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Environmental Correspondence of Coloring for Elevated Freeways using Image Processing System

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Abstract

Environmental correspondence of coloring for elevated urban freeways is discussed in this research. An image processing system was used to create color simulation models of elevated freeways in urban settings, and landscape rations based on these models were made in order to explore future color schemes for elevated freeways. Results showed that landscape comprised primarily of greyish man-made materials look better when elevated freeways also have a monochromatic grey or cool color scheme and are contrasted with their surroundings by means of differing value (brightness). Landscape in which neutral colors predominate look better when elevated freeways have the same hue as their surroundings and are contrasted by means of differing chroma.

Purpose of Research

In recent years, more attention has been paid to the landscape aspects of urban settings, and in particular to the role of color. Elevated urban freeways can be problematic because of their overwhelming size and the resulting strong impact of their color. In this research, an image processing system was used to create color simulation models for elevated urban freeways, and landscape ratings based on these models were made in order to explore future color schemes that might make elevated freeways more attractive.

Research Method

1) *Understanding the landscape characteristics of the basic images and creating color simulation models*

Photos featuring elevated urban freeways were taken in five distinct land-use areas, each of which had a different color environment. The five areas were business-use, low-rise residential, high-rise residential, rural, and city park as shown in Photo 1 to 5. These photos were used as the basic images in the color simulation models. To analyze landscape characteristics, the basic images were broken down into their component parts as shown in Photo 6, and then classified by material and by hue. The percentage of screen surface covered by each material and hue was then measured.

Next, the image processing system (Nexus-Qube) was used to change the color of the freeway's girder section in each basic image to create new color simulation models. 11 colors (within 8 hues) used in this research were taken from the Munsell scale. The warm colors were R (red), YR-1 (orange), and YR-2 (brown). The neutral colors Y-2 (emerald

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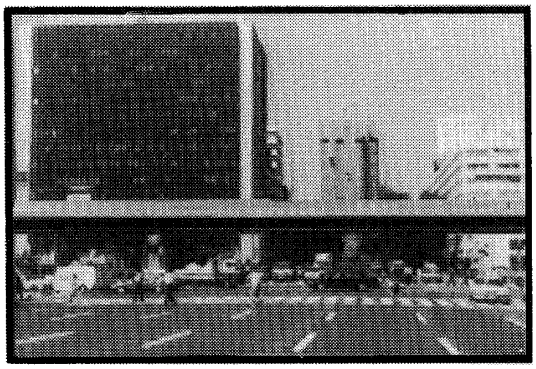

