Proceedings of the Eastern Asia Society for Transportation Studies, Vol. 5, pp. 1548 - 1556, 2005

AN INTRODUCTION OF INDICATOR VARIABLE TO DEVELOP A NEW LOGIC FOR INCIDENT DETECTION ALGORITHM

SangGu KIM
Assistant Professor
Department of Transportation Engineering
Yosu National University
San 96-1, Dundeok-Dong, Yeosu City, Jeollanam-Do
550-749 Republic of Korea
Fax: +82-61-659-3349
E-mail: kimsg@yosu.ac.kr

Abstract: This study is performed to propose a new variable named an indicator that can easily detect the incident on freeways. To verify the usefulness of indicator for detecting the incident, 3 indicators of the flow, speed, and occupancy are built and they are compared with incident records. Even though there is a time lag due to an accumulation period, the stochastic natures of traffic variables can be resolved and it appears more stable traffic pattern than when the traffic variables are directly used. This makes it possible to easily find the threshold that an incident can be declared. If the value of the speed indicator is greater than the threshold, it can be judged that the incident may happen around the station. In this study it is appropriate to decide the thresholds that are -0.4 for 2-minute accumulation period or -0.3 for 5-minute accumulation period.

Key Words: indicator, incident, threshold, detector, accumulation

1. INTRODUCTION

Automatic incident detection is one of the most important ingredients of a freeway traffic management system (FTMS). An ideal logic would detect all incidents immediately on occurrence and would not produce false alarms when there are no incidents. However, most incident detection algorithms that have developed so far are not satisfied to accomplish this ideal performance.

Of the current incident detection approaches, the most popular appears to be the comparative (California-type) algorithms in which specified differences in traffic operations between two adjacent detector stations indicate the presence of an incident. Another approach also bases detection on traffic operations at a single station. The California-type algorithms developed by Technology Services Corporation (TSC) did not perform as well during independent off- and on-line tests as they did in initial off-line tests. This algorithm that expect an increase in occupancy upstream of an incident and a drop downstream is significantly affected by factors such as detector station spacing, operation conditions, duration of the incident, and the location of the incident relative to the detector stations. On the contrary, single-station algorithms have their weaknesses that are the complexity of distinguishing incident from nonincident congestion and the difficulty of controlling for non-incident-related changes in traffic operation because of factors like weather.

Such existing logics using for the incident detection algorithm are based on traffic variables such as the flow, the speed, and the occupancy obtained by each detector station. The logics such as the California-type and Double Exponential Smoothing (DES) algorithms use the occupancy to detect the incident and the McMaster algorithm makes use of the relationship between the flow and the occupancy.

It is common knowledge that freeway traffic data such as speeds, flows, occupancies, and densities exhibit patterns that relate to traffic states. This, in essence, is the guiding principle of incident detection in general. Because there is, however, random fluctuation of traffic data, it is not easy to directly identify the actual changes in traffic variables induced by the change in traffic conditions using raw traffic data. In order to overcome such a shortcoming, this study employed a new variable named indicator.

Therefore, the purpose of this paper is to introduce a new indicator variable and to test the feasibility to see if a new logic can be developed to perform closer to the ideal for incident detection.

2. DESCRIPTION OF INDICATOR VARIABLE

In order to build the indicator, 30-sec. interval values of the flow, the speed and the occupancy are accumulated during a given period (in this study 2- or 5-minute period). Differences between the two accumulated data elements are divided by the sum of both data elements, as given in Equations 1, 2, and 3. The indicators emphasize the actual changes of traffic variables, while the random fluctuations of traffic variables are minimized. In this study, 3 indicators are used, i.e. the flow indicator (Equation 1), the speed indicator (Equation 2), and the occupancy indicator (Equation 3).

$$q_{indicator} = \frac{\sum_{i=n-4}^{n} q_i - \sum_{i=n-9}^{n-5} q_i}{\sum_{i=n-9}^{n} q_i} \tag{1}$$

$$v_{indicator} = \frac{\sum_{i=n-4}^{n} v_i - \sum_{i=n-9}^{n-5} v_i}{\sum_{i=n-9}^{n} v_i} \tag{2}$$

$$O_{indicator} = \frac{\sum_{i=n-4}^{n} k_i - \sum_{i=n-9}^{n-5} k_i}{\sum_{i=n-9}^{n} k_i} \tag{3}$$

By accumulating the short interval values of traffic variables during the accumulation periods, noises like the random fluctuations are eliminated and real changes in traffic variables remain. The values of the indicators range from -1 to 1 by normalization, which makes it possible to directly compare the indicators of 3 traffic variables one another. The shorter the accumulation period is, the greater the indicator value could fluctuate.

