Calculation Method for Sliding-window Length: A Traffic Accident Frequency Case Study

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Abstract: For choosing a TAF zone, we need to develop standards for range and location. South Korea uses standards that adopt a uniform criterion for all road types. However, here are some inherent problems. Roads have different structures according to design speed. There is a need to configure the range reflecting characteristics for traffic flow. This study calculates a new length using the concept of stop minimum sight distance and Sliding-window. Then, we develop modified calculation factors, and compare these factors with existing length standards and new standards for selecting a TAF zone. The study divides four sections at the intersection. The newly calculated Sliding-window length is 55m, 70m, 40m, and 10m for each section. The results of the study suggest that an analyst can search cause of an accident detailed for each window section.

Keywords: Intersection, TAF zone, Sliding-window, Sliding-window length

1. INTRODUCTION

South Korea has grown rapidly with a developed transportation system. Transportation growth contributes to communication between regions and enhances socio-economic areas such as strengthening national competitive power. Moreover, economic growth enhances the quality of life. The public considers their vehicle as a necessity.

On the other hand, it is essential to recognize social problems such as traffic congestion and accidents, and air pollution created by heavy transportation traffic. The transportation policy for South Korea is focused more on growth rather than safety and environment.

Recently, the South Korea government has recognized these social problems and has provided continuous studies. However, the level of transportation safety is lower in South Korea than in more advanced countries that has recognized these challenges and has provided research.

Researchers in Korea have studied about safety concerns regarding traffic accidents.

The focus of these studies analyzes the causes of accidents and suggestions for improvement. Implementing a traffic accident frequent zone (TAF zone) selection is the premise of these studies.

By improving the TAF zone and removing the cause of accidents, the probability of an accident can be reduced.

For choosing the TAF zone, we need to provide standards that are focused on range and location. Presently, we use standards that have been adopted. These standards are 200m on a single-route situated at a city area, and 400m on an expressway. For selecting a work selection, we used the sliding-window method and apply 75m in the city area and 190m in an expressway.

However, there are associated problems. Roads have different structures according to their design speed. Hence, we need to configure the range reflecting the characteristics of traffic flow.

Therefore, this study establishes standards that help select TAF zone that analyzes with the Sliding-window method.

2. RELEVENT THEORY & LITERATURE REVIEW

A TAF zone is defined as follows. “The point where the frequent accident happened on the Single-route, intersection, road-access-point, bridge, and tunnel etc. is selected area by bases of selecting”

The purpose of selecting a TAF zone is to conduct an improvement project that considers accidents as a group by its causes so that each accident can be clearly analyzed.

With this in mind, the purpose for the selection TAF zone is that an accident of a similar form is considered a monolithic group, and then finds cause of the accident for implementing improvement projects.

2.1 Concept of Sliding-window

According to the Improvement of Potentially Hazardous Roadway Segment Identification, the Sliding-window is a method for selecting an accident with frequent intervals while overlapping a certain length. Although this method is a progressive method for selecting a TAF zone, it does not haves even optimal value and an alternative for the length and placement method.

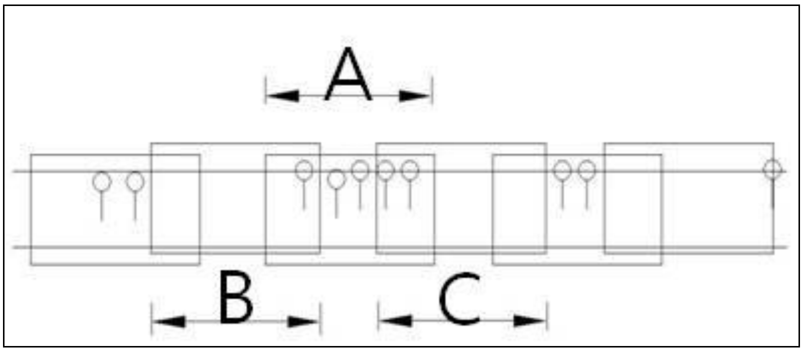


Figure 1. Technique of a Sliding-window

As shown in Figure 1, the selected section is a TAF zone or not, and depends on the placement method. Therefore, the major focus for the study is to analyze the length and placement method for each section. The placement that is the most used is the two-way method. The first placement method analyzes a section that is divided by regular intervals. The second placement method is an all accident point apply, “start · middle · end point” for the analysis of a section. The two placement methods are shown in Figure 2.

