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DEVELOPENT FOR THE OPTIMUM DISPLAY COLOURS ON ROAD INFORMATION BOARDS WITH CONSIDERATION FOR COLOUR VISION BARRIER FREE

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DEVELOPENT FOR THE OPTIMUM DISPLAY COLOURS ON ROAD INFORMATION BOARDS WITH CONSIDERATION FOR COLOUR VISION BARRIER FREE

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Abstract

Road information boards displaying seven colours are getting popular in Japan. For the display colours of the road information boards, the previous studies reported that white is easy to see for both colour vision normal person and colour vision impaired person under any weather conditions, and also, that red is difficult to see for colour vision impaired persons.

We conducted the experiments of the visibility evaluation on the display colours of the road information board in the environmental simulated facility and in the real environment under various weather conditions.

This study includes the following technical investigation and analysis:

1) The optimum display colours

2) The display methods of the new barrier free measures for colour vision variation by fully using the seven multicolour function

The significant results obtained from this study show that white is the optimum display colour for each weather condition, leading to further improving the display methods.

Keywords: Colour vision barrier free, Optimum display colours

1 Introduction

Honshu-Shikoku Bridge Expressway (HSBE) manages 3 route highways connecting Honshu Island and Shikoku Island in Japan including the world class long sea-spanning bridges. Due to the distinctive weather conditions of the strait area where the environment is exposed to the severe weather such as fog and rain, the road information boards are placed to accurately and promptly convey the road information toward the road users on highways. The road information boards are now under renovation works because of deterioration for long use. (Figure 1, Table 1, Photo 1)

The number of display colours of road information boards is being upgraded from 3 colours to 7 colours. The experiments of visibility evaluation were conducted by 138 experiment participants to find out the optimum display colours under various weather conditions and to study the display methods to improve visibility for colour vision variation.

Although the multicolour road information boards displaying 7 colours are expected to improve visibility in providing the road information, the visibility deference under various weather conditions and the optimum display colours providing the road information are not figured out yet.

In this study, in order to take advantage of the multicolour function, we studied the optimum display colours under various weather conditions and the improvement measures of visibility toward colour vision normal person and colour vision impaired person. We also suggest the new barrier free measures to improve safety for vulnerable drivers.

We use the expressions such as “colour vision impaired person” and “colour vision normal person” in this paper although defect of visual performance is described as “colour vision variation” since visual performance is diverse.

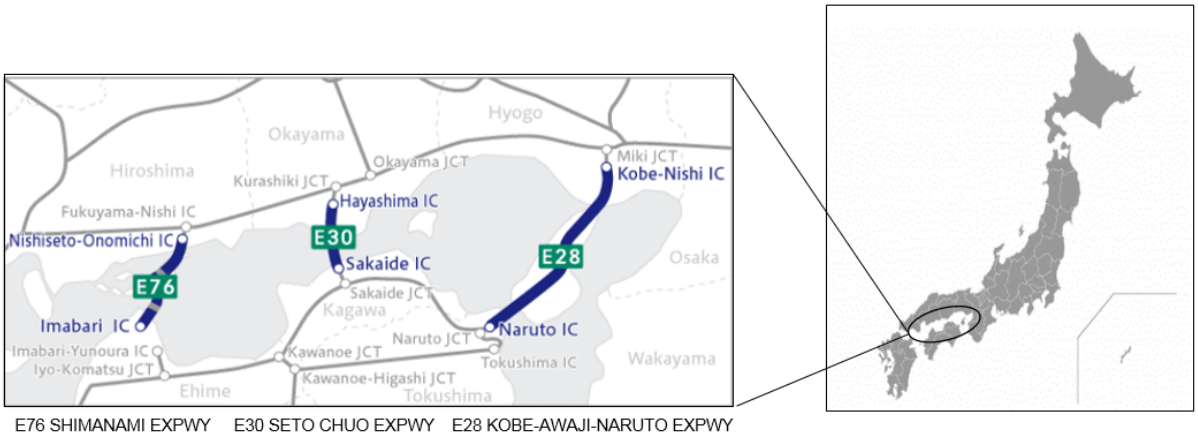


Figure 1 – Route map of Honshzu-Shikoku Bridge Expressway

Table 1 – List of road information board display

Type	Red	Orange	Yellow	Yellow green	Green	Light blue	White
3colours	○	○	–	○	–	–	–
7colours	○	○	○	○	○	○	○