Photo 1 Business-use area

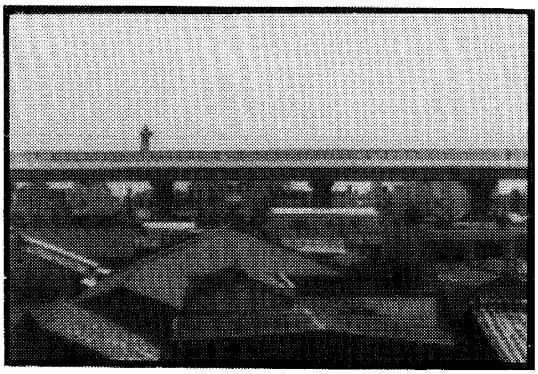

Photo 2 Low-rise residential area

Photo 3 High-rise residential area

Photo 4 Rural area

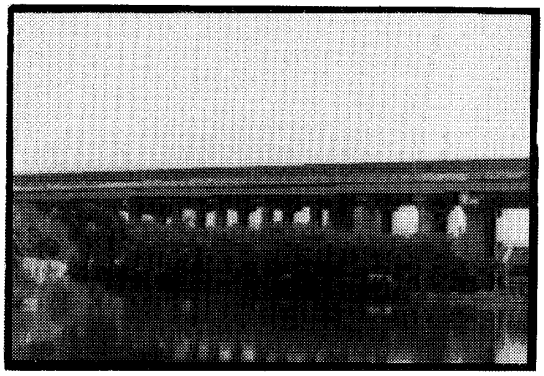

Photo 5 City park area

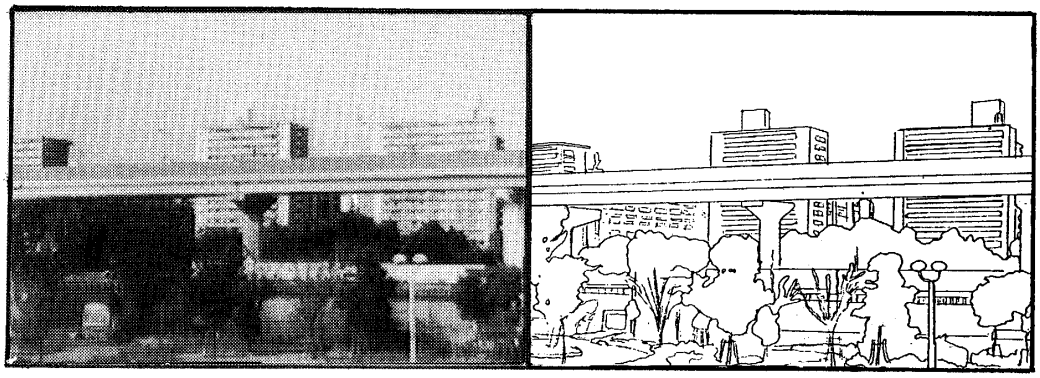

Photo 6 Breakdown of basic image into components (high-rise residential area)

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green), GY-1 (deep green-yellow), GY-2 (pale green-yellow), and G (green). The cool colors were BG (blue-green), B (blue), and PB (indigo). Monochromatic grey (N) was also used, for a total of 12 colors. Each color was transposed onto the elevated freeways image in each of the five land-use areas, for a total of 60 color simulation models.

2) *Method of rating the color simulation models and analyzing*

In November 1990, slides of the 60 color simulation models were shown to 32 students enrolled in this department of University of Osaka Prefecture. The landscape characteristics of each model was rated by the students on 10 scales consisting of word pairs with opposite meanings (e.g. beautiful - ugly). Each scale was divided into five points, ranging from complete agreement with the first half of the word pair (e.g. beautiful) to complete agreement with the second half (e.g. ugly)

Numerical values from -2 to 2 were assigned to the ratings given on the five-point scales. Mean ratings were calculated, and this basic data was used to carry out a factor analysis by land-use area. Factor scores were then used in considering research results.

Results and Discussion

1) *Landscape characteristics of the basic images*

The basic images are broken down by material in Figure 1, and by hue in Figure 2.

Buildings dominate the basic images of business-use and low-rise residential areas. The percentage of viewed space occupied by man-made materials is 75.0% and 55.5%, respectively. The breakdown by hue shows that monochromatic greys occupy 68.1% and 43.3% of these images, respectively. However, the low-rise residential area differs from the business-use area in having a more dominant sky (43.9%) and a correspondingly large percentage of space occupied by the color blue. Also, roof tiles in the low-rise residential area tend to add colors to this image that are lacking in the business-use area.

The image of the high-rise residential area is almost evenly divided between man-made materials, natural materials, and sky. The breakdown by hue shows that warm, neutral, and cool colors occupy similar percentages of space in this image, giving it an overall balanced look. Green occupies a higher percentage of space (21.2%) in the high-rise residential area than in any of the other four images.

In the image of the rural area, man-made materials occupy only 13.2% of the viewed space, and are therefore less evident than in any of the other images. Sky and vegetation are the dominant components of the rural image. Since this photo was taken near harvest time, yellow occupies a very high 25.5% of the viewed space.

In the image of the city park area, man-made materials once again occupy only a small fraction of the viewed space (16.4%), while the sky occupies roughly 50% and water about 20%. As a result, 67.6% of the city park image is blue. This is the highest percentage for blue in any of the five images.

In each of the basic images, the elevated freeway accounts for 10–15% of the viewed space, while the girder section where colors were colors were experimentally changed accounted for only 3–4% of each image's total space.

2) *Results of color simulation model ratings*

Table 1 shows th eigenvalues and factor loadings for each of the five land-use areas on the 10 rating scales.

