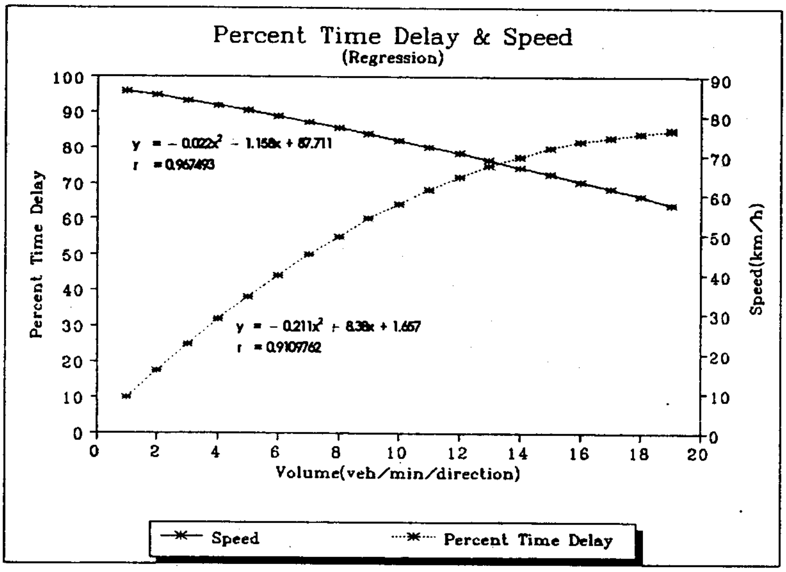

Figure 7. Relation of Percent Time Delay and average Speed

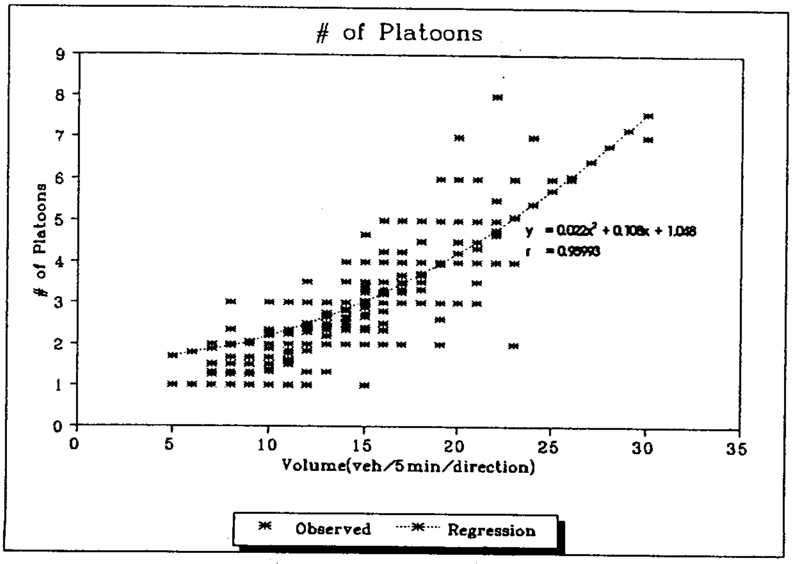

Figure 8. Relation of Number of Platoons versus Volume

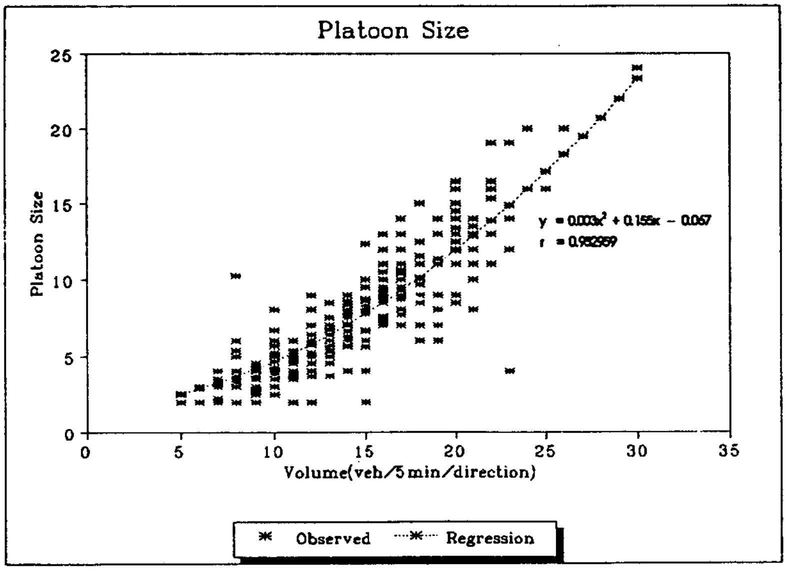

Figure 9. Relation of Platoon Size versus Volume