Photo 1 – Overview of road information board

2 Previous studies

By far, Ministry of Land, Infrastructure, Transport and Tourism (MLIT) and Highway Companies have studied the display colour of the road information board. According to these studies including visibility of the variable display information board [1], and the study of the display colour of the road information board [2], colour vision normal person can well see white, red and orange, and colour vision impaired person can well see white and yellow. However colour vision impaired person has difficulty seeing red. (Figure 2)

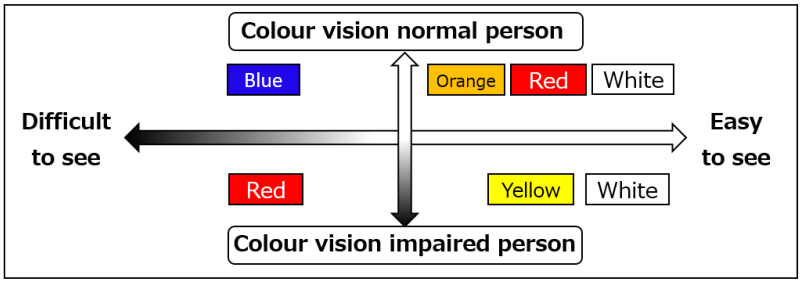


Figure 2 – Optimum display colour in previous research

3 Previous colour vision barrier free measures

Previous colour barrier free measures of the road information board focused on red colour itself. Prior to 2005, the dominant wavelength of the red colour displayed on the road information board of had been 640nm due to the characteristic of the LED elements. Dominant wavelength is quantified number corresponding to the wavelength of the light colour perceived by human eyes. But after 2005, the research result of universal design of colour information on the road information board [3] has been adopted.

Accordingly, HSBE specifies the dominant wavelength of the red colour of the LED on the road information board is 623nm. This value of the dominant wavelength is complied with the range of the red colour of the traffic signals in Japan based on the specification of International Commission on Illumination (CIE).

This colour is red close to orange within the range where colour vision normal person can differentiate from orange to red. And the wavelength of the colour is also considered for the visibility of colour vision impaired person.

4 New colour vision barrier free measures

Promptly conveying accurate information toward the road users is realized by using optimal colour in providing the road information. Three colours, red, orange and green are usually used on road information boards. Red is used for important events such as emergency and road closures, orange is used for alerts concerning weather and traffic congestion, and green is used to highlight instructions such as traffic safety campaign. It is, however, difficult to recognize red used for emergency and important events toward colour vision impaired persons.

According to the previous studies, it was reported that white is easy to see for both colour vision normal person and colour vision impaired person under any weather conditions, and also, that red is difficult to see for colour vision impaired persons. Therefore, we verified these results.

In addition, we evaluated the visibility improvement of the white character with background colour such as red, orange and green, and the efficacy as a new barrier-free colour visibility measure was verified while taking into account the current situation where red is used for important events in actual operation and ensuring consistency with actual operation.

5 Experiment method

Using the small LED display board as a virtual road information board, in an environmental simulated facility comprising a glass greenhouse that can simulate the normal, rain and thick fog weather conditions, the experiments of "character colour evaluation" and "character with background colour evaluation" were conducted (Table 2).

For the normal environment (Sunny day), the visibility of the small LED display board was evaluated in the environmental simulated facility where the visual environment is equivalent to outdoor environment.

For the rain environment, the visibility of the small LED display board was evaluated in the environmental simulated facility with rainy situation where the precipitation was 20mm/h. The

visibility evaluation was conducted through the transparent acrylic board as windscreen with raindrops, which was placed in front of the experiment participants.

For thick fog environment, the small LED display board was placed in the facility simulating 50m visibility range since visibility range of less than 50m in fog is the criterion for road closure. (Photo 2, Figure 3)

Table 2 – Specification of small LED board

Colours	Luminance(cd/m^2)		Dominant Wavelength(nm)
	Day time	Night time	
Red	1,600	85	623
Orange	2,900	205	597
Yellow	3,800	205	572
Yellow green	2,200	120	552
Green	2,200	120	510
Light blue	4,300	230	481
White	2,700	145	485