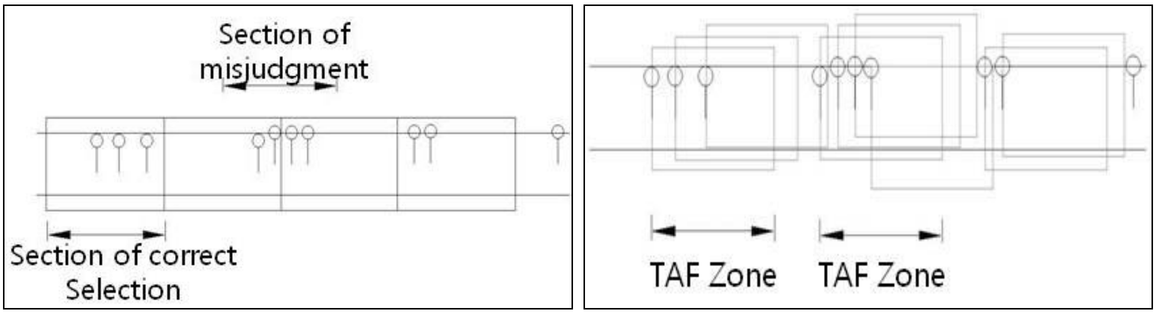


Figure 2. Regular Intervals and All Points Placement Methods

The advantages and disadvantages for the Regular Intervals and All Points Placement Methods are listed in Table 1

Table 1. Advantages and Disadvantages of the Two Placement Methods

Placement Method	Advantages	Disadvantages
Regular Intervals	Simple Fast searching speed	Imprecision of selection TAF zone
All Points	Precision of selection TAF zone	Low searching speed

2.2 Concept of Minimum Stop Sight Distance

The purpose of selecting a TAF zone is to conduct an improvement project that considers if the minimum stop sight distance is enough distance for a driver to recognize an unexpected situation and whether to decide to proceed or stop. The formula for stop sight distance is the following:

$$D = \frac{V}{3.6} \times t + \frac{V^2}{2g \times f \times (3.6)^2} = 0.694V + \frac{V^2}{254f} \quad (1)$$

where,

D : stop sight distance (*m*),
V : speed (*km/h*),
t : recognition response time (RRT) (2.5*sec*),
g : acceleration of gravity (9.8 m/s^2),
f : coefficient of sliding friction.

Based on the above formula, the standard for stop sight distance when there is wet surface conditions in South Korea are shown in Table 2.

Table 2. Stop Sight Distance with a Wet Surface Condition

Design Speed (*km/h*)	*f*	Calculated Value	Applied Value
120	0.28	285.8	280
110	0.28	246.4	250
100	0.29	205.3	200
90	0.30	168.8	170
80	0.30	139.6	140
70	0.31	110.9	110
60	0.32	85.9	85
RRT		2.5*sec*	

2.3 Related Literature Review

Kim Jung-Hyun *et al.* (2002) judged that it is difficult to apply for all kinds of road structures with a fixed length range of 200m. This study assumes that the new length to be 140m by using the Sliding-window method, and collects accident data within a 37km range of national road #17. The Sliding-window is selected randomly at a 7km range. 90 human-damaged accident cases are also studied. When design speed is 80kph, reducing the analysis range from 200m to 140m has validity for finding the range to have potential risk. Kim Sun-Young (2011) insisted that vehicles are approaching an intersection with consistent speed and decelerating until they access in front of the stop line about 30~40m from the rear. Then, they are deciding to either stop or pass. Im Chang-Sik *et al.* (2002) drew a conclusion regarding the friction coefficient among different types of asphalt and anti-slip pavement. Kim Won-Chul *et al.* (2010) analyzed that with an increase in speed, more reduced RRT resulted. It is reasonable to conclude that if the speed is lower than 40km/h, RRT is higher than 2.5s. On the contrary, if the speed is higher than 40km/h, RRT is 2.5s. Rane Elvik (2008) compared dangerous road standards in eight European- countries. Except for Germany, the other seven countries use the Sliding-window method.

