Study on Improvement of Star Rating Approach to Extract Traffic Hazardous Location in Nakhon Ratchasima Province, Thailand

Takeru MIYOKAWA[1], Atsushi FUKUDA[2], Rattanaporn KASEMSRI[3], Hiroki KIKUCHI[4], Tuenjai FUKUDA[5]

[1]Student member of JSCE, Dept. of Transportation Systems Eng., Nihon University
(Narashinodai 7-24-1, Funabashi-shi, Chiba 274-8501, Japan)
E-mail:csta20016@g.nihon-u.ac.jp
[2]Member of JSCE, Professor, Dept. of Transportation Systems Eng., Nihon University
(Narashinodai 7-24-1, Funabashi-shi, Chiba 274-8501, Japan)
E-mail: fukuda.atsushi@nihon-u.ac.jp
[3]Member of JSCE, Lecturer, Inst., Industrial Science, Suranaree University of Technology
(111, Maha Witthayalai Rd, Suranari, Mueang Nakhon Ratchasima District, Nakhon Ratchasima 30000, Thailand)
E-mail: rattanaporn7777@gmail.com
[4]Member of JSCE, Research association, Dept. of Transportation Systems Eng., Nihon University
(Narashinodai 7-24-1, Funabashi-shi, Chiba 274-8501, Japan)
E-mail: kikuchi.hiroki@nihon-u.ac.jp
[5]Member of JSCE, Senior researcher, Dept. of Transportation Systems Eng ., Nihon University
(Soi Sukhumvit 25, Klongtoey-Nua Wattana, Bangkok 10110, Thailand)
E-mail: noynoifukuda99@gmail.com

Road traffic accident data is not properly collected in developing countries, so traffic accident analysis is not sufficiently carried out. It is often not possible to consider appropriate traffic safety measures. In many countries, iRAP (International Road Evaluation Program) proposes without relying on road traffic accident analysis. The evaluation method by Star Rating approch of iRAP is used to select the places where traffic safety measures are required by external inspection of road facilities (road geometric structure, road attachments, road surface condition). However, the degree of danger evaluated by Star Rating approach and the danger point based on traffic accident data may not match. It is not always clear whether Star Rating approach contributes to reducing road traffic accidents. In this study, we clarified the problems of the existing Star Rating approach by comparing the evaluation results with the hazardous locations based on the traffic accident data and the “Hiyari Hatto” data for the local cities in Thailand, and improve the existing Star Rating approach.

Key Words : *road safety, Star Rating, Hiyari Hatto, traffic accident, developing country*

1. INTRODUCTION

In ASEAN countries, the rapid increase in road traffic fatalities and injuries has become a major social problem due to the rapid progress of motorization. The implementation of traffic safety measures is required immediately. However, these countries cannot be identified the cause of the traffic accident and selected appropriate traffic safety measures because traffic accident data is not collected correctly.

To tackle these problems, Thailand, Malaysia, the Philippines and Vietnam evaluate the safety of roads by the approach of road facilities (road geometric structure, road attachments, road surface condition) which is proposed by iRAP (International Road Evaluation Program)[1)]. This approach chooses for the road segment where should be implemented road safety measures based on Star Rating Score (SRS). However, there are reports that the evaluation by SRS correlates with the number of road traffic accidents, or not. It is necessary to improve the approach by SRS evaluation.

Therefore, this paper confirmed whether the evaluation by SRS reflected the actual occurrence of road traffic accidents in Nakhon Ratchasima Province, Thailand as a case study. Additionally, if the road traffic accidents were not reflected in the SRS, the Star Rating approach was improved.

2. LITERATURE REVIEW

In previous research on extracting traffic danger points using SRS, Hoque et al.[2] conducted a verification in Bangladesh. They found that the type and danger of a particular accident are related to the road design. Harwood et al.[3] compared SRS and crash rates on roads in Iowa and Washington State in the U.S., and clarified the relationship between SRS and crash rates. In many studies, the Star Rating approach has been applied to evaluate road traffic safety. However, Kamiya et al.[4] evaluated the SRS for roads in Japan and compared it with the accident data. As a result, there was no correlation between the risk level based on the SRS and the road traffic accident data. As a characteristic of the sections where no correlation, road traffic accidents with casualties occurred at intersections with no right-angled (deformed intersections).