Photo 2 – Experiment situation in environmental simulated facility

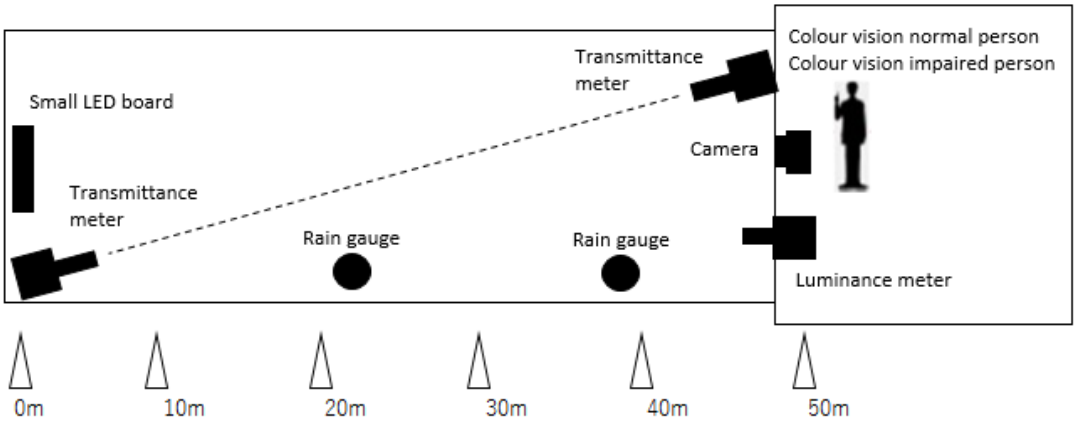


Figure 3 – Arrangement of equipment for evaluation test

The licensed drivers between ages 20 and 60 (vision acuity of 0.7 or more in both eyes) attended the experiments. For verification of barrier-free colour visibility measures, an observation was performed using a spectacle type colour weak simulation filter which simulates the perception of colour vision impaired persons [4]. As the evaluation character sample, a Chinese character meaning “time” was used on the boards during the experiments based on “the evaluation that are derived from the report on the advancement of the road technology 5-year plan road sign indicator” [5].

Although the same experiments at the real environment in the field of Akashi Kaikyo Bridge were conducted, thick fog did not occur during the experiment so that the experiments were conducted in only the normal weather condition. In this section, we describe the two types of experiments conducted in the environmental simulated facility as follows.

Experiment 1: character colour evaluation experiment

For character colour evaluation experiment, a different colour for "time" was displayed on the left side and on the right side of the small LED board in the facility in order to perform pairwise comparison. Visibility evaluation was classified in five categories: (1) left side is good, (2) left side is slightly good, (3) cannot judge, (4) right side is slightly good, (5) right side is good.

Experiment 2: characters with background colour evaluation experiment

For evaluation of the characters with background colours, background colours of red, orange, green, and black were imposed behind a white character or yellow character, and experiment participants saw the Chinese character with a different background colour displayed on the left side and the right side in order to perform pairwise comparison. In addition, border font and non-border font were used for these characters in the experiment. Visibility evaluation was classified in five categories: (1) left side is good, (2) left side is slightly good, (3) cannot judge, (4) right side is slightly good, (5) right side is good.

6 Experiment results

In compiling the result of the pairwise comparison, Nakaya's variation based on Scheffe's paired comparison was utilized for ranking by intercomparison of multiple samples.

Nakaya's variation is a suitable method in the case of both the effect of experiment orders is not necessary to consider and the participants conduct each pairwise comparison for all experiments. Nakaya's variation is well balanced method for evaluation due to higher reliability than simple average method [6].

In the evaluation sheet of this experiment, the five grade evaluation was converted that 0 was given to (3) cannot judge, (1) left side is good: -2, (2) left side is slightly good: -1, (4) right side is slightly good: +1, and (5) right side is good: +2. Each result of display colour evaluation was totalled as the scores.

The value on the vertical axis of average preference level in Figure 4 and Figure 5 is obtained from Nakaya’s variation, distributing from -2 to +2. Average preference level represents that the lower is negative value, the higher is positive value and 0 is correspondent to “cannot judge”. Each result was indicated in the order from high level in terms of average preference level. The results of each experiment are described as follows.