Even though the length of the Sliding-window is different, they usually used the value between 100m and 1,000m. These values define a dangerous section in terms of magnitude. Three years of accumulated data were analyzed.

2.4 Implications

Whereas research in the length of Sliding-window is progressing, it is insufficient to study about the length of a Sliding-window at an intersection. It is also a real condition that is a standard for a continuous application with interrupt flow. This may be the cause for possible error. Generally, the Sliding-window length is a consistent result calculated by speed, RRT, and friction coefficient in sight distance. However, this calculation is presently applied uniformly. Thus, this study calculates a new length and assumes modified calculation factors. In addition, the study compares with an existing length standard and new standard.

3. METHODOLOGY AND STUDY RESULT

3.1 Methodology

The study assumes new length reflected intersection characteristics and compares it with old length reflected intersection characteristics. A study flow chart is shown in Figure 3.

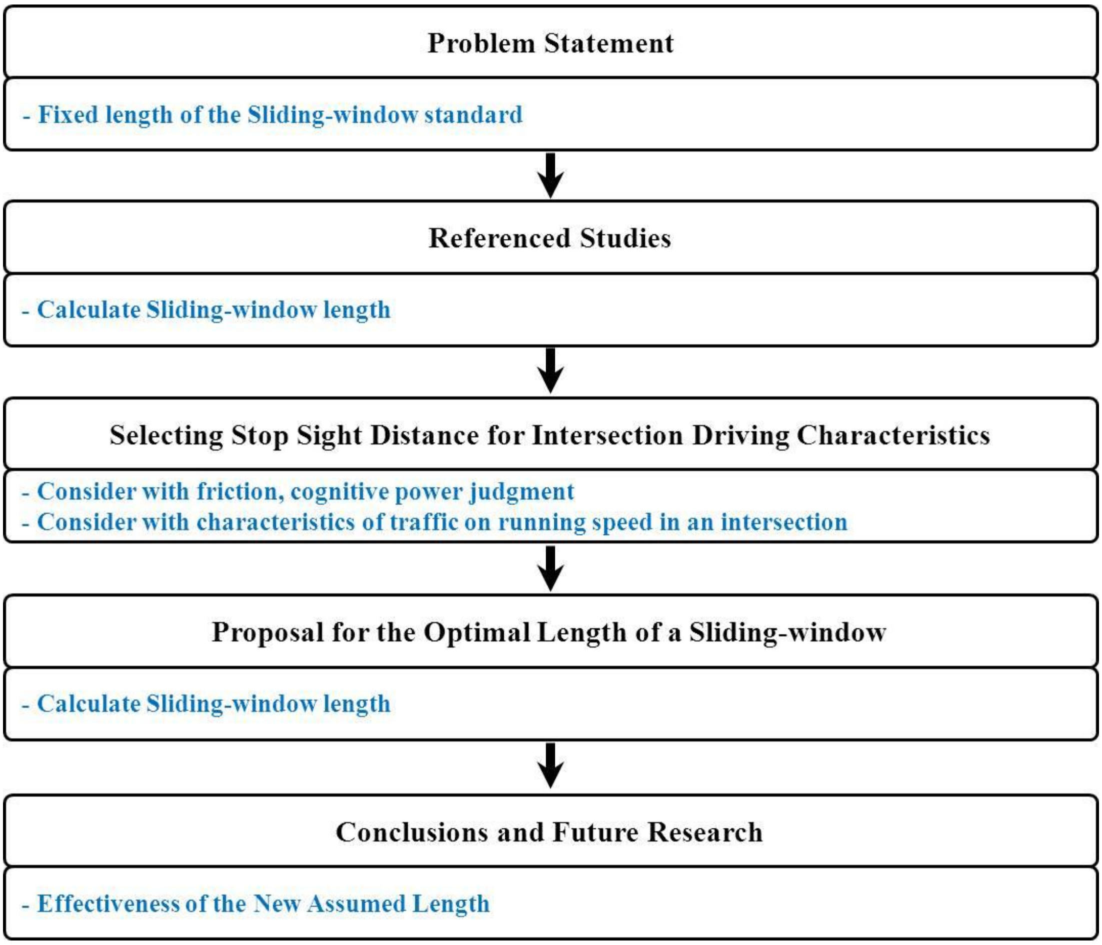


Figure 3. Study Flow Chart

According to the Improvement of Potentially Hazardous Roadway Segment Identification, most accidents occur when drivers do not recognize traffic incident handle enough.

This study applies the concept of minimum stop sight distance. A formula for distance is shown as:

$$D = \frac{V}{3.6} \times t + \frac{V^2}{2g \times f \times (3.6)^2} = 0.694V + \frac{V^2}{254f} \tag{1}$$

where,

D : stop sight distance (m),
V : speed (km/h),