3. DESCRIPTION OF THE DATA

Seven days of data from the Korea Highway Corporation (KHC) FTMS were stored to test the logic, from the period April 14 to April 20, 2004. The study sites selected for a feasibility test of the proposed logic are a portion of each Seohaean, Joongang, and Namhae freeways in Korea. Each portion is the span that includes 5 detector stations centering the incident location. The prime reason for the selection of these freeways was their good data compared with other freeways.

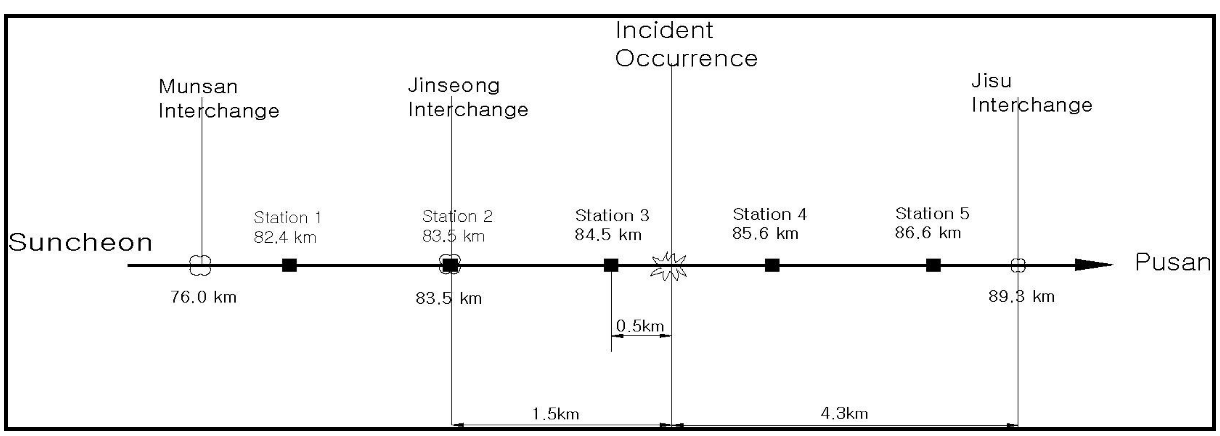
Three traffic variables such as speed (km/hr), volume (number of vehicles), and occupancy (percent) are summarized at 30-sec intervals 24hr a day at each of three sites. Before commencing the research for this paper, 7 days of data for each site had been stored for related research. The data base includes one incident day and 6 incident-free days at each site. Each data set contains 24 hr of 30-sec summaries of average speed, volume, and occupancy. Only the median lane (called lane 1) data were used in the analysis, primarily because trucks are prohibited from using the median lane. Consequently, volume counts were used directly without conversion to passenger car units. Therefore this test depends strongly on the assumption that any incident or bottleneck will cause a queue in the median lane that grows at least as fast as queues in the other lanes.

All incident records detected by an operator's log are appeared in Table 1 below and Figure 1 shows the schematic diagram for each site where the data are used in this study. The starting time that the incident appears in log file may be different from the real time the incident happened due to several reasons. Therefore, these records are just used to confirm the existence of incident comparing with the records that are detected by indicator variables.

