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ESTABLISHMENT OF THE METHOD TO MEASURE DRIVER'S VISIBILITY DISTANCE DEPENDING ON FOG DENSITY AND LOW LIGHTING COLOR TEMPERATURE

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ABSTRACT

A line lighting installed at driver's eye level after supplementing the traditional pole lighting has been emerged as the innovative road lighting system, but a line lighting also shows the limit in extending the driver's visibility distance. According to precedent studies, lower color temperature is safer in foggy condition but the effect on driver's visibility distance on a real road has yet to be verified because of the limit in time and space. Thus this study is aimed at establishing the test method to measure the change to visibility distance of the subject depending on fog density and visible distance, thereby identifying the optimal color temperature applicable to line lighting. Should the verification test be conducted according to the method proposed in this study, color temperature of line lighting which is appropriate to foggy condition could be identified.

Keywords: *Line Lighting, Road Lighting, Visibility Distance, Color Temperature*

I. INTRODUCTION

Roadway lighting is one of the typical public infrastructure to ensure the driver has the frontal visibility for safe driving. A pole type street lighting which is one of traditional roadway lighting system has difficulty in satisfying the roadway lighting requirement which is the minimum base to obtain the visibility in the nighttime and in inclement weather (road alignment and lane) because of structural and functional limit due to different elevation between lighting source and road surface.

A line illumination is designed to significantly improve the shortcoming of such traditional pole type lighting system. A line illumination provides the driver with more favorable driving environment in terms of driver's safety but still remains vulnerable to inclement weather such as foggy conditions.

According to precedent studies, the lower the color temperature of road lighting the safer the visibility of the driver at night and foggy condition, but due to the limit in space and time, verification test which is intended to measure the driver's visibility distance that varies depending on visible distance using several subjects on a real road has been rarely conducted. This study thus is intended establish the test method to measure the driver's visibility distance depending on fog density and variation of color temperature of line lighting by employing 100 subjects in a bid to seek the color temperature which would be appropriate to the line lighting. Given the test requires a several subjects and is conducted in a real road which is in need of a considerable amount of budget, through plan and verification shall follow. Should a verification test be conducted using this test method, relationship between the visible distance and driver's visibility distance depending on change to color temperature would possibly be identified.

II. LITERATURE REVIEW

2.1 CORRELATIONS BETWEEN COLOR TEMPERATURE AND VISIBILITY

Huaizhou Jin et al(2015) identified the correlations between color temperature and visibility through the experiment using the subject and the model, thereby investigating the optimal color temperature of illumination as street lighting. Color temperature used for the experiment includes 1870K, 2490K, 3007K, 4075K and 5020K and measured the time taken for dark adaptation, accuracy in distinguishing the color of the object and mist penetration ratio and according to the experiment result, the lower the color temperature the shorter the time to be adapted to

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darkness and under illuminance 2490K and 1870K, mist penetration ratio is high but accuracy in distinguishing the color is lower than high color temperature.

2.2. THE EFFECT OF VISIBILITY DISTANCE ON TRAFFIC FLOW

Fog is classified by visibility distance according to international guideline as follows.

Tables

Table 1. International classification of visibility (Meteoro-logical Office, 1969)

Visibility	Description
Less than 40m	Dense fog
40 ~ 200m	Thick fog
200-1000m	Fog
1-2km	Mist(if mainly due to water droplets) Haze(if mainly due to smoke or dust)
2-4km	Poor visibility
4-10km	moderate visibility
10-40km	Good visibility
over 40km	Excellent visibility

According to international classification, it's classified into dense fog is when visibility distance is 40m or less, thick fog for 40 ~ 200m and thick fog indicates the visibility distance which is most important to the road user (Moore and copper, 1972)

White and Jeffery (1980) said it's dangerous for the driver when visibility distance is 150m or less.
Young-Tae Son and Jin-Sook Jeon(2013) collected weather and traffic data and conducted the study on change of traffic flow characteristic depending on change to visibility distance and as a result of conducting statistical analysis (variance analysis) to verify the difference in traffic flow depending on visibility distance level, traffic volume and travel speed were variable depending on visibility distance level and thus road design and operation approach considering inclement weather that reduces the visibility distance shall be developed.

III. ESTABLISHMENT OF EXPERIMENTAL METHOD

3.1 TEST-BED & SUBJECT

This test is subject to control of fog density and requires a completely closed space which is not affected by the light at all times and the vehicle movement shall be completely under the control to ensure the free and safe test will be allowed. As the site satisfying such condition, a straight alignment section in tunnel under construction on national highway #39 was selected as Figure 1. This construction of this tunnel is completed but yet to open for travel and has at least 200m-long straight alignment.

Figure

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Figure 1 Test bed location & the entrance

The age of the subjects is evenly distributed from 30s to 70s over 100 subjects so as to distinguish the behavior of old subject from younger subject

3.2 LIGHTING CONDITIONS

A line lighting is installed at 1m above the ground surface, aiming at the road surface, unlike the pole lighting and thus the stand is installed at 1m height as Figure 2 and a 1,200mm-long straight pipe lamp was installed and the lighting fixtures were placed every 10m over a 200m-long section. A straight pipe lamp has 4 different color temperatures such as 590nm, 2700K, 4000K and 6500K of Table 2.

Tables:

Table 2 Color Temperature Type

Color Temperature	Electricity
590nm	23W
2700K	
4000K	
6500K	

Figure

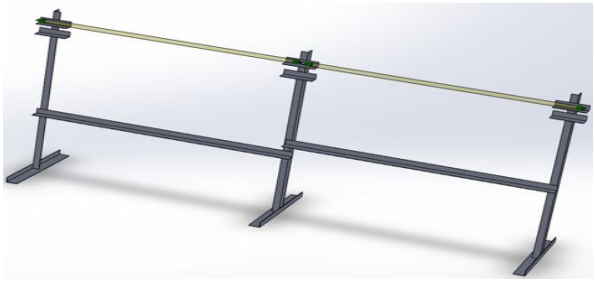

Figure 2. Lamp Holder

3.3 FOG GENERATION AND MEASUREMENT

Fog is generated by two fog generators using colorless and odorless water-soluble liquid so as to provide the required visibility distance. Visibility distance is stored every 10 seconds in tunnel using Biral's visibility meter (Model: VPF-710)

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To maintain the foggy situation, a shield is installed at start and end point of the section and to maintain the uniform fog density and eliminate the fog, a blower and ventilator were installed.

3.4 EXPERIMENT PROCESS

This test is repeated according to a certain procedure and test procedure is as follows.

- **Step 1):** The lighting within 200m for measurement section was fixed with a single color temperature.
- **Step 2):** The fog was controlled to realize the desired visibility using Biral visibility meter (fog density stored on a real time)
- **Step 3):** The distance where the subject recognizes the obstacle is recorded while the experiment time is checked by the operator

To realize various visibility distances at a single color temperature, step 2~3 was repeated 10 times while changing the fog density before measuring

Step1 ~ Step 4 procedure is conducted at 4 different color temperatures (590nm, 2700K, 4000K, 6500K)

IV. RESULT & DISCUSSION

This study is intended to identify the optimal color temperature which will be applied to foggy and low lighting condition. Should the test plan method be improved by incorporating the opinions, more accurate test result would be obtained. As this test is conducted with 100 subjects, more reliable test result is expected.
Based on analysis of the data collected, relationship between visibility distance obtained from visibility meter and driver's visible distance and the effect of color temperature of road lighting on driver's visible distance would be identified. Based on analysis result, color temperature applicable to fogy and low lighting is expected to be identified.

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