t : recognition response time (RRT) (2.5sec),
g : acceleration of gravity (9.8 m/s^2),
f : coefficient of sliding friction.

The results for applying an existing Sliding-window length of 75m to the National institute of Crop Science Intersection in Miryang are shown in Figure 5.

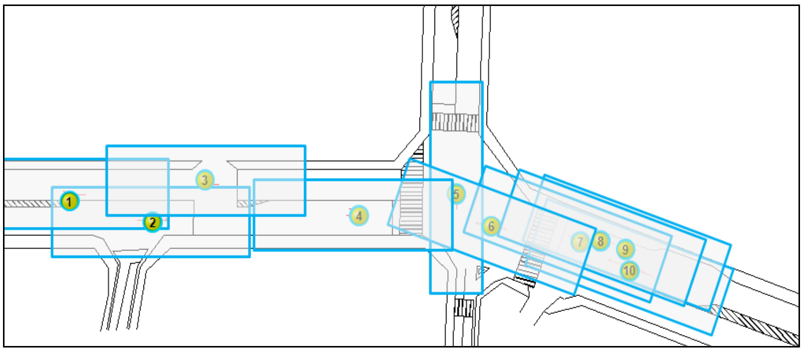


Figure 3. Applying an Existing Sliding-window Length

Table 3. The Number of Traffic Accidents for each Window

Number of Windows	Number of Accidents
#1	2
#2	2
#3	1
#4	2
#5	1
#6	3
#7	4
#8	4
#9	4
#10	4
Average	3.1

Table 4. Rate of Hazard Section

Total Length of Section A	Hazard Length B	Rate of Hazard Section (B/A)*100
250m	100m	40%

Table 3 lists selected TAF zone and the number of traffic accidents for each window. The #6-10 windows (100m section) are selected as a TAF zone. Table 4 is the arranged total length of section A, length of hazard length and rate of hazard section. As shown in Table 4, 40% is selected as a hazard section. This demonstrates the difficulty for finding a hazardous element when analysts select a TAF zone. An analyst has search for a hazardous element in general, and not in detail.

The variable for stop sight distance is *V*(Speed), *t*(RRT), and *f*(coefficient of sliding fraction).

3.2 Advancing a New Sliding-window Length

Before advancing a new sliding-window length, this study analyzed an example of a taxi trip using Black-box data at three points. The location points are Seoul and Gyeonggi-do. The routes of intersection without a passage were chosen. Table 6 and Figure 4 are general information regarding the selected intersections.

