Strategy for Development of Enhancement and Evaluation Technologies for Driver's Visibility on Nighttime

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1. Introduction

Drivers obtain over 90% of necessary data through the sense of sight while driving, and thus, visual environment of nighttime roadway is closely connected with traffic accidents. Drivers traveling on the nighttime roadway can identify potentially dangerous situations ahead and the driving route by relying on road lightings and vehicle headlights. In the no road lighting section, the vehicle headlight (low beam) is the only means to secure visual environment. However, the headlight reaching distance is merely 50 ~ 60m, failing drivers to secure stopping sight distance. Therefore, there is always a risk of crash against dangerous objects ahead and a risk of lane departure accidents caused by faint traffic lanes even within the headlight reaching distance due to rapid deterioration of retroreflective performance after installation. All these indicate that the no lighting section is very poor nighttime roadway environment.

Road lighting is the typical infrastructure for securing nighttime visual environment. However, due to high installation/operation cost, it has always been pushed away in the priority of the government budget allocation. As a result, about 88% of the arterial road in Korea is operated without lightings and the local traffic lane, without prompt re-painting, is even unidentifiable by drivers because the line is too faint.

In this regard, this study established a research strategy to secure validity of the government budget support on no lighting sections and to develop/commercialize technology to provide a proper level of minimum visual environment at night with appropriate performance at reasonable cost.

2. Relationship between Road lighting and Traffic Accidents

A great number of studies have already proved that improved roadway visibility at night is directly related to decrease in traffic accident rate. Fatality in no road lighting sections tends to increase drastically compared to that in lighting sections.

According to a press release by Korea Ministry of Trade, Industry & Energy (2007), the US nighttime traffic accidents decreased by 40% after installing streetlamps on highways and when the UK turned off 50% of public lightings for wintertime energy saving, the nighttime traffic accident casualties increased by 12%, which incurred 16 times higher insurance and vehicle repair cost, compared to power saving expenses. Ogden. K. W (1996) presented the accident reduction rate by accident type while classifying the road into high/low speed crossroads and general high/low speed section. According to the study results, when lightings are installed, the traffic accident decrease by 20~30% on the high-speed crossroads, 15~25% on the low-speed crossroads, 20~50% on the general high-speed section and 20~40% on the general low-speed section.

Retroreflectivity is another important element that affects nighttime traffic accidents. Korea Expressway Corporation (2003) compared the number of accidents (related to retroreflectivity) that occurred for 2 months before/after lane repainting period (spring and fall) on Gyeongbu and Honam Expressway for 5 years (1997~2001) to study relations between traffic accidents and retroreflectivities. According to the study results, about 18% of traffic accidents could be prevented by increasing lane visibility.

3. Analysis of Domestic Environment

Technology enhancement and facility investment has been made continuously to improve roadway visibility, but the nighttime traffic accident has accounted for 50% of the entire traffic accident since 1980. The nighttime traffic accident in 2011 (107,530 cases) actually took 48.5% of the entire traffic accident (221,711 cases); while the death toll in 2011 (2,795 people) reached 53.5% of the total death toll (5,229 people). Although the nighttime traffic amount only took about 30% of the entire traffic, the nighttime traffic accident took 48.5% and its death toll occupied 53.5% (as of 2011), indicating 3 times higher risks in nighttime driving compared to daytime in consideration of nighttime traffic load.

Fig.1 Limitation of Existing Technology

Identifying such issues, the Korean government has established the top-rank national traffic safety plan, `National Traffic Safety Master Plan (2012~2016) with the objective of reducing the nighttime traffic accident fatality (up to 50%). The government has set up the task of `Securing Visibility of Pavement Markings at Nighttime and in Rain (2013~)` with the essential tasks of repainting lanes based on retroreflective performances of pavement markings and improving application standards after studying enhancement of retroreflective performances.

4. Expert Survey to Determine Direction of Technology Alternatives

To determine future direction of technology development for securing nighttime visual environment and technology alternatives to be developed, a survey was conducted by experts on the primary task for achieving the national roadway safety objective (50% decrease in nighttime traffic accident fatality).

According to the survey results, to secure nighttime roadway safety, there are more urgent tasks such as improving pavement marking performances, establishing measures for no lighting sections and developing investigation/evaluation technologies of nighttime roadway visibility, rather than developing/applying advanced technology.