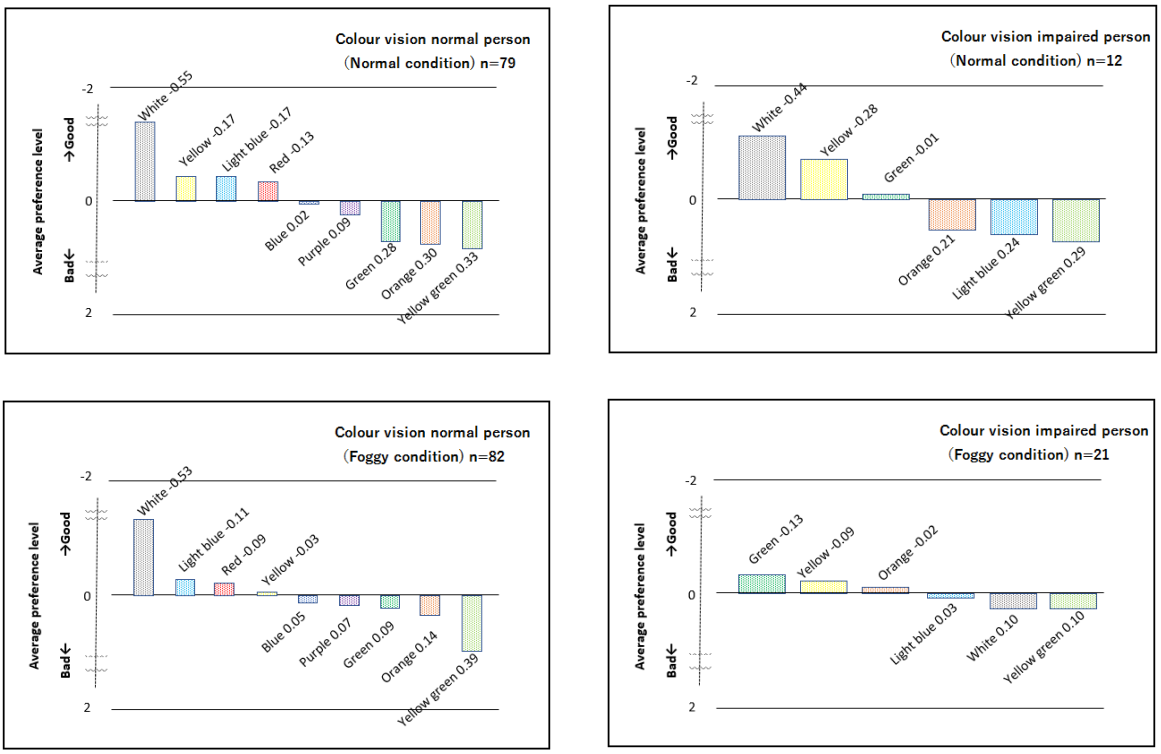


Figure 4 – Evaluation result of character colours

(Remarks: Normal)

(Remarks: Thick fog)