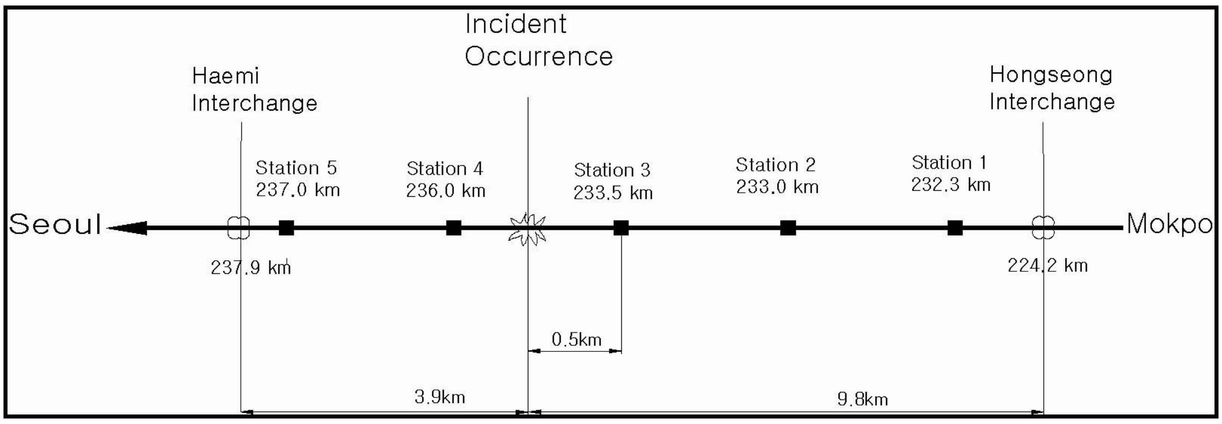
Table 1. Incident Occurrence Records

Freeway Name	Date	Duration	Lane[1]	Locations[2]
Namhae	2004.04.16.	16:54 ~ 17:15	1/2	85 km
Seohaean	2004.04.18.	15:07 ~ 15:32	2/2	234 km
Joongang	2004.04.18.	19:01 ~ 20:16	-/2	118 km

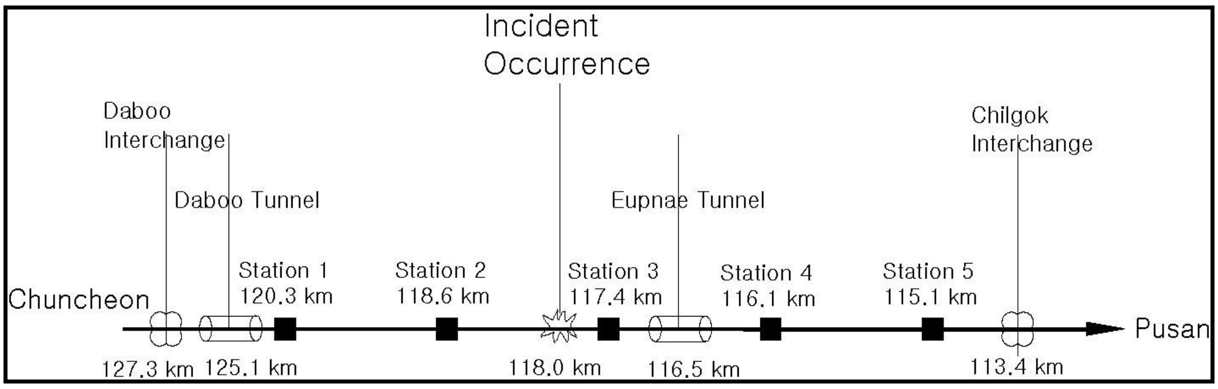
Note: 1) Incident Lane / No. of Lanes
2) Location from the origin of each freeway and see Figure 1.