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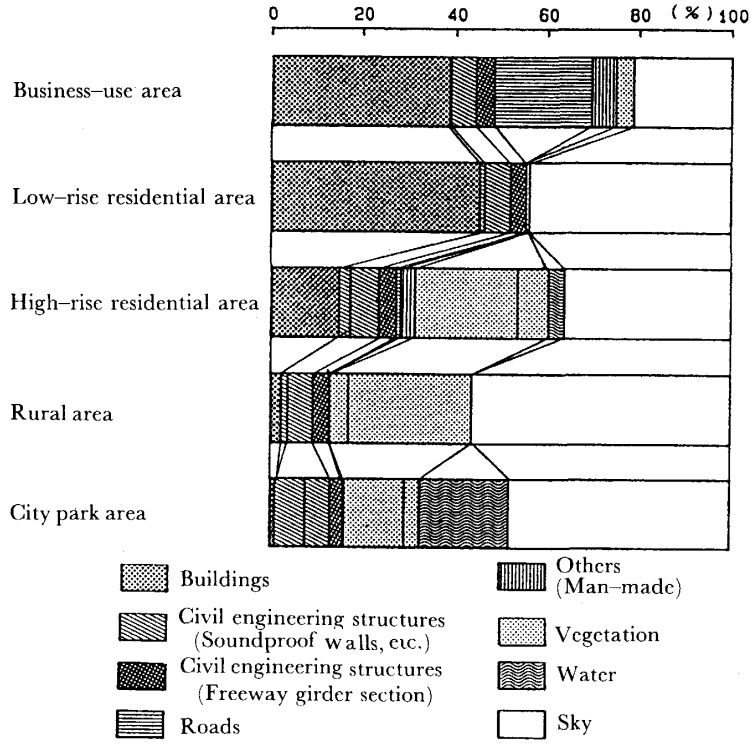

Fig. 1 Composition by material

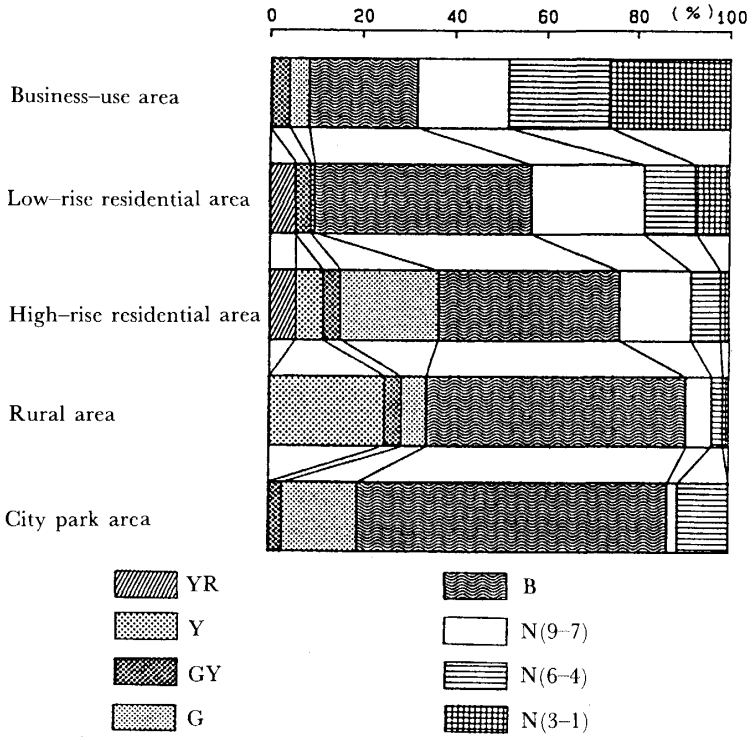

Fig. 2 Composition by color (hue)

Analysis of ratings for each land-use are showed that eigenvalues for all factors after the second factor were less than 1.0. Therefore, only the first and second factors were considered.