Photo 3 – Character colour evaluation experiment

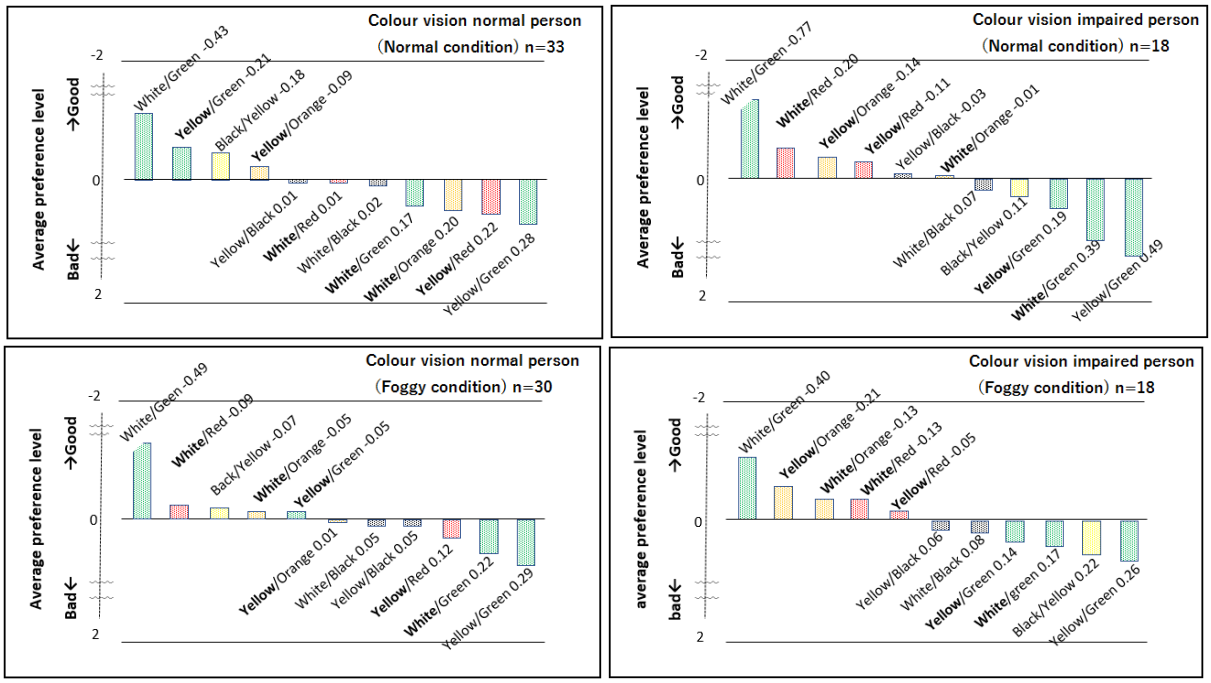
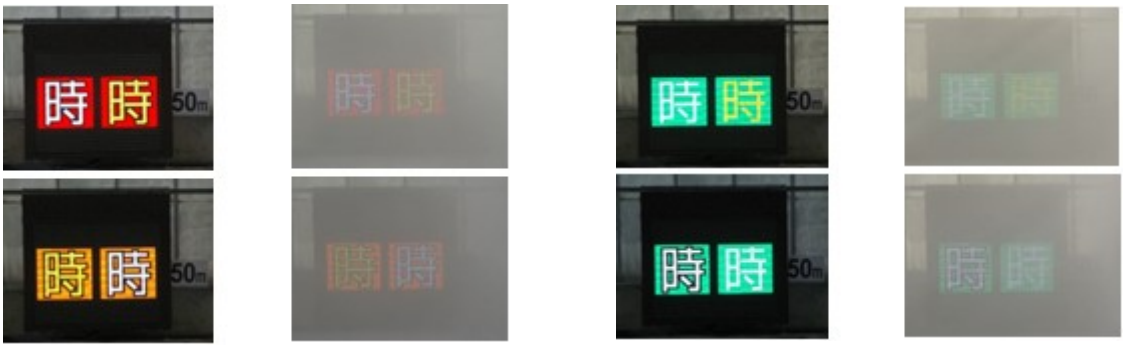


Figure 5 – Evaluation result of character colours with background colours



(Remarks: Left: Normal, Right: Thick fog) (Remarks: Left: Normal, Right: Thick fog)

Photo 4 – Evaluation of the character colours with background colours

a) Evaluation of character colours experiment

Experiment 1: For evaluation of character colours experiment, white, yellow and green of the 7 colours were the most prominent in visibility under the normal condition by colour vision impaired person, but in heavy fog the difference among the colours was small (Figure 4, Photo 3). This indicates that there is not much difference in character visibility in thick fog, and we can infer that there is not a problem in setting the character colour of white which has the highest display luminance.

b) Evaluation of the character colours with background colours experiment

Experiment 2: For evaluation of the character colours with background colours experiment, white non-border character with green background colour resulted in the highest evaluation (Figure 5, Photo 4). Evaluation of white character with red or orange background is better than black background. Especially, white character with red background was well recognized by colour vision impaired person and was confirmed as a measure to improve the visibility.

7 Results

From the results of each evaluation experiment, it is decided that white character is used on the upper part describing the occurring place of the event and the lower part describing the content of the event is as follows.

(1) For the display of the high rank events, white character (with black border) with red background

(2) For the display of the low rank events, white character (with black border) with orange background

(3) For the display of the general and other events, white character (with non-black border) with green background.

8 Conclusions

The following findings were obtained from the experiments. For each weather condition, white is the optimal display colour for colour vision normal person and colour vision impaired person. In addition, characters with colour backgrounds positioned as a new barrier-free colour measure was confirmed to have a positive impact on visual recognition of colour vision impaired persons for providing road information on warnings and cautions. We obtained results that contribute to improvement of visibility and safety for drivers, taking into account the impact on colour vision variation on visibility.

We applied this results for the multicolour road information board on Akashi Kaikyo Bridge renovated in 2018, starting operation in January 2019. This new display method is valued as a part of universal design considering colour vision variation, and is expecting to contribute to advanced information providing.

Photo 5 – New road information board renovated in 2019

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