a. Namhae Freeway



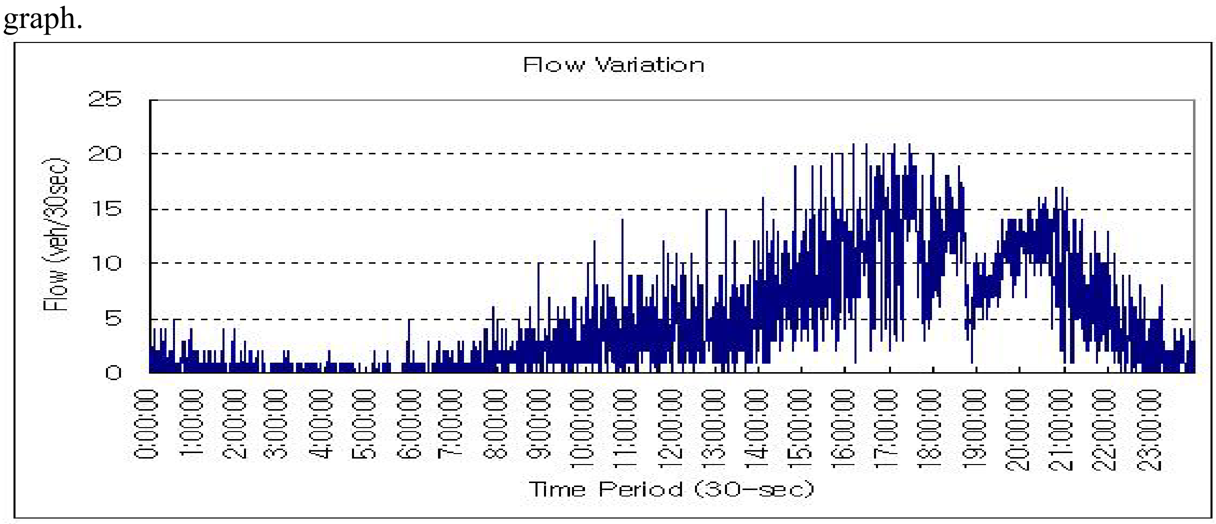
b. Seohaean Freeway



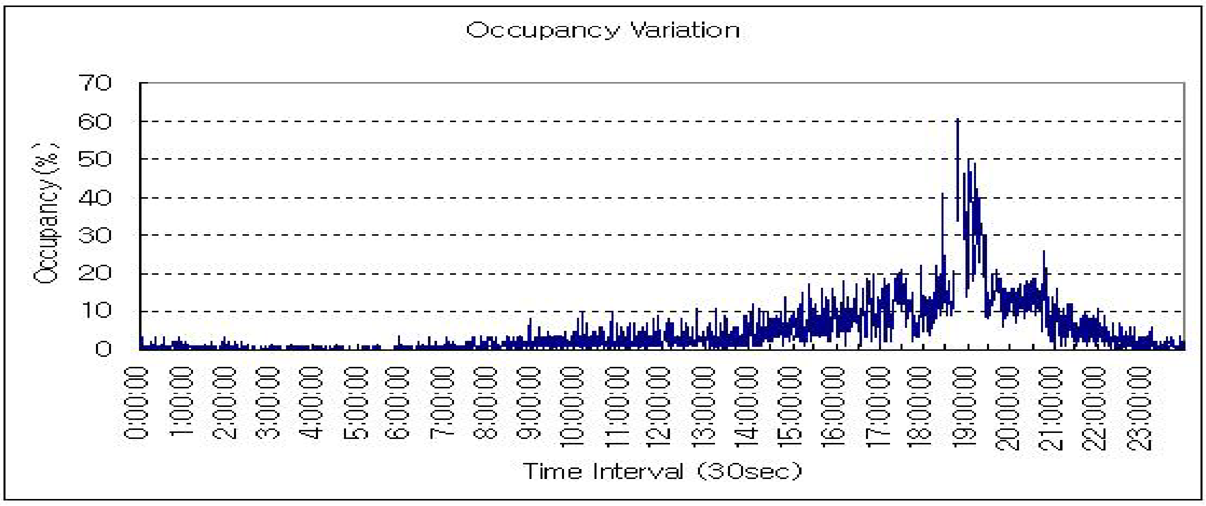
c. Joongang Freeway

Figure 1. Schematic Diagram of Study Sites

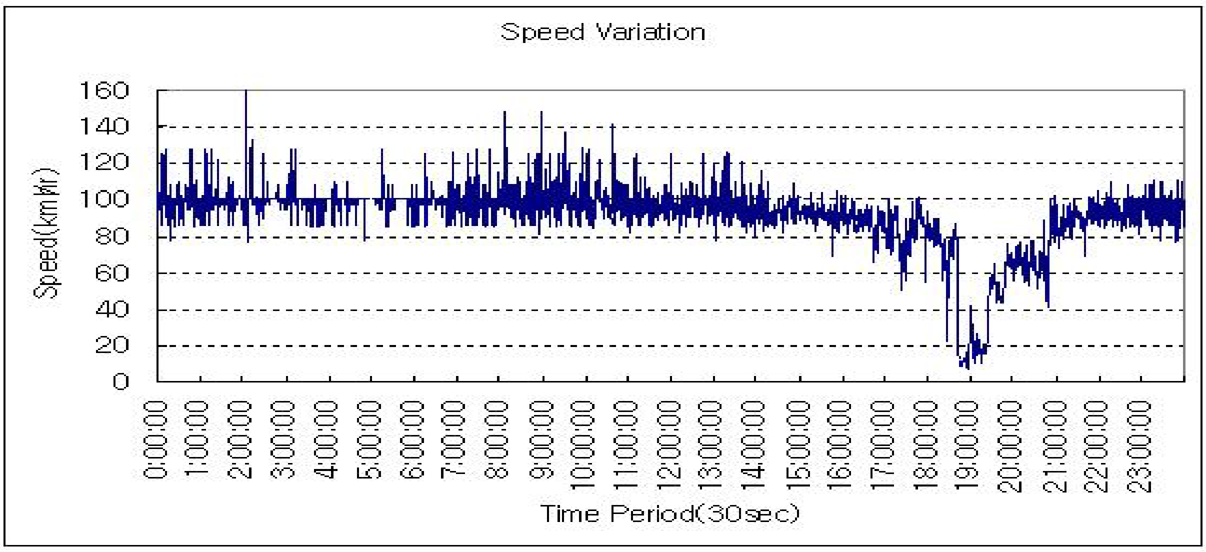
This study has mainly focused on the station 3 of each site that is the nearest to the incident location. This is because the data of this station might be affected the most by the incident. Figure 2 shows the time series variation for the