Table 6. Information for Selected Intersections

Classification	Location	Length (m)
#1	Dangsan-dong 3-ga, Yeongdeungpo-gu, Seoul	170
#2	Gugal-dong, Giheung-gu, Yongin-si, Gyeonggi-do	470
#3	Choji-dong, Danwon-gu, Ansan-si, Gyeonggi-do	540

#1	
#2	
#3	

Figure 4. Aerial Photographs for the Present Condition Selected Intersections

The study results for the speed of passing vehicles suggests the changing speed in front of the stop line at intersection B, 20~40m at the rear. Also, there is tendency pattern for vehicles to stop near the stop line.

Therefore, the zone was divided into four sections: A. Acceleration; B- Driving (except for A, C, and D sections); C- Judgment; and D- Response for observation of speed patterns.

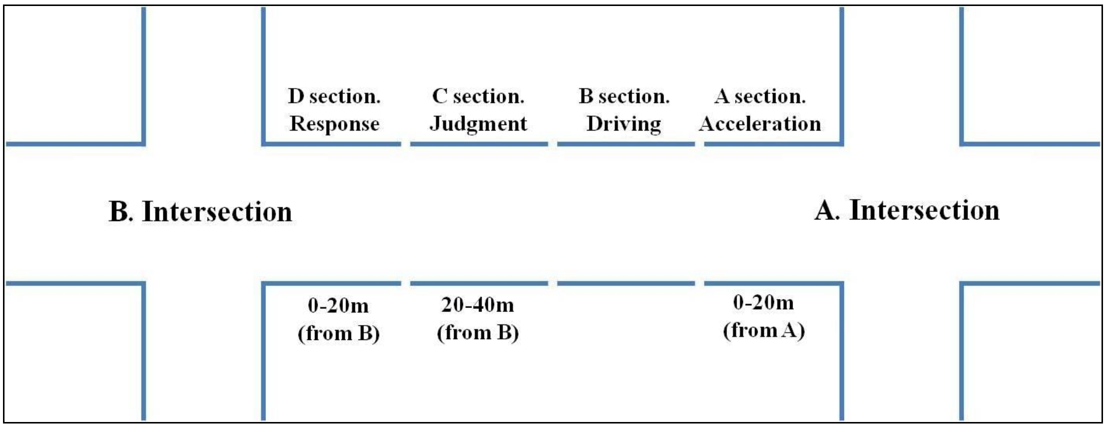


Figure 5. Section Division of Intersection

3.2.1 Consideration of *V* (speed)

Table 8. Arranged vehicle speed for each intersection from the Black-box data.

[Table 8. Speed Data for Each Point(km/h)]

	#1				#2				#3			
No.	A	B	C	D	A	B	C	D	A	B	C	D
1	44	60	44	10	35	67	46	11	45	68	47	15
2	44	50	39	11	42	70	41	11	45	67	45	15
3	36	54	39	14	43	69	45	17	40	67	48	14
4	41	50	42	9	47	64	42	10	47	70	43	11
5	36	48	46	9	39	53	39	12	46	71	48	8
•	•	•	•	•	•	•	•	•	•	•	•	•
•	•	•	•	•	•	•	•	•	•	•	•	•
•	•	•	•	•	•	•	•	•	•	•	•	•
46	42	53	41	10	43	53	44	9	36	58	46	12
47	35	64	44	11	38	70	42	8	45	69	37	8
48	36	53	44	10	36	49	40	15	38	56	41	13
49	36	54	41	9	36	67	39	15	47	59	42	9
50	42	53	40	15	38	62	46	13	48	67	38	8
Ave.	39.6	55.5	41.6	11.1	42.2	61.1	42.9	12.9	42.4	62.8	41.4	12.1

The results indicate that the speed of passing vehicles affected the changing speed in front of the stop line. The study applied vehicle speed data during the off-peak time because during peak time, the general speed with traffic congestion cannot be estimated. The Average vehicle speed for the selected three intersections is shown in Table 9.