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Table 1 Eigenvalues and factor loadings

	Business-use area		Low-rise residential area		High-rise residential area		Rural area		City Park area	
	1st score	2nd score	1st score	2nd score	1st score	2nd score	1st score	2nd score	1st score	2nd score
Beautiful–Ugly	0.7595	0.1529	0.9560	0.1175	0.9170	0.1936	0.6112	−0.5586	0.9048	−0.0291
Orderly–Disorderly	0.9519	0.0837	0.9178	0.0576	0.9405	−0.1081	0.5409	−0.6575	0.8265	−0.1901
Open–Oppressive	0.7196	0.3817	0.6727	0.3884	0.7626	0.3373	0.4816	−0.6325	0.8010	−0.0472
Varied–Monotonous	−0.2495	0.9436	−0.3469	0.4279	−0.4380	0.8589	−0.2410	0.8832	−0.1685	0.9548
Gentle–Brutal	0.4040	0.6077	0.7107	0.6499	0.6432	0.6100	0.4711	−0.4728	0.8524	−0.1738
Lively–Lifeless	0.2502	0.8335	0.0018	0.9152	0.1962	0.9426	0.4381	−0.1165	0.5363	0.2325
Harmonious–Inharmonious	0.9263	−0.1207	0.8362	0.0304	0.9690	−0.1084	0.7681	−0.4123	0.9018	−0.1702
Relaxed–Agitated	0.8144	−0.4737	0.7975	−0.1570	0.9810	−0.1312	0.8244	−0.3916	0.8896	−0.2330
Sophisticated–Unsophisticated	0.9323	0.1306	0.9364	0.1091	0.8603	0.1994	0.7455	−0.2499	0.6626	−0.1512
Natural–Synthetic	0.4421	0.2059	0.8160	−0.0074	0.9507	0.1275	0.7657	−0.4494	0.9087	−0.1680
Eigenvalue	6.3997	2.4707	6.6558	2.1764	7.1771	2.2117	8.4932	0.7112	8.2417	1.0981

Looking at the factor loadings for the first factor, it is seen that the values for "beautiful," "harmonious," "relaxed," and "sophisticated" were above 0.7 in every land-use area. From this, it is determined that the first factor is "overall landscape evaluation." Factor loadings for the second factor show that values for "varied" and "lively" were also above 0.7 in every land-use area. The second factor was therefore called "landscape accect evaluation."

Figure 3 shows profiles of the first factor (e.g. overall landscape evaluation) sores for the color simulation models in each land-use area. Scores in the high pluses indicate a highly favorable overall landscape evaluation. Figure 4 shows profiles of the second factor scores. Scores in the high pluses indicate a highly favorable landscape accent evaluation.

Looking at the overall landscape evaluation of color simulation models in each land-sue area, it is seen that the N (monochromatic grey) model was rated highest in the business-use area. Overall, cool colors were preferred in the business-use area, followed by neutral colors and then warm colors. R (red) and YR-2 (brown) were rated especially low. In the low-rise residential area, the BG (blue-green) model received the highest rating. Cool colors were rated highest as a group, followed by neutral colors and then warm colors. The Y-1 (yellow) model was rated lowest. In the high-rise residential area, the

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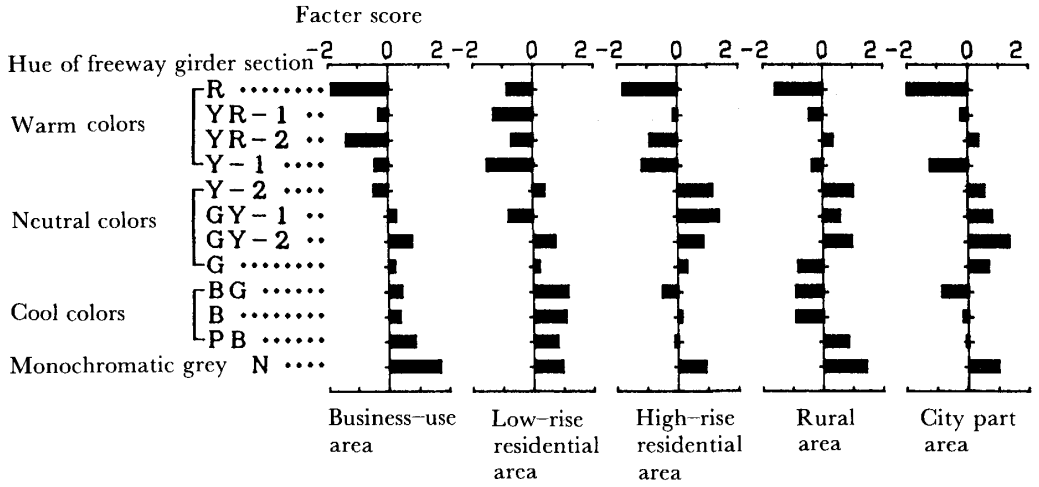