flow, the occupancy, and the speed. It appears that the traffic pattern starts to vary after around 18:30. The flow and the speed become decreased after then, while the occupancy gets increased. As expected, the traffic variables tend to be fluctuated. It seems like it is not easy to found the incident time exactly at each graph.



a. Flow



b. Occupancy



c. Speed

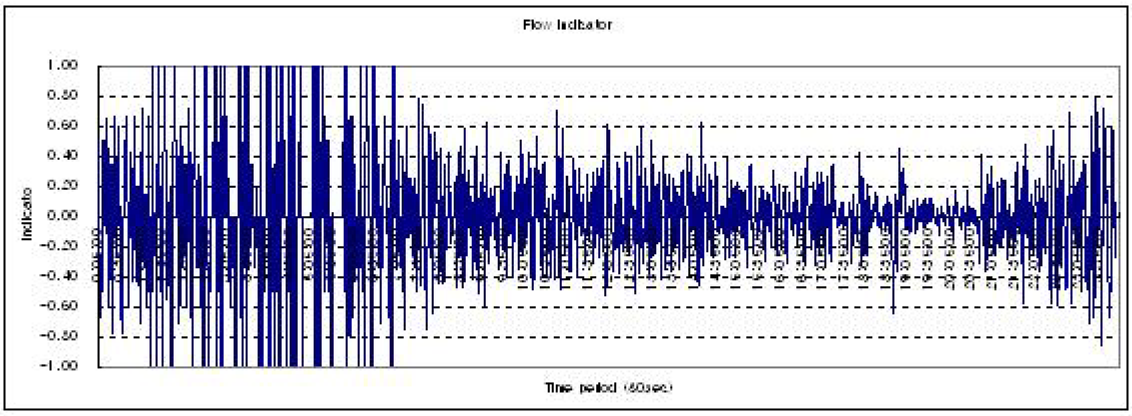
Figure 2. Traffic Variables Variation (Joongang Freeway)

