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RESEARCH ON THE INFLUENCE OF LIGHT SOURCE COLORS ON VISUAL SURROUNDINGS OF SIDEWALKS AT NIGHT

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SUMMARY

This is a report on visibility evaluation testing performed using both elderly and non-elderly persons to clarify what influences differences in light source color (color temperature) used for pedestrian lighting have on the visibility and comfort of pedestrians.

The study clarified that the influences on pedestrians of differences in light source color are sense of glare, sense of brightness, and the impression or atmosphere that pedestrians feel in the space that is illuminated. But it also revealed that obstructions and visibility of people on a sidewalk that are the most important factors for a pedestrian moving on the sidewalk are not influenced by differences in light source color and that it is vital to provide appropriate illuminance.

1. INTRODUCTION

Today's traffic safety facilities must be designed and installed to provide greater safety considering the physical characteristics of various kinds of road users. And as road users' demands on road facilities diversify, a variety of auxiliary road structures must be provided to meet their needs. This study focused on pedestrian lighting that plays an important role in guaranteeing the safety of pedestrians using sidewalks at night to study the influences of differences of the light source color of pedestrian lighting on the visibility environment of pedestrians etc.

2. DESCRIPTION OF THE STUDY

This study was a visibility evaluation testing of elderly and non-elderly persons to clarify what influences differences in light source color of light sources used for pedestrian lighting have on pedestrians' sense of safety, fear of crime, sense of comfort, and the impression or atmosphere they experience. And the influence on road users of differences in light source color, the characteristics of each light source color, and appropriate places to use each light source color were studied based on the results of the testing.

3. VISIBILITY EVALUATION TESTING

(1) Outline of the testing

A temporary sidewalk was installed on a test track in the National Institute for Land and Infrastructure Management and used to perform the evaluation testing. Triangular cones simulating obstructions and electrical wire rubber covers simulating level differences were installed and other pedestrians approached from the opposite direction. Light source colors with three color temperatures of 2,050K, 3,900K, and 6,500K were used (the light sources were high pressure sodium lamps, fluorescent mercury lamps, and metal halide lamps respectively). The test subjects were 10 elderly persons of 65 or older and 10 non-elderly persons younger than 65. Four pedestrian lights were installed to illuminate the test section that was 81m in length, In order to adjust the brightness of the road surface, filters with varying transmissivities were combined and applied to the front glass of the luminaires. The average illuminance on the road surface was set at five levels: 1.5, 3, 5, 10, and 20(lx). These five levels included four standard illuminance values (3, 5, 10, 20 (lx)) in Japan Industrial Standard (JIS Z 9111) [1] that is most often applied to pedestrian lighting design in Japan and a value of 1.5(lx) that is the minimum illuminance level set by the International Commission on Illumination (CIE (Commission Internationale de l'Eclairage): Pub 115) [2] as a result of surveys of illuminance standards for pedestrian lighting in various countries and international organization. And in order to maintain the uniformity of the brightness of the road surface, the target for the value obtained by dividing the minimum road surface

illuminance in the test section by the average road surface illuminance was set at 0.2[3] (Fig. 1, Photographs 1,2,3)

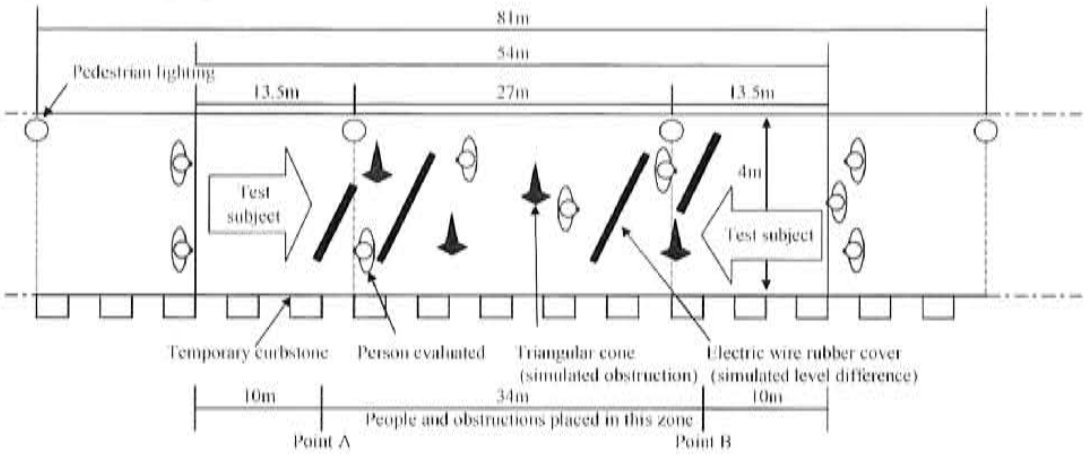

Fig 1. Map of the Test Sidewalk

Photograph 1
View of the Test at Color Temperature of 2,050K

Photograph 2
View of the Test at Color Temperature of 3,900K

Photograph 3
View of the Test at Color Temperature of 6,500K

(2) Items evaluated

The test subjects responded to a questionnaire concerning sense of safety, fear of crime, comfort, and the impression or atmosphere of the pedestrian space they experienced when walking at normal speed under different levels of illuminance set for each lighting light source in the test section. Table 1 presents the items evaluated using the questionnaires and the evaluation criteria (Table 1).