Thus, when the Star Rating approach is applied in ASEAN countries, it is necessary to check whether there is a correlation between the road points where actual road traffic accidents occur or Hiyari Hatto points with a high degree of danger. If there is no correlation, it is necessary to understand the cause of the no correlation and improve the Star Rating approach. In this paper, the evaluation index for SRS was added as an approach improvement.

3. METHODOLOGY

(1) Study outline

This paper calculates the SRS by applying the Star Rating approach of iRAP, and compares the correlation of the SRS results with the number of Hiyari Hattoes and the number of road traffic accidents collected by the Department of Highway in Thailand (DOH). Especially, this paper focuses on the road segment that are rated as relatively safe by the SRS but have a high number of Hiyari Hatto and accidents. In order to improve the Star Rating approach, the missing index is added to the existing evaluation index of the approach. Finally, the SRS of the same road segment is calculated using the improved Star Rating approach.

(2) Star rating approach

a) Overview of Star Rating approach

The Star Rating approach evaluates the safety of road facilities (road geometry, road accessories, and road surface condition), which affect the likelihood of road traffic accidents and the degree of damage. The safety level of each road segment is determined for each user (car occupants, motorcyclists, bicyclists, and pedestrians) based on the SRS. This approach has been applied in many countries, such as the UK, Australia, the US, and New Zealand. Many ASEAN countries such as Thailand, Malaysia, Vietnam, and the Philippines have introduced the Star Rating approach on a trial basis.

Historically, the Star Rating approach was first developed by the Euro RAP[5] in 1999. The EuroRAP approach model was based on assessments of road attributes, such as safety barriers, that afford protection to car occupants in the event of a crash. The equations and risk factors used in the EuroRAP model were developed by a working group comprising representatives of the Swedish National Road Administration, the Dutch Ministry of Transport, National Roads Authority, Republic of Ireland, Transport Research Laboratory (TRL) and with contributions from the English Highways Agency, Germany federal research agency, BASt, and engineers and analysts from leading European motoring organizations and EuroRAP staff. After Euro RAP was developed, the AusRAP[6] was also developed the Star Rating approach in 2013. The AusRAP approach model was based on assessments of road attributes that affect both the likelihood that a crash will occur such as delineation and those that provide protection in the event of a crash such as safety barriers. The AusRAP model was used over the period 2006 to 2008 to assess more than 20,000km of national highways and more than 5,000km of State highways.

b) How to calculate SRS with Star Rating approach

The SRS is calculated for each 100 meters segment of road, using the following equation (1):

$$SRS = \sum Crash\ Type\ Scores \tag{1}$$

The SRS represents the relative risk of death and serious injury for an individual road user as the following equation (2).

$$\begin{gathered} Crash\ Type\ Score = Likelihood \times Severity \times \\ Operating\ speed \times External\ flow\ influence \times \\ Median\ travers\ ability \end{gathered} \tag{2}$$

Likelihood refers to road attribute risk factors that account for the chance that a crash will be initiated. Severity refers to road attribute risk factors that account for the severity of a crash. Also, operating speed refers to factors that account for the degree to which risk changes with speed. External flow influence factors account for the degree to which a person's risk of being involved in a crash is the function of another person's use of the road. Median travers ability factors account for the potential that an errant vehicle will cross a median (only applies to vehicle occupants and motorcyclists' run-off and head-on crashes).

Crash Type Score is calculated by weighting Attribution and Evaluation Index. Evaluation Index is finely classified according to the road geometric structure as shown in Fig. 1. For example, the Evaluation Index for Intersection is subdivided into five items as shown in Table 1.