4. FEASIBILITY TEST OF PROPOSED INDICATOR

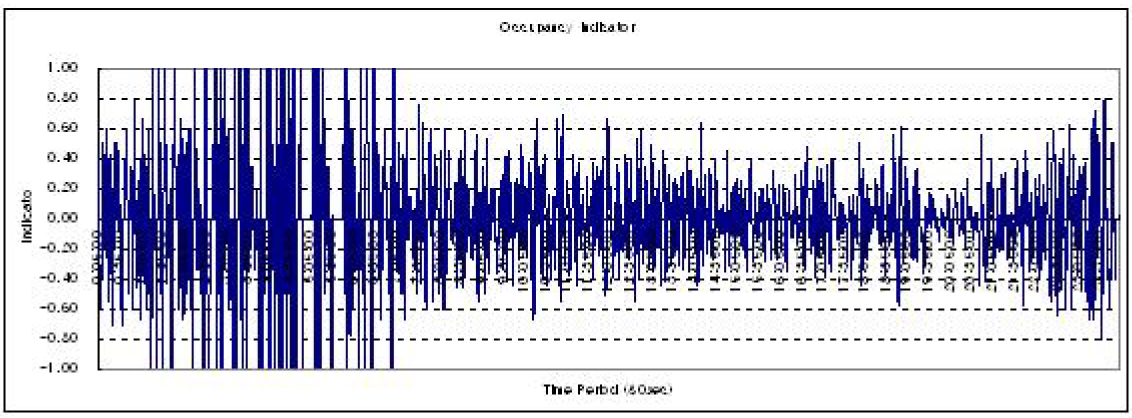
To verify the usefulness of indicator for detecting the incident, 3 indicators of the flow, speed, and occupancy were built in this study and they are compared with incident records in real fields. To test the feasibility of proposed logic, it is very important to confirm that indicator parameters have any characteristics when incident happens. The values of indicators for incident period should show any distinct changes compared with those of indicators in normal condition.

If the values of traffic variables show stable pattern without any fluctuation as a time goes by, the indicator values will move up and down around zero (0). However, in case the values of variables become smaller and smaller, the indicator will take the negative values. If the values of variables return to get increased, the indicator will convert the positive values. Therefore, the occupancy indicators may take the positive values after the incident occurs while the speed indicators may take the negative values.

According to Figure 3, it is shown that the variation pattern of the flow indicator is very similar with that of the occupancy indicator. In the case of the flow and the occupancy indicators, it seems like there are no any distinct characteristics associated with the incident occurrence. In addition, these indicators appear at the low range of values during the incident period, but it is difficult to find the exact time when the incident happens.