(3) Results of the testing

The testing revealed that major influences of differences in light source color on pedestrians are glare (Fig. 2) and brightness (Fig. 3) that are items used to evaluate comfort, and the impression or atmosphere experienced by pedestrians in the illuminated space (Fig. 4). The evaluations of visibility of obstructions or people, sense of danger, sense of security, and sense of comfort revealed that although evaluations of light sources with low color temperature tended to be low, the difference was small, and that these were almost completely unaffected by differences in light source color. The evaluation of sense of glare revealed that people's sensitivity to glare rose as the

Table 1. Evaluation Content and Evaluation Items

Evaluation Content	Evaluation Items	Evaluation Criteria
Safety	Visibility of existence of obstructions	Visibility 1. Very visible. 2. A little visible. 3. Barely visible. 4. Invisible Sense of safety (Do you feel that you might trip over an obstruction or level difference or bump into an object or a person?) 1. I felt safe. 2. I felt a little danger. 3. I felt danger. Sense of danger (Did you feel that a passing person might attack you?) 1. I did not sense danger. 2. I sensed a little danger. 3. I sensed danger. Sense of security 1. I felt secure. 2. I felt a little insecure. 3. I felt insecure. Sense of comfort 1. I felt comfortable. 2. I felt a little uncomfortable. 3. I felt uncomfortable. Sense of glare 1. I didn't bother me. 2. It bothered me, but didn't interfere my walking. 3. The glare made walking difficult. Sense of brightness 1. It was too bright. 2. The brightness was just right. 3. It was a little dark. 4. It was dark
	Visibility of level differences	
	Sense of safety	
Crime protection	Visibility of existence of persons	
	Visibility of faces of persons	
	Sense of danger	
Comfort	Sense of comfort	
	Sense of glare	
	Sense of brightness	
	Impression and atmosphere in the illuminated pedestrian space*	

*Respondents selected three of the following 26 adjectives that classify the impression or atmosphere that respondents sensed in the illuminated pedestrian space.
Warm, pleasant, unnerving, frivolous, showy, gentle, dynamic, refreshing, cold, lonely, fearful, solemn, plain, hard, static, squalid, calm, bustling, safe, secure, cheerful, exciting, wretched, dangerous, scary, gloomy

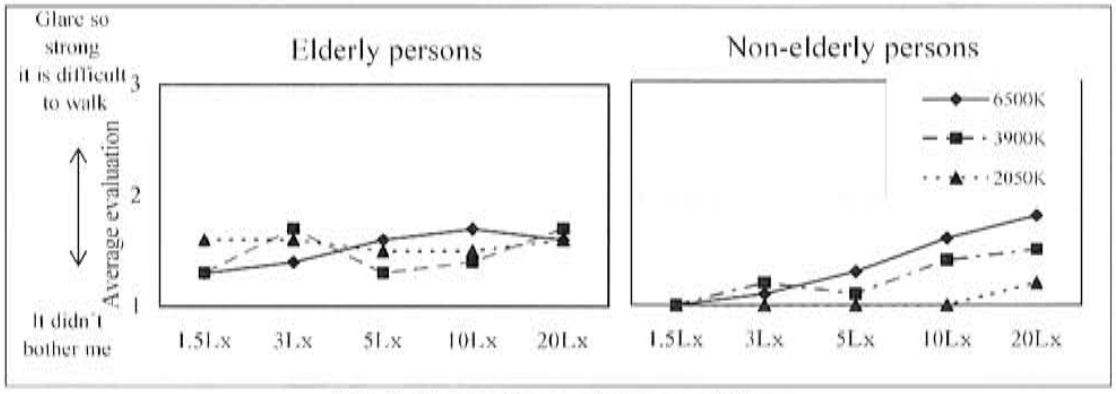

Fig 2. Evaluations of Sense of Glare

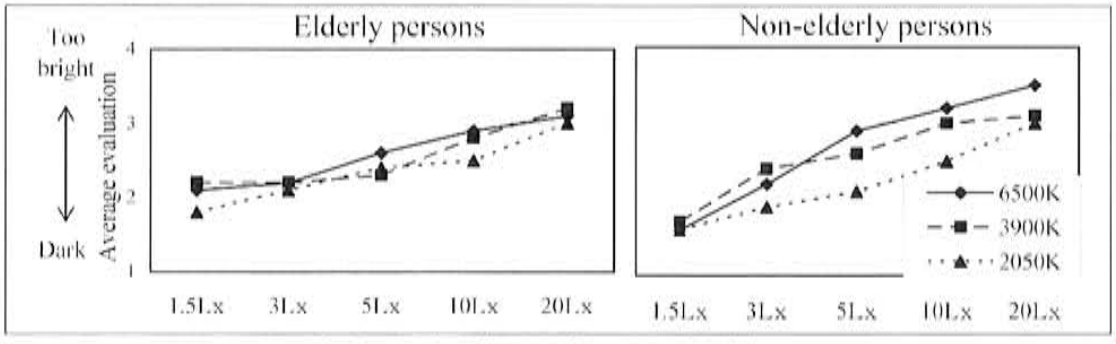

Fig 3. Evaluations of Sense of Brightness

illuminance increased and as the color temperature increased. Comparing the results for elderly and for non-elderly persons shows that while non-elderly persons sensed glare as the illuminance increased and the color temperature increased, elderly persons already sensed glare under relatively low illuminance. The evaluation of sense of

