

Effect of Colour Rendering for University Campus Landscape Lighting at Night in a Snowy Region

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ABSTRACT: *The importance of the landscape lighting of urban nightscapes is increasing with the urban lifestyle for a 24-hour-life. In addition, the feature of landscape lighting has changed from emphasis on the lighting design for the conventional purpose of safety and the degree of brightness to a lighting plan which matches with the view in the region as well as in consideration of psychological comfort. By the way, snow is sometimes a fearful thing which brings about a major disaster, but at the same time, it has beauty appealing to people's heart and wonderful attraction. Accordingly, what is sought in a design for landscape lighting in such an environment must be an atmosphere in the space such as an "element which has an effect to alleviate the coldness of snow" or an "element that enables the beauty of snow to be enjoyed". In this study, we tried to evaluate the effect which the difference in a hue of the light source in landscape lighting gives to urban scenery perception in a snowy region quantitatively and at the same time to examine and consider about "how landscape lighting should be in a snowy region". We selected six kinds of typical urban landscape lighting as samples. We took photographs of these nightscapes. We made another samples which landscape lighting colour changed to "red", "orange", "yellow", "white" or "skyblue" using computer, and presented to subjects. We applied SD technique to the evaluation for these samples. Also, we analyzed the difference between three samples, using factor analysis. From the results, we found that the landscape lighting of "red" and "orange" provided an active impression to the urban nightscape. On the other hand, the landscape lighting of "skyblue" provided a beautiful impression to the urban nightscape.*

Keywords: *Landscape lighting, color rendering effect, psychophysical evaluation, factor analysis*

I. INTRODUCTION

Accompanying the development and spread of new lighting that is superior in producing color effects by mainly using a fluorescent light, etc., the concept of lighting has largely changed with the times. Especially in recent years, the way of thinking that the most appropriate "lighting design" should be carried out, depending on the purpose, has become widely and generally accepted. The feature of outdoor lighting has also changed from emphasis on the lighting design for the conventional purpose of safety and the degree of brightness to a lighting plan which matches with the view in the region as well as in consideration of psychological comfort. This can be said to be one of the typical examples where the role of lighting has become increasingly more wide-ranged in line with the change in social needs.

By the way, Yan Tai City, which is located in the farthest north in the Lu Dong district, is one of the snowiest regions in China. Snow is sometimes a fearful thing which brings about a major disaster, but at the same time, it has beauty appealing to people's heart and wonderful attraction. Accordingly, what is sought in a design for outdoor lighting in such an environment must be an atmosphere in the space such as an "element which has an effect to alleviate the coldness of snow" or an "element that enables the beauty of snow to be enjoyed".

On the other hand, a number of papers have been published reporting on the impression and evaluation concerning the most appropriate outdoor lighting design for urban scenes. Nevertheless, in reality, at present, there are very few papers reporting on the effect which the difference in the hue of the light source gives to perception of a scene and further the effect of the same on perception of a scene accompanied by fallen snow.

Accordingly, the purpose of this study is to evaluate the effect which the difference in a hue of the light source in outdoor lighting gives to urban scenery perception in a snowy region quantitatively and at the same time to examine and consider about "how outdoor lighting should be in a snowy region".

II. METHODS

The procedure of our experiment is as follows:

- (1) We selected three locations for lighted-up night scenery samples for observation and take photos of them. This scenery sample of the photographed night view was used as samples for the experiment by changing the hue of the light source into 5 phases with the use of computer aided graphics software in a calculator (Figure 1).



Figure 1 Sample picture

- (2) Similarly, samples for the experiment were prepared in respect to a scene of night views, when snow has fallen, at the same angle in the three locations.
- (3) Each sample was presented on a screen by a projector. The subjects shall carry out image evaluation using the SD method^{1), 2)} where they observe each presented sample for the experiment, and evaluate the impression of each sample as one of the 7 stages choosing from the 25 pairs of adjectives.

In this connection, with regard to the hues of light sources, five kinds of models for change in color temperatures were selected (Figure 2).

- (i) “Red” color model for which 1000K light color is used with $(x, y)=(0.653, 0.334)$.
- (ii) “Orange” color model for which 2000K light color $((x, y)=(0.527, 0.413))$ is used.
- (iii) “Yellow” color model for which 3000K light color $((x, y)=(0.437, 0.404))$ is used.
- (iv) “White” color model for which 6000K light color $((x, y)=(0.322, 0.332))$ is used.
- (v) Blue white” model for which 10000K light color $((x, y)=(0.24, 0.23))$ is used.