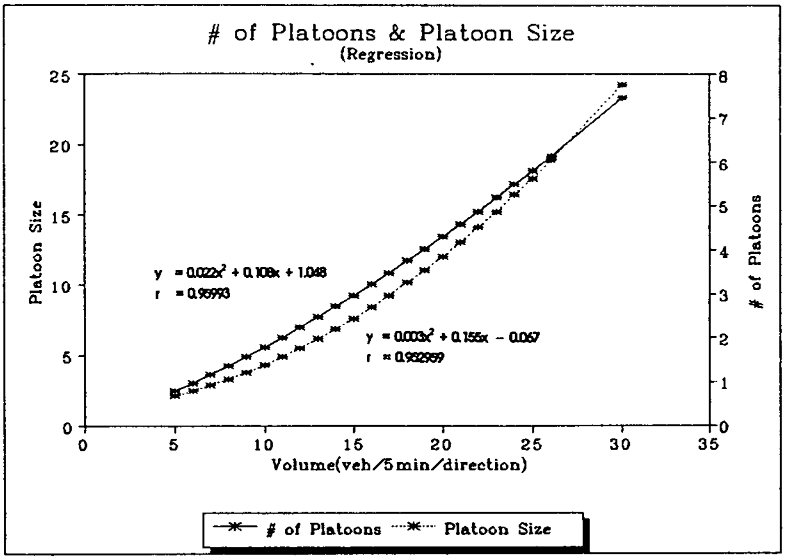

Figure 10. Relation of Number of Platoons and Platoon Size versus Volume

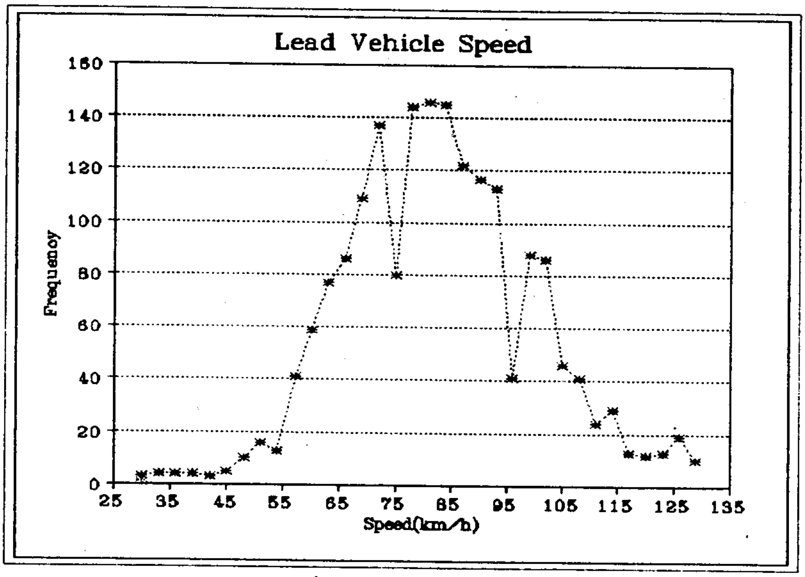

Figure 11. Distribution of Lead Vehicle Speeds
15% - tile = 64.40(km/h)
85% - tile = 100.40(km/h)