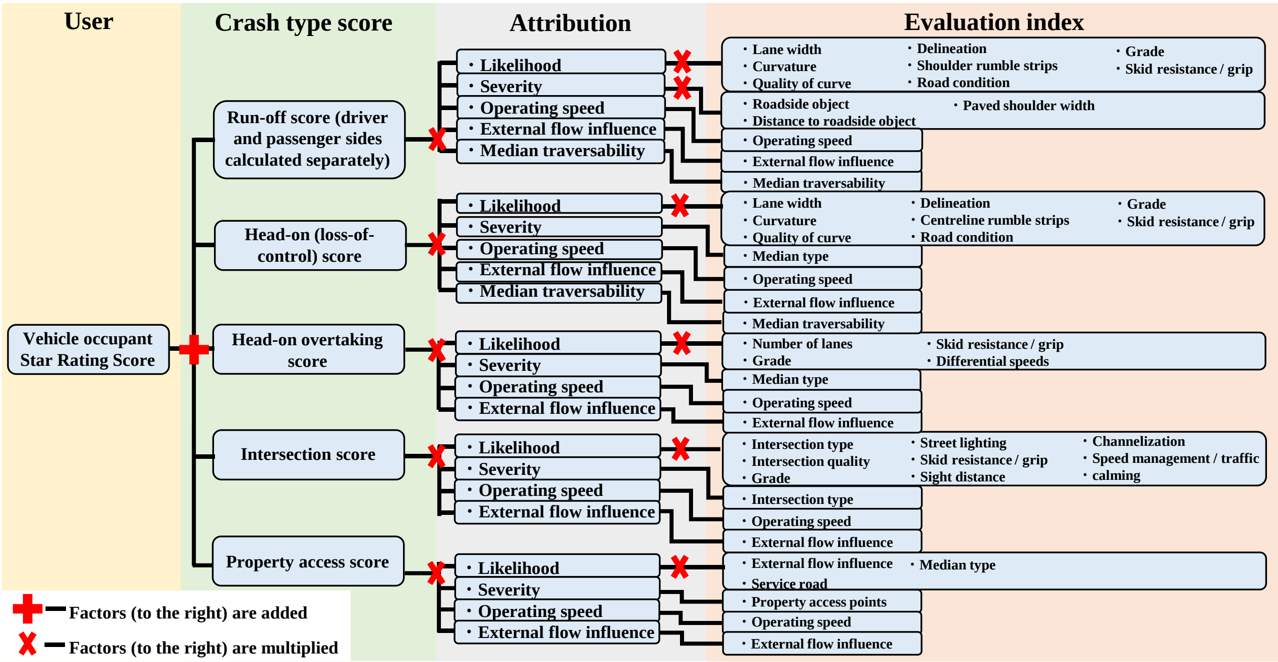


Fig.1 Vehicle occupant SRS

Table 1 Evaluation index for "Intersection"

Intersections	Intersection type	3-leg (signalised) with protected turn lane
		3-leg (signalised) with no protected turn lane
		4-leg (unsignalised) with protected turn lane
		4-leg (unsignalised) with no protected turn lane
		4-leg (signalised) with protected turn lane
		4-leg (signalised) with no protected turn lane
		Unused code (non-major inters.)
		None
		Railway Crossing - passive (signs only)
		Railway Crossing - active (flashing lights/boom gates)
		Median crossing point - informal
		Median crossing point - formal
		Mini roundabout
		** Commercial access 1+
		** Residential access 1+
		** Residential access 1 or 2
	Intersection channelization	Not present
		present
	Intersecting road volume	≥15,000 vehicles
		10,000 to 15,000 vehicles
		5,000 to 10,000 vehicles
		1,000 to 5,000 vehicles
		100 to 1,000 vehicles
		1 to 100 vehicles
		Not applicable
	Intersection quality	Poor
		Adequate
		Not applicable
	Property access points	Commercial Access ≥1
		Residential Access ≥3
		Residential Access <3
		None

(3) Study area

A case study is Nakhon Ratchasima province in Thailand. Nakhon Ratchasima Province is located in the Northeast part of Thailand (about 259 km from Bangkok of the capital city). This study focused on the road segment in this province. The road segment is a part of national highway No. 2, which runs through the central part of Nakhon Ratchasima Province, has much passing traffic in the city. The target section of this study is about 36 km of the city area and suburban area Highway No. 2 as shown in Fig. 2.

(4) Data collection

a) Traffic accident data

This study used traffic accident data between 2015-2020 from the Highway Accident Information Management System (HAIMS), provided by DOH. This data is recorded traffic accident information such as the location of accident occurrence, collision type, road type, the severity of traffic accident, and time of accident occurrence on the national roads under their jurisdiction.

b) Hiyari Hatto data

The Hiyari Hatto data was collected by conducting a questionnaire survey. This survey targeted residents who use the national highway No.2 in their daily. The data such as Hiyari Hatto spot, time of Hiyari Hatto occurrence, and road type were collected from the questionnaire survey.

4. RESULTS

(1) Result of SRS

Fig. 3 shows the result of the SRS on the target segment of national highway No.2 for each of the inbound lanes and outbound lanes. The graphs indicate the road segment every 100 meters on the horizontal axis and the SRS on the vertical axis. The SRS every 100 meters are displayed on the blue line. The SRS resulted in many segments of one star on the outbound lanes in suburban areas, especially. This means that these segments are evaluated as "unsafe" by the criterion of Star Rating approch.