[Table 9. Average Vehicle Speed Each Intersection(km/h)]

Classification	A Section	B Section	C Section	D Section
#1	42.22	61.12	42.94	12.86
#2	42.44	62.82	41.36	12.06
#3	39.60	55.50	41.58	11.08
Average	41.42	59.81	41.96	12.00

The Average speed for sections A through D is: 41.2km/h, 59.81km/h, 41.96km/h, and 12.00km/h, respectively. In this study, we rounded-off to the nearest whole number. Thus, sections A through D are: 41km/h, 60km/h, 42km/h, and 12km/h, respectively. The average vehicle speed results for each section are shown in Table 10.

[Table 10. Average Vehicle Speed for Each Section(km/h)]

Classification	A Section	B Section	C Section	D Section
Average	41	60	42	12

3.2.2 Consideration of *t* (RRT)

For the case of RRT, results are directly determined. Consequently, RRT was similar to the results found in related literature. In the Kim Won-Chul *et al*. (2002) study, the RRT value is supported. Accept for this study, if the speed is lower than 40km/h, the RRT is 3.2sec (Hooper and McGee, 1983). The second speed is applied at 2.5sec.

3.2.3 Considering of *f* (Coefficient of sliding fraction)

A result cannot be estimated for either fraction. We applied the fraction results from related literature. Im Chang-Sik *et al*. (2010) suggests a coefficient of sliding fraction according to the asphalt type. In this study, we assume a general asphalt fraction. The general asphalt coefficient of sliding fraction is shown in Table 11.

[Table 11. Coefficient of Sliding Fraction for General Asphalt]

Classification	50km/h	60km/h	70km/h
Dry Condition	0.77-0.80	0.75-0.82	0.70-0.73
Wet Condition	0.53-0.61	0.48-0.58	0.55-0.57

The mean value is applied when there is a reflect value in the formula. For example, the fraction value 0.785 of the mean is 0.77-0.80 when the speed is 50km/h. Ultimately, this study applies the values shown in Table 12.

[Table 12. Applied Coefficient Sliding Fraction]

Classification	50km/h	60km/h	70km/h
Dry Condition	0.785	0.785	0.715
Wet Condition	0.57	0.53	0.56

3.2.4 Advancing a New Sliding-window Length

As mentioned above, values are shown in Table 13, and are classified into four sections (A-D).

[Table 13. Each Value for Sections A-D]

Classification	Speed (V, km/h)	RRT(t)	Fraction(f)	
			Dry	Wet
A	41	2.5	0.785	0.57
B	60	2.5	0.785	0.53
C	42	3.2	0.785	0.57
D	12	3.2	0.785	0.57

The Sliding-window length is calculated by values given in Table 13. Formula 1 is used for the calculation. The results for each section are shown in Table 14.

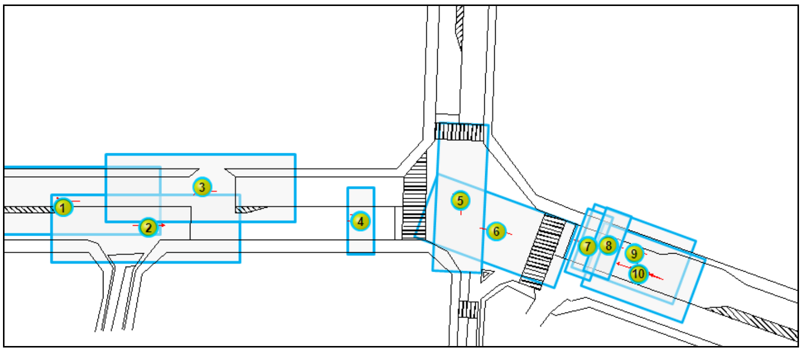
[Table 14. Sliding-window Length of Each Section]

	A Section	B Section	C Section	D Section
Dry Condition	50m	60m	40m	10m
Wet Condition	55m	70m	40m	10m

However, information for road conditions cannot be determined in the accident data. Furthermore, in the existing calculation method, the fraction value for wet conditions is reflected in the formula. Thus, the study accepts the results for the wet conditions calculated in sections A-D: 55m, 70m, 40m, and 10m-for comparing the existing Sliding-window length and the new Sliding-window length

4. COMPARATIVE ANALYSIS OF EXISTING AND NEW SLIDING-WINDOW LENGTH

This chapter compares existing and new Sliding-window lengths. The results for applying an existing Sliding-window length are shown in Tables 3 and 4, in Chapter 3. The number of average accidents is 3.1 and the Hazard section is selected at 40% of the total section. The results for applying the new Sliding-window length are shown in Figure 7.