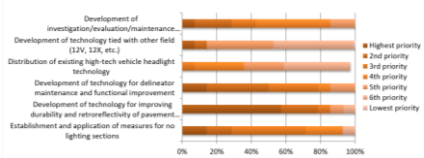

Fig.2 Strategy of Achieving National Roadway Safety Objective (Technology Alternative)

5. Establishment of Strategy

Based on the analysis of technology and environment trend and the expert survey results, this study classified the core elements of improving nighttime visibility into the following three areas and established a comprehensive technology development strategy.

5.1. Technology Development for Nighttime Visibility of Drivers

Many countries around the world have focused only on the supporting policy and technology development for sections with road lighting. In particular, the supporting policy is limited to energy cost saving and reduction of CO2 emission in road lighting sections. Considering the fact that visibility improvement in no lighting sections greatly affects decrease in traffic accidents, it is necessary to secure validity of the government budget support for no road lighting sections and to develop technology for a proper level of minimum nighttime visual environment with appropriate performances at low cost.

Based on such review, this study defined the following core element technology with the objective of securing validity of the government budget support for application of visibility improvement technology in no road lighting sections by means of developing low (no)-power, low-cost nighttime technology for visibility which can replace the existing high-cost, high-performance streetlights, thereby ultimately securing visibility for drivers in no road lighting sections:

· Minimum lighting technology by maximizing light distribution range of single light source
· Infra-independent nighttime delineation technology
· Vehicle detecting technology and alternative energy utilization technology to save installation/operation cost of lightings

5.2. Technology Development for Securing Visibility on Pavement Markings

Pavement markings are the most basic system to promote safety and smooth flow of roadway traffic, showing road lines clearly and drawing drivers' attention at night. Various methodologies have been adopted to improve performances of pavement markings, but a limitation exists in securing durability and overseas countries are considering adoption of new technology such as photo-luminescent materials.

Based on such review, this study defined the following core element technologies with the objective of utilizing new materials for replacing the existing pavement markings in which retroreflectivity at night is rapidly deteriorating, developing highly-efficient and highly-durable nighttime pavement marking technology and developing individual vehicle-based nighttime pavement marking technology:

· Photo-luminescent pavement marking technology with maximum afterglow time and durability
· OBU (On-Board-Unit)-type Identification technology of nighttime pavement marking

5.3. Development of Nighttime Roadway Visibility Evaluation System

In the visibility evaluation of individual system, a measuring instrument is installed in each investigating section and the mean visibility value of the sections becomes the reference value, which is considerably unfavorable in terms of reliability, investigation time, manpower and equipment. Therefore, we need a technology that quantifies and evaluates suitability of roadway driving environment at night from the perspectives of drivers while drastically reducing the frequency of investigation. For this technology, it is desirable to implement technology and equipment system for visibility investigation/evaluation and perform consecutive investigation in real-time.

Based on the results, this study defined the following core element technologies with the objective of developing the standard and quantification method of evaluating roadway visibility and the rapid/accurate evaluating system of nighttime roadway visibility, thereby securing feasible nighttime roadway visibility technology:

· Development of standard for visual environment evaluation and quantification method from the driver's perspectives
· Development of automated investigation/evaluation system of visual environment in nighttime roadway

6. Acknowledgement

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7. Reference

[1] Gallagher, D., Cyrus, H. M., Bassey, R(2009), Photoluminescent Material Evaluation, Technical Note, DOT/FAA/AR-TN09/35, Federal Aviation Administration, US.
[2] Korea Expressway Corportation(2003), Traffic Accident and Lane retroreflectivity.
[3] Korea Expressway Corportation(2012), A Study for Expressway Road Lighting Design Guideline.
[4] KoROAD (2012), 2011 Statistical Analysis of Traffic Accidents
[5] Ministry of Land, Infrastructure, and Transport(2012), National Traffic Safety Master Plan (7th, 2012~2016)
[6] Ministry of Land, Infrastructure, and Transport, Traffic Information System, <www.road.re.kr>
[7] Ogden. K. W(1996), Safer Road: A Guide to Road Safety Engineering, Avebury Technical. US.