a. Flow Indicator

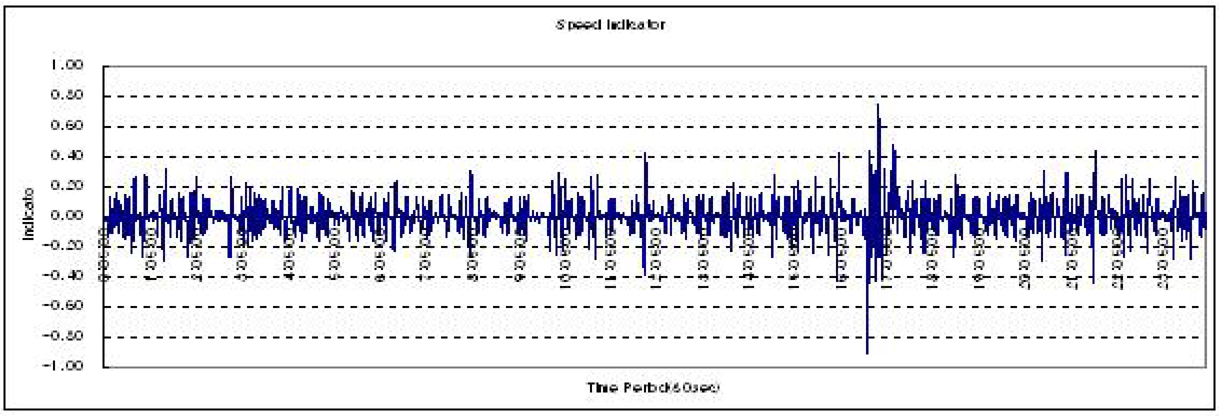


b. Occupancy Indicator

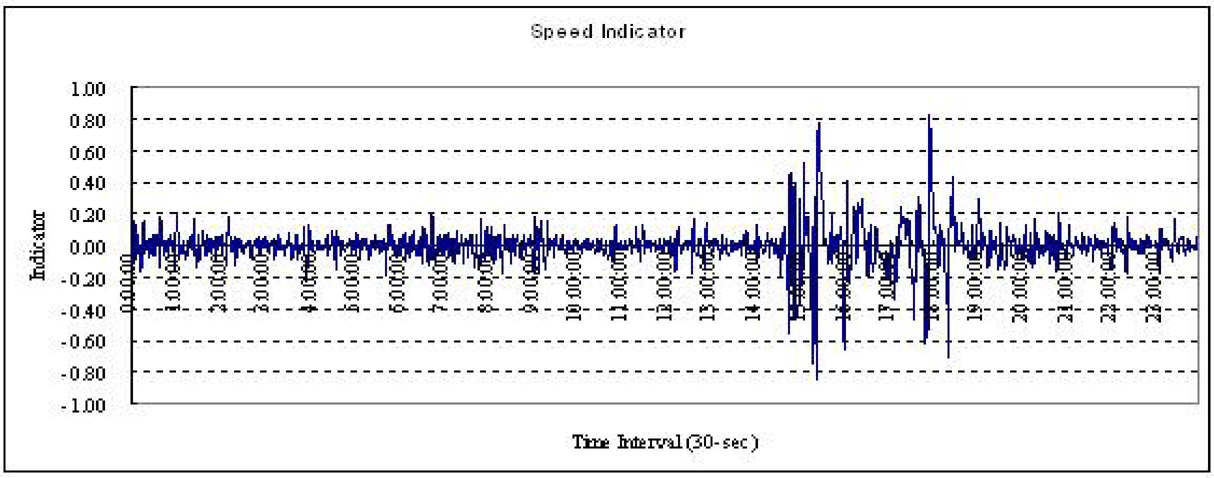
Figure 3. Indicators of traffic variables (Joongang Freeway)

On the contrary, it is shown that the values of speed indicator range from -0.3 to 0.3 for a normal traffic situation while these values are greater than 0.3 during an incident situation. Therefore, if the value of the speed indicator is greater than 0.3, it can be judged that the incident might happen around the station. As soon as the incident occurred, the first speed indicator will take the lower negative value than -0.3 and will fluctuate up and down until the traffic stabilizes in synchronized flow. From the moment the incident ends, the indicator value will jump up again higher than 0.3.

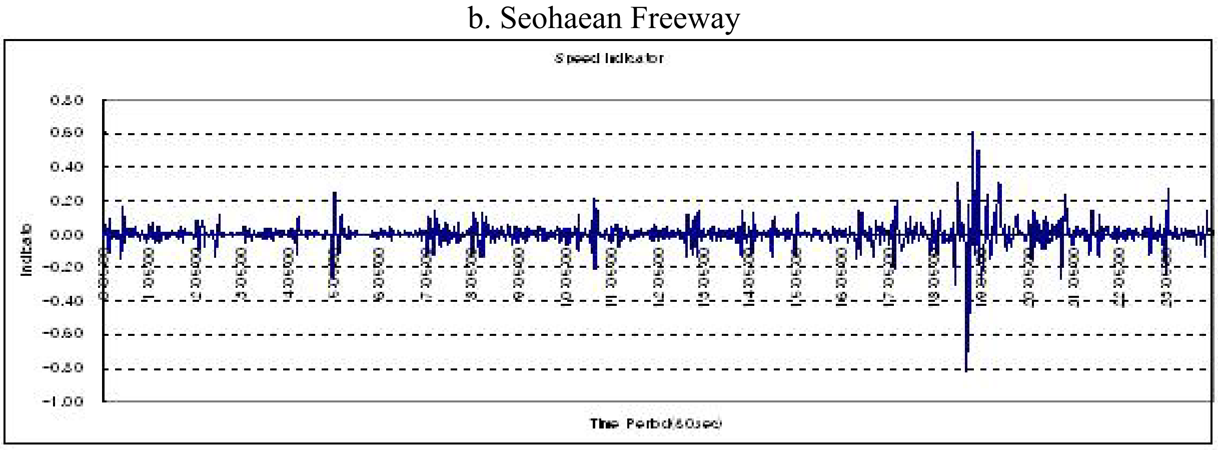
All in all, it is said that the speed indicator is the most remarkable variable that would detect the incident among three indicators.



a. Namhae Freeway



b. Seohaean Freeway



c. Joongang Freeway

Figure 4. Speed Indicator at Study Sites (5-minute accumulation)

This study analyzes the difference of indicators by the accumulated periods that are 5-minute and 2-minute, and also analyzes each detector data at downstream and upstream of the nearest detector from the location that an incident occurs.