[Figure 7. Applying New Sliding-window Length]

The number of window is 10, for the number of accidents is 10 as the results of applying the existing Sliding-window length.

[Table 15. The Number of Accidents Classified by the New Window]

Number of Windows	Number of Accidents
#1	2
#2	2
#3	1
#4	1
#5	1
#6	2
#7	2
#8	3
#9	3
#10	3
Average	2.0

[Table 16. The New Rate of Hazard Section]

Total Length of Section A	Hazard Length B	Rate of Hazard Section (B/A)*100
250m	215m	94%

A selected TAF zone determined by the new number of traffic accidents for each Window is shown in Table 15. Windows 1and 2 and windows 6-10 in the select TAF zone have an average accident at 2.0. The total length of section, hazard length, and the rate of hazard section is shown in Table 16. 92% is represented in the hazard section. Table 17 summarizes the applied existing and new Sliding-window length.

[Table 17. Applied Result of Existing and New length]

	The Number of Windows	The Number of Average Accidents	Rate of Hazard Section
Existing	10	3.1	40%
New	10	2.0	94%

The number of windows is the same as the number of accidents, which are 10. However, the number of average accidents and the rate of hazard section differ between the existing and new Sliding-window length. The number of average accidents declined from 3.1 to 2.0., while the rate of hazard section greatly increased from 40% to 94%. That is to say, as the number of average accidents declined, the analysis searched all sections for finding cause of the accident. In the case of the hazard section, the issue may exist in the intersection.

However, in the existing case, analysis and searching for an accident may be macroscopic because the Hazard section is continuous at 100m. On the other hand, the new suggested case can be divided into three accident section: #1 and 2 windows (105m), #6 window (75m), and #7- 10windows (45m). Also, analyst search accident cause detailed each accident section.

5. CONCLUSIONS AND FUTURE RESEARCH

This study aims to establish a standard for Sliding-window length by reflecting road and traffic characteristics. Roads have different structures according to design speed, accident cause and distribution, and may be different depending on the road type.

However, there are some inherent problems. Roads structure is different according to design speed. Thus, we need to configure the range reflecting the characteristics of traffic flow. Therefore, this study establishes a standard that helps select TAF and analyze while applying the Sliding-window method.

At present, usually the speed variable is considered when calculating the Sliding-window length. Without road and traffic characteristics, a problem exist applying uniform equal length.

This study advances a new Sliding-window length that reflects road and traffic characteristics through analysis of real vehicle speed using existing related literature and Black-box data. The result is shown in a Table 14. The existing equal length as an existing standard is 75m, and is departmentalized as 55m, 70m, 40m, and 10m. Furthermore, the results of applied existing and new Sliding-window length are shown in Table 17. Although the rate of total hazard section has grown largely, analysts can reasonably estimate accident causes for each section as departmentalized sections.

If a TAF zone is selected with the study results, selecting a section with reflecting road and traffic characteristics can be reasonable as compared with existing lengths. However, in the case of classifying sections between intersections and calculating speed variable, the length of Sliding-window and the speed characteristic for off-peak time is reflected by the RRT and the coefficient sliding fraction. They are applied through the results of related literature.

Therefore, we need to find a representative value and sample size that contains substantial contents for an accurate output on the following study. In this study, all coefficient sliding fractions are assumed at 50km/h, 60km/h, and 70km/h. For future research, we need to develop the coefficient sliding fractions for each case.

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