Color temperature: Low ⟷ High

Illuminance: Bright ↑ Dark ↓

	2,050K		3,900K		6,500K	
20Lx	Feeling of security	16	Safe	12	Safe	15
	Safe	11	Feeling of security	11	Worry free	13
	Calm	11	Calm	10	Calm	7
10Lx	Safe	9	Feeling of security	12	Safe	12
	Feeling of security	8	Safe	11	Worry free	11
	Warm	8	Calm	9	Calm	10
5Lx	Calm	9	Safe	8	Safe	8
	Warm	7	Lonely	8	Calm	8
	Safe	6	Calm	6	Refreshing	6
	Refreshing	6		6		
3Lx	Lonely	7	Cold (cool)	7	Cold (cool)	9
	Warm	6	Lonely	7	Lonely	6
	Gloomy	6	Calm	6	Plain	5
			Plain	6	Safe	5
					Refreshing	5
1.5Lx	Lonely	11	Lonely	12	Lonely	9
	Warm	6	Scary	7	Cold (cool)	8
	Wretched	6	Cold (cool)	6	Gloomy	7
			Gloomy	6	Scary	7
			Plain	6		

Numbers represent the number of responses

Fig 4. Evaluations of Impression of Atmosphere

brightness revealed that, like the sense of glare, sensitivity to brightness increased as the illuminance increased and as the color temperature increased. But comparing the results for elderly and for non-elderly persons shows that the way non-elderly persons sense brightness is influenced by differences in light source color, but elderly persons are not influenced very much by differences in light source color.

The evaluations of impression or atmosphere reveal that when the illuminance is high, the test subjects often had an impression of a sense of security, safety, and calm regardless of the light source color. But if the illuminance fell, many experienced an unpleasant impression; fear, coldness, and gloominess if the color temperature was high. When the color temperature was low, they felt a warm impression regardless of the illuminance. It also reveals that a high color temperature gives a refreshing impression.

(4) Considerations

The characteristics of each light source color and examples of their applications based on the test results are summarized below.

[1] Color temperature of 2,050K

This light source color gives a warm soft impression and it does not tend to cause a sense of glare as much as other light source colors, even when its illuminance is high. It is better suited as lighting to appropriately illuminate calm spaces such as community zones or roads around parks rather than on sidewalks in central downtown areas where vigor is required. Seasonally it will be used in the winter.

[2] Color temperature of 3,900K

Compared with the other color temperatures, this color temperature reveals no particularly conspicuous trends regarding the levels of the evaluations and the impressions. It is suited for ordinary sidewalks where there is no particular need for special illumination effects.

[3] Color temperature of 6,500K

As its illuminance level rises, people's sensitivity to glare increases, and if the illuminance is lowered, people tend to sense more unpleasant impressions such as frightening, cold, and gloomy. Therefore, using it on sidewalks with particularly dark surroundings would cause problems: for example, people's sensitivity to glare is high in places with dark surroundings, and if the illuminance is set low to prevent glare, people's sense of discomfort increases. It has been concluded that it can be effectively applied on sidewalks in cities centers where the surroundings have high illuminance and where it is necessary for people to sense vigor and brightness. Because the light color provides a refreshing and cool impression, it will be used in the summer.

4. CONCLUSIONS AND FUTURE CHALLENGES

The study revealed that visibility of obstructions and people on a sidewalk that are the most important factors for a pedestrian moving on the sidewalk are not influenced by differences in light source color and that it is vital to provide appropriate illuminance. It has also shown that the impression created by light source color has considerable influence on the comfort of pedestrians walking on a sidewalk. Additionally, it revealed that the influence of differences in light source color on comfort is smaller for elderly people than for non-elderly people. These results serve as basic reference information that road managers will use to select light sources for pedestrian lighting in the future.

The object of this study is pedestrian lighting, but it is assumed that a study with road lighting for vehicles as its object would reveal that differences in light source color have some influence on the traffic visibility environment experienced by drivers. Such a study will be a future challenge.

REFERENCES

1) JIS Z 9111-1988, *Roadway Lighting Standard,* Japanese Industrial Standards

2) CIE 115-1995 *Recommendations for the Lighting of Roads for Motor and Pedestrian Traffic*

3) JIEC-006, *Outdoor Public Lighting Standards for Pedestrians*, The illuminating Engineering Institute of Japan, 1994