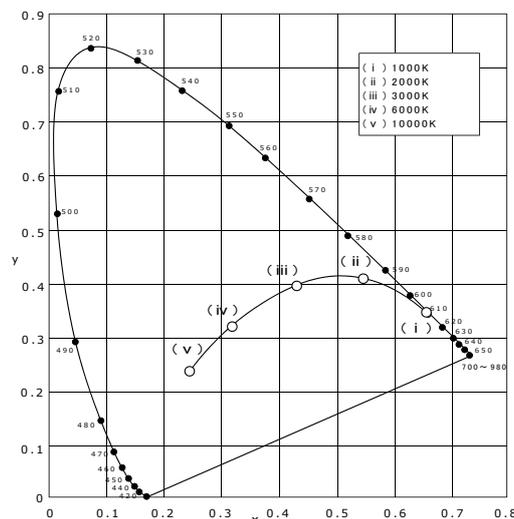


Figure 2 Chromaticity diagram of each samples

III. RESULTS AND DISCUSSION

We collected adjectives which have similar meanings out of the adjectives which were arranged without any order and rearranged them by carrying out a cluster analysis for the purpose of representing them in polar coordinates to be able to see the results of image evaluation easily, that is to say, to make the results of the experiment more easily understandable. At this time, we used the Euclid distance method for distance calculation, and the longest distance method for classification. As a result, they were classified into the

following four clusters.

- (1) The first class is the “refreshing” cluster including adjectives such as “neat”, “simple”, and “pure”.
- (2) The second class is the “evaluation” cluster including adjectives such as “quiet”, “harmonious” and “beautiful”.
- (3) The third class is the “stimulating” cluster including adjectives such as “exciting”, “cheerful” and “imposing”.
- (4) The fourth class is the “activity” cluster including adjectives such as “dynamic”, “soft” and “lively”.

We plotted the results of the experiment in Figure 3 by rearranging the order of the adjectives on the polar coordinates on the basis of these results of the cluster analysis. The average of the image evaluation results of all the samples is shown in (a) without snow, and in (b) with snow. Adjectives are plotted in the direction of the circumference (on the positive side only), and evaluation values are plotted in the direction of the radius. The figure for each adjective indicates the class of the results of the above analysis. The parameter was made the color temperature.