Fig. 3 Overall landscape evaluation

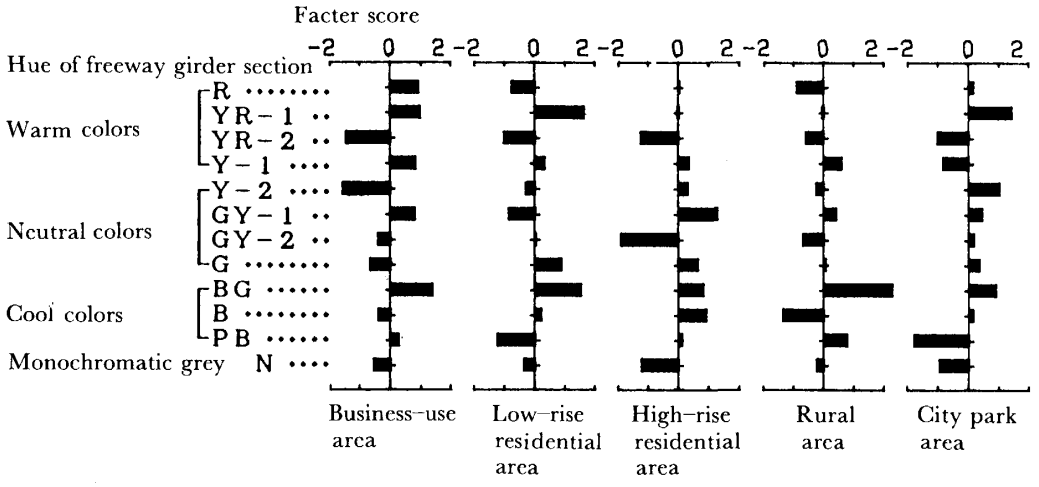

Fig. 4 Landscape accent evaluation

GY-1 (deep green-yellow) model received the highest rating. Neutral colors and N (monochromatic grey) were looked upon favorably, while cool colors were moderately popular, and warm colors were rated lowest. In the rural area, the N (monochromatic grey) model was rated highest. Neutral colors were generally popular, followed by warm colors and then cool colors. There were two eye-catching discrepancies in the rural area results : 1) the PB (indigo) model received a high rating despite the overall poor showing of cool colors, and 2) the R (red) model was rated very low despite the moderate popularity of warm colors. In the city park area, the GY-2 (pale green-yellow) model was rated highest. Other neutral colors were also well received, as was the N (monochromatic grey) model. Cool colors were somewhat less popular, while warm colors were rated lowest. As in other land-use areas, R (red) got the lowest rating of any single color.

Results of landscape accent evaluation differed from the overall landscape evaluation in that there were no visible trends according to the classification of warm, neutral, and cool color groups. Instead, pronounced characteristics were evident for each color model. The BG model was rated highest in the business-use area, while the R, YR-1, Y-1, and GY-1 model were also rated favorable. In the low-rise residential area, the YR-1 and BG models got the highest ratings, followed by the G model. In the high-rise residential area,

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the GY-1 model was rated highly, followed by the G, BG, and B models, all of which received moderately high ratings. In the rural area, the BG model got a far higher rating than any other, while the Y-2, GY-1, and PB models were all rated moderately high. In the city park area, the YR-1 model received a very high rating, which was followed by high rating for the Y-2 and BG models.

If the results for the overall landscape evaluation and the landscape accent evaluation are combined, it is still found that there are certain colors which contributed to the landscape characteristics of the models. For example, the BG and PB models in the business-use area ; the G, BG, and B models in low-rise residential area ; the Y-2, GY-