Compared Figure 4(b) with Figure 5, the indicator values for 2-minute accumulation period fluctuate greater than those for 5-minute accumulation period. It is shown that the threshold value to decide an incident must be changed by the accumulation period. In this case the threshold values are -0.4 for 2-minute accumulation period or -0.3 for 5-minute accumulation period.

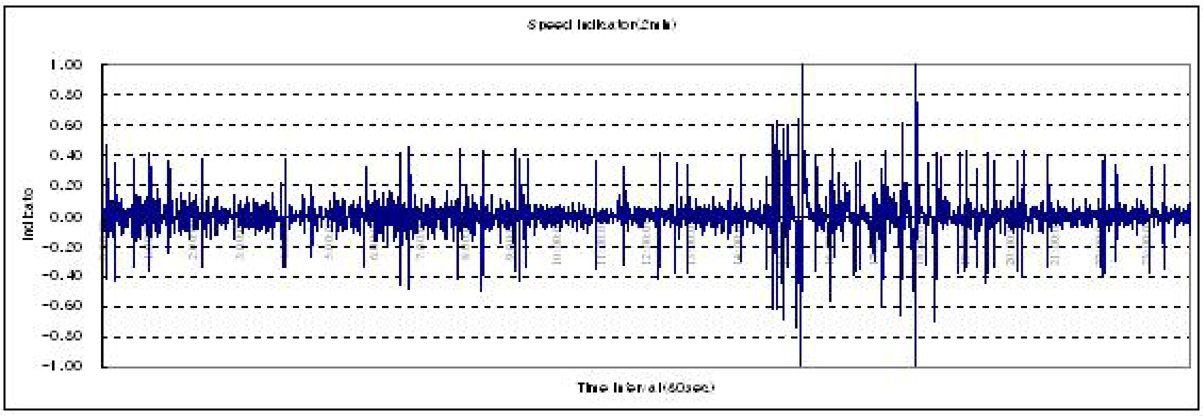


Figure 5. Speed Indicator on Seohaean Freeway (2-minute accumulation)

5. CONCLUSIONS

Many algorithms for incident detection have been developed using traffic variables such as the flow, the occupancy, and the speed. However, no algorithm so far is satisfied to accomplish the ideal performance that would detect all incidents immediately on occurrence and would not produce false alarms when there are no incidents. As far as an incident still occurs on freeways, researches on this ideal logic should be performed to maintain the traffic on freeways effectively. Therefore this study has been performed to propose a simple variable that can easily detect the incident on freeways.

According to the result, this indicator can be used for detecting an incident at single detector. Even though there are a time lag until an incident detects due to an accumulation period, the stochastic natures of traffic variables can be solved and it appears more stable traffic pattern than when the traffic variables are directly used. This makes it possible to easily find the threshold that an incident can be declared.

It was found that a speed indicator is the most remarkable variable that could detect the incident among 3 indicator variables. In addition, it is very important to decide an accumulation period when the speed indicator is made because the threshold depends on the accumulation period. In this study it is appropriate to decide the thresholds that are -0.4 for 2-minute accumulation period or -0.3 for 5-minute accumulation period.

A new incident detection algorithm could be developed using this indicator in the future. In addition, it is anticipated that a new logic including indicator could be applied with ease and may show a high performance for the incident detection.

REFERENCES

Gall A.I. and Hall, F.L. (1989) Distinguishing Between Incident Congestion and Recurrent Congestion: A Proposed Logic, **Transportation Research Record 1232**, 1-8.

Hall, F.L., Shi, Y., and Atala, G. (1992) On-Line Testing of the McMaster Incident Detection

Algorithm Under Recurrent Congestion, **Transportation Research Record 1394**, 1-7.

Persaud, B.N. and Hall, F.L. (1989) Catastrophe Theory and Patterns in 30-Second Freeway Traffic Data-Implications for Incident Detection, **Transportation Research Part A, Vol. 23A, No. 2**, 103-113.

Persaud, B.N., Hall, F.L., and Hall, L.M. (1990) Congestion Identification Aspects of the McMaster Incident Detection Algorithm, **Transportation Research Record 1287**, 167-175.