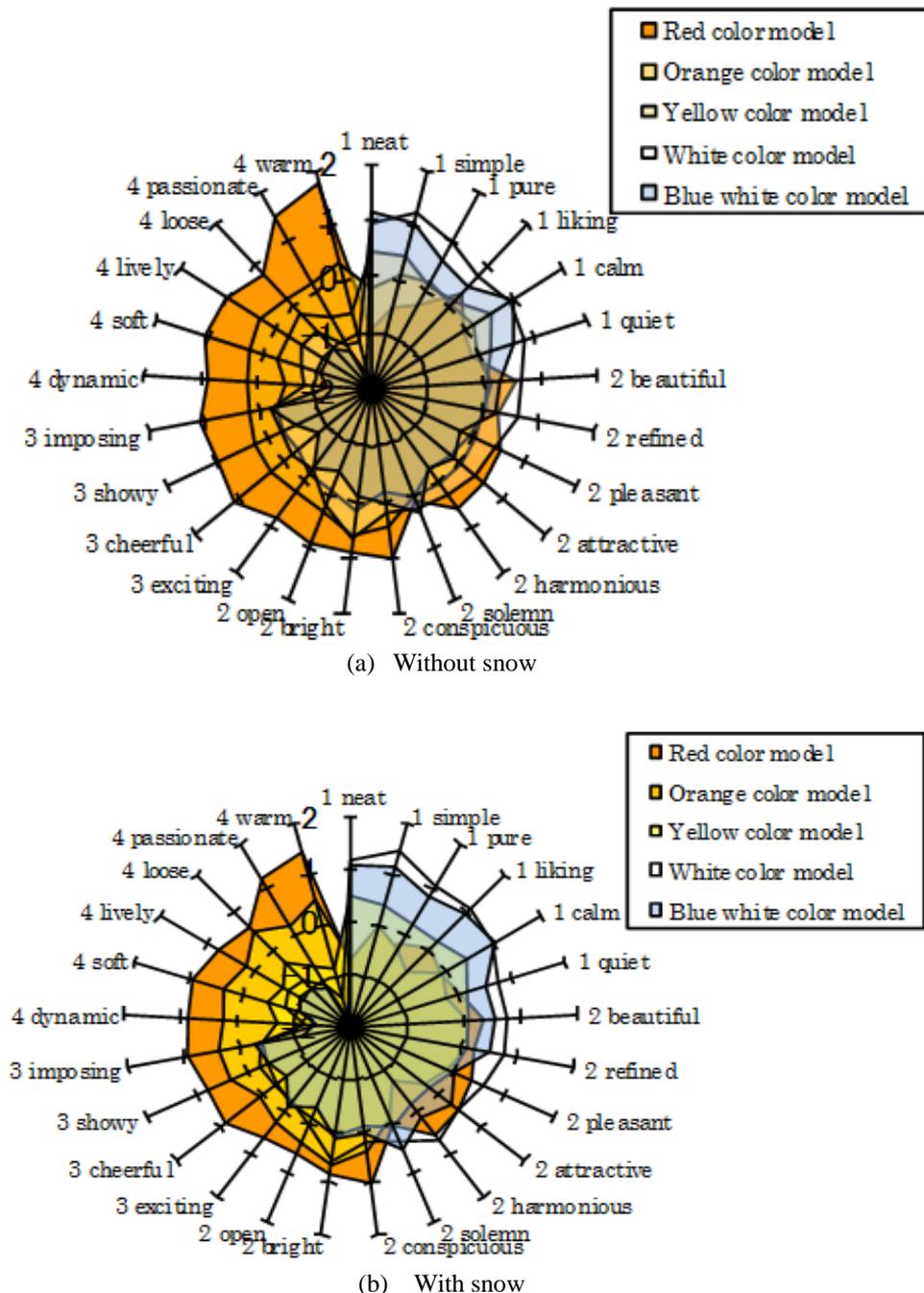


Figure 3 The results of the experiment on the polar coordinates.

The result is that evaluation values tended to be high in each sample in the blue white color, white color and yellow color models with a color temperature of 3000K or over in the “refreshing” class, which is the first class, that includes adjectives such as “neat”, “simple”, and “pure”. The evaluation values of the whole color model were the highest. On the other hand, in the orange color and the red color models with a color temperature of less than 2000K, the evaluation values were high in the adjectives in the “stimulating” class, which is the third class, and the “activity” class which is the fourth class, and that shows that they give a very “exciting” and “active” impression. Especially in these classes, the evaluation value of the “red color model” was extremely high.

From the above, it is indicated that where the color temperature is low as a whole, that is, when the color temperature is below 2000K, it gives an “exciting and active impression” to a scene, and when the color temperature is 3000K or over, it gives a “refreshing impression”.

Furthermore, it is indicated that the “effect which gives a refreshing impression to a scene” in the light of a high color temperature is even greater where there is snow. On the contrary, it is also clarified that the effect of the lighting of a low color temperature which gives an active impression is restrained.

IV. Acknowledgements

The results clarifies that where the color temperature is low, that is to say, where the color temperature is below 2000K (orange model), it gives a warm impression, which is also active and vigorous, to a scene, and that, on the contrary, the lighting with a color temperature of 3000K (yellow model) or over gives a static and refreshing feeling and this tendency is the most effective at a color temperature of 6000K (white model). In addition, it was also clarified that there is a tendency that the psychological effect of the lighting with a high color temperature tends to be even greater in snowy conditions. In consideration of these results, we considered a lighting plan sought for snowy conditions. The result is the following two points:-

- (1) In carrying out a design, it is desirable to put an emphasis on lighting with a high color temperature which brings out the characteristics of snow, and especially 6000K (white model) lighting, for places (e.g. the site of a snow festival, etc.) where people enjoy the refreshing feeling, beauty, etc. which are the characteristics of snow itself.
- (2) It is desirable to use lighting with a low color temperature which has the effect of softening the characteristics of snow in places where snow is not desirable, in order not to give the feeling of coldness and strain that snow has, which is represented by road.

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