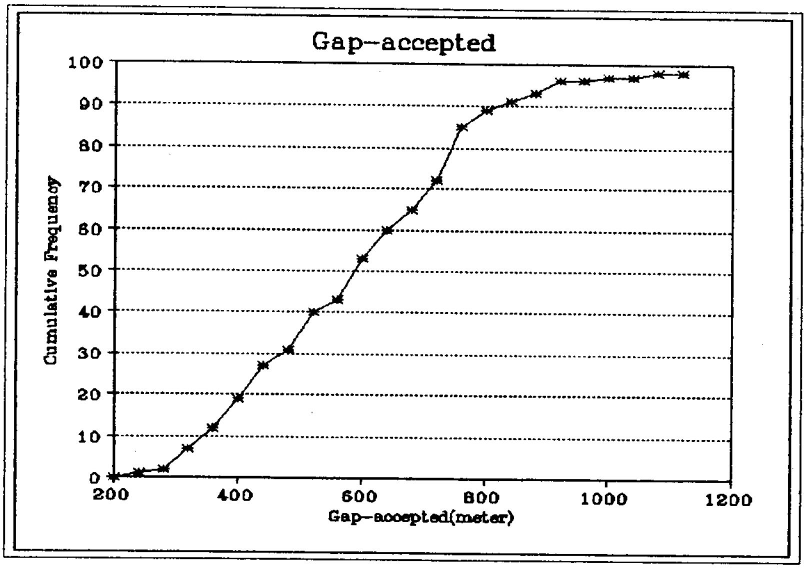

Figure 12. Cumulative Distribution of Gap-Accepted
15% - tile = 375.43(m)
85% - tile = 754.77(m)

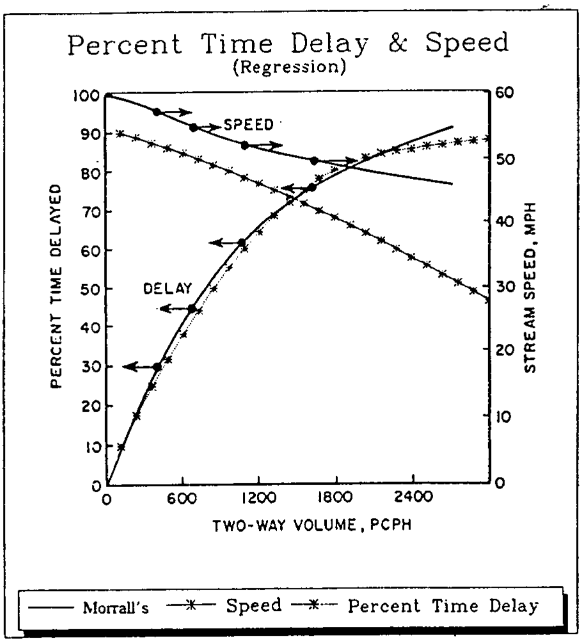

Figure 13. Comparisons of percent time delay and average speed against the 1985 USHCM values.

Conclusions

In this research, the basic characteristics of two-way highways were analyzed based both on the structure of no-overtaking model and on Korean field study results. It was considered that the models developed earlier for two-way highways simulation seemed to focus too much on explaining overtaking mechanism, leaving the reality associated with extremely high amount of heavy vehicle percentage and no-passing zone problems intact. This in fact limited seriously the applicability of simulation models. Recently this problem was relieved by the SMV model in some extent, but a problem still remains in categorizing slow moving vehicles. In fact this model considered only one type of a slow moving vehicle. In case where slow moving vehicles are more than two types, this model could not be applied. A more refined form of slow moving vehicle model was developed in this research to account for this situation.

Additionally, the field study was made for more than three month study period and the results seemed to state the typical Korean two-lane highway conditions.

- Major traffic flow parameters on two-lane highways could be described by traffic volume with high degrees of accuracy.
- The earlier study results including the ones done by John Morrall were comparable to the field study results made in this research, but the points obtained in this research showed underestimated values.
- 85 %-tile values for lead vehicle speed and

gap-accepted showed 100.4 km/h and 754.8 m, respectively.

In addition to these fidings, an attempt was made to develop a new set of Level of Service criteria for two-lane highways. Percent time delay was selected as the most appropriate level of service criterion, as it showed an identical values compared to the USHCM values.

A further research is required for developing a more generalized form of no-overtaking model such as adopting vehicle speed distribution for delay estimation. Also, plottings based on hourly volume are desired in the near future.

As this point in time, a comparison study between the results from model developed in this study and the ones from field study was not made due to time constraint. Subsequent studies are to be done soon.

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References

1. TRB special report 209, "Highway Capacity Manual," 1985

2. John R. McLean, "Two-lane Highway Traffic Operations (Theory and Practice)," Gordon and Breach Science Publishers

3. TRB special report 165, "Traffic Flow Theory (A Monograph)," 1975

4. John Morrall, et al, "Planning for Movement of Very Large, Slow-Moving Vehicles," Journal of Transportation Engineering, Vol. 118, No.3, 1992

5. ARRB, "Road and Transport Research," September 1995, Vol 4, No.3

6. Jaisung Choi, "A Method for the Development of Design Guides for Passing Lanes on Two-Lane Highways," Korea Transportation Research Society, Vol. 13, No.3, 1993

7. Jaisung Choi, Byungguk Choi, "Design Method of Passing Lanes," Korea Transportation Research Society, Vol. 7, No.2, 1989