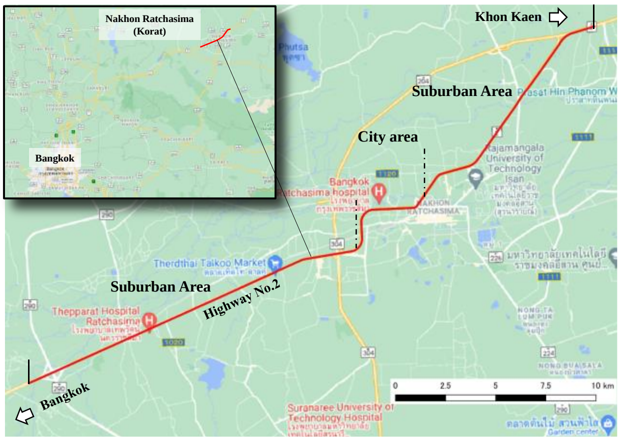


Fig.2 Map of study area

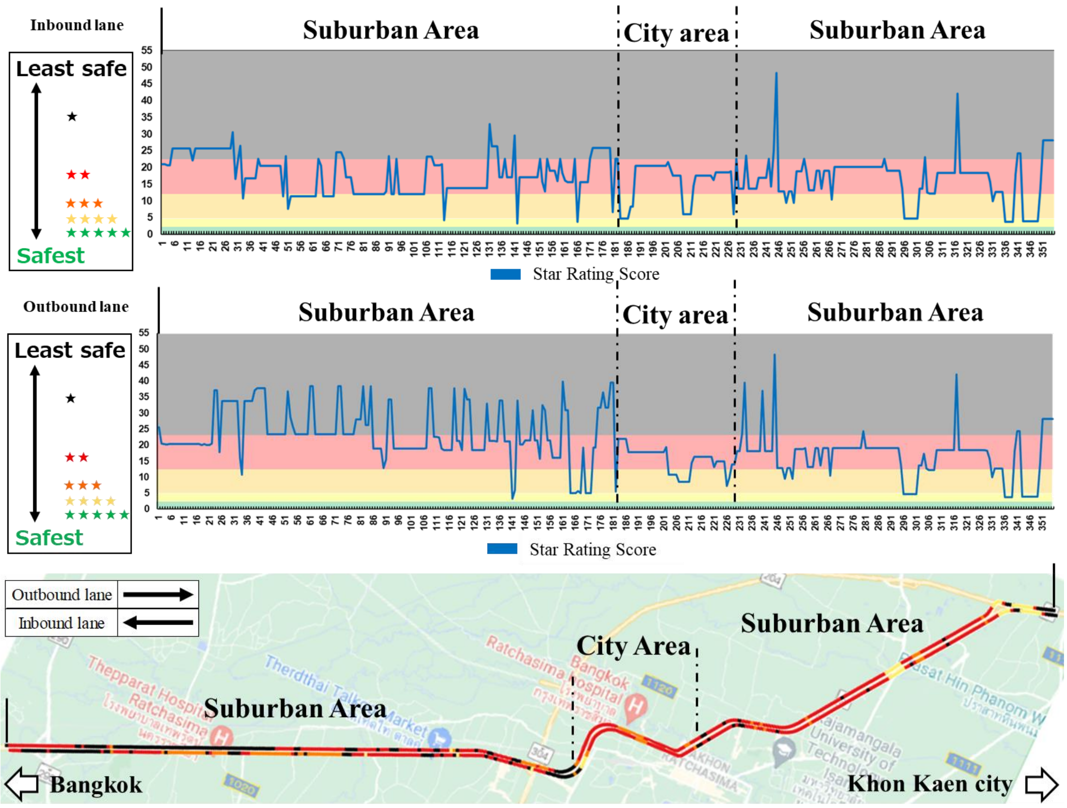


Fig.3 SRS in Highway No.2

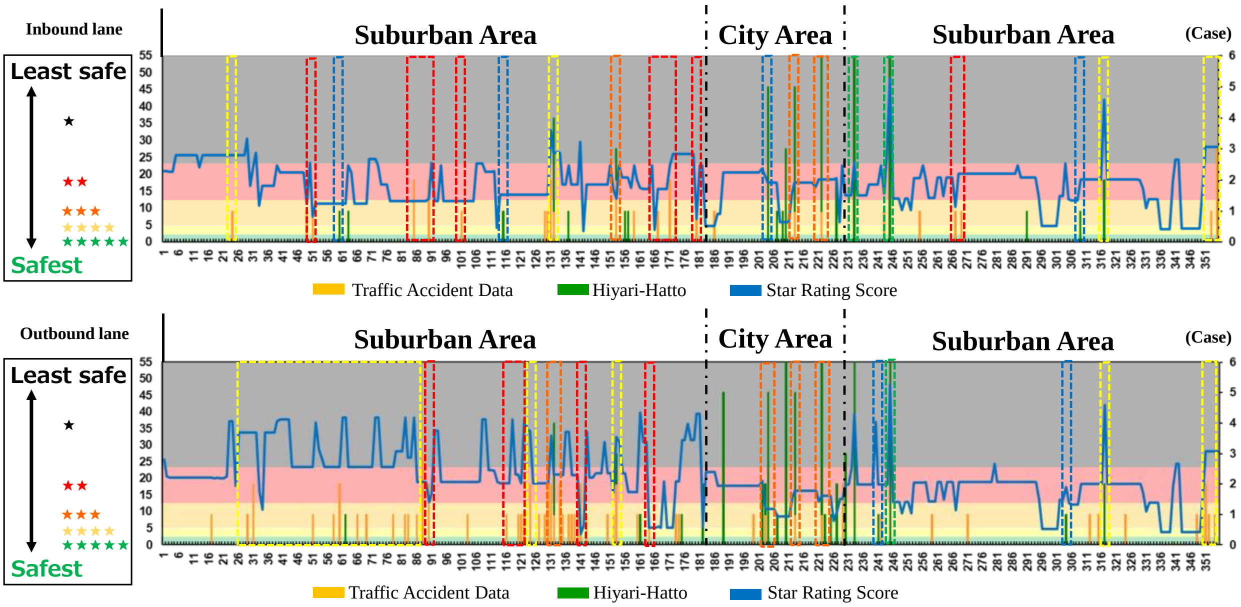
(2) Relationship between SRS and Hiyari Hatto data and traffic accident data

In order to clarify the reason that low SRS in suburban areas, the SRS result was compared with data of the number of traffic accidents, and the number of Hiyari Hatto as shown in Fig. 4. The Fig. 4 shows the five classification of relationship between the SRS, the number of traffic accidents and the number of Hiyari Hatto. This study focused on the classification of c, d, e because the SRS has no relationship with the number of Hiyari Hatto and road traffic accidents on a part of road segments. On the analysis of the Hiyari Hatto and traffic accident data, it was found that these road segments have something in common. The most common event was rear-end collisions on U-turn lanes. The list of the events on the road segments is shown in Table 2. In order to understand the factors that caused Hiyari Hatto and traffic accidents in the U-turn lanes, the U-turn lanes of road segment 226-227 was analyzed details as an example.

The existing evaluation indexs for the U-turn lanes are as follows:

- the speed limit is 60km/h for city areas
- the number of routes is four
- the width of the lanes is 2.75m to 3.25m
- the median has a concrete guardrail (shoulder width is 0m to 1m)

The results of SRS were 18.89 scores with two stars (inbound lanes), and 7.30 scores with three stars (outbound lanes). This is indicated as the safe in the SRS despite the Hiyari Hatto was occurred. Therefore, the target segments were checked by Google Street View as shown in Fig. 5. The reason for the occurrence of Hiyari Hatto is that the lack of the auxiliary lanes for safe vehicle entry into the main lanes after the U-turns. Also, the exisitng Star Rating approach has no evaluation indexs for the auxiliary lanes in the U-turn lanes. It is necessary to add these evaluation indexs.



a Star Rating Score : High — Traffic Accident : Occurred

b Star Rating Score : High — Hiyari-Hatto : Occurred

c Star Rating Score : Low — Traffic Accident , Hiyari-Hatto : Occurred

d Star Rating Score : Low — Traffic Accident : Occurred

e Star Rating Score : Low — Hiyari-Hatto : Occurred

Fig.4 Relationship between SRS, Hiyari Hatto data and traffic accident data

Table 2 List of events on road segments

Aria	Road type	SRS	Hiyari-Hatto (case)	Accident (case)
Inbound lane				
48-49	Arterial roads	★★★	0	1
50-51	Arterial roads	★★★	0	1
59-60	Arterial roads	★★★	1	0
84-85	Arterial roads	★★★	0	2
100-101	Arterial roads	★★★	0	1
179-180	Curve	★★★	0	1
209-210	Arterial roads	★★★	3	0
266-267	Arterial roads	★★★	1	0
Outbound lane				
Aria	Road type	SRS	Hiyari-Hatto (case)	Accident (case)
140-141	U-turn-lane	★★★★	0	2
163-164	Arterial roads	★★★	0	1
203-204	Intersection U-turn-lane	★★★	5	0
209-210	Parking lot entrance	★★★	12	0
226-227	U-turn-lane	★★★	2	0
347-348	Arterial roads	★★★★	0	1

Fig.5 Google Street View of outbound lanes on segment 226-227

(3) Improvement of evaluation indexs for U-turn lanes in Star Rating approach

This study proposed the improvemnet of evaluation indexs for U-turn lanes in the Star Rating approach based on the analysis of the SRS and the Hiyari Hatto and traffic accident data. The proposed evaluation indexs are described in Table 3. The improvement is to add the evaluation indexs of median crossing point-protected turn lane in the intersection type. Thus, this improvement is reflected to the SRS the characteristic of the occurrence of Hiyari Hatto and traffic accidents at U-turn lanes in Thailand.

Table 3 Improvement of evaluation indexs for U-turn lanes

Intersections	Intersection type	3-leg (signalised) with protected turn lane
		3-leg (signalised) with no protected turn lane
		4-leg (unsignalised) with protected turn lane
		4-leg (unsignalised) with no protected turn lane
		4-leg (signalised) with protected turn lane
		4-leg (signalised) with no protected turn lane
		Unused code (non-major inters.)
		None
		Railway Crossing - passive (signs only)
		Railway Crossing - active (flashing lights/boom gates)
		Median crossing point - informal
		Median crossing point - formal
		Median crossing point - protected turn lane
		Mini roundabout
		** Commercial access 1+
		** Residential access 1+
		** Residential access 1 or 2
	Intersection channelization	Not present
		present
	Intersecting road volume	≥15,000 vehicles
		10,000 to 15,000 vehicles
		5,000 to 10,000 vehicles
		1,000 to 5,000 vehicles
		100 to 1,000 vehicles
		1 to 100 vehicles
		Not applicable
	Intersection quality	Poor
		Adequate
		Not applicable
	Property access points	Commercial Access ≥1
		Residential Access ≥3
		Residential Access <3
		None

5. CONCLUSION

In this study, road segments of Highway No. 2 in the city areas and suburb ares, which passes through the Nakhon Ratchasima Province was evaluated by Star Rating approach. In addition, the number of Hiyari Hatto and accidents were compared with the SRS, and the problems in the evaluation indexs of the Star Rating approch were grasped. As a result, it was clarified that there were problems in the evaluation indexs of the Star Rating approach for the U-turn lane and that the danger of the U-turn lanes could not be grasped. In addition, by improving the evaluation indexs of the U-turn lanes in the SRS, it will be possible to further determine the danger points in the U-turn lanes.

In the future study, it is necessary to verify the effectiveness of the Star Rating approch by actually improving the rating items and conducting the evaluation in cities other than the target city.

REFERENCES

1) iRAP : Star Rating, https://irap.org/3-star-or-better/.

2) Hoque, M., Hossain, Z. and Mahmud, S. : Improving highway safety in bangladesh: Road Improvement and The Potential Application of iRAP, 24th ARRB Conference – Building on 50 years of road and transport research, Melbourne, Australia 2010, 2010.

3) Harwood, D., Bauer, K. and Gilmore, D. : Validation of U.S. road assessment program star rating protocol, Article in Transportation Research Record Journal of the Transportation Research Board December 2010, Vol. 2147, pp. 33-41, 2010.

4) Kamiya, S., Ozaki, Y. and Yabu, M. : A study on the extraction method of black spot area based on road geometric structure for effective traffic safety countermeasure, Japan Society of Civil Engineers. Infrastructure Planning and Management., Vol. 50, CD-R, 2014.
5) EuroRAP : http://www.eurorap.org.
6) AusRAP : http://www. http://ausrap.aaa.asn.au/.

(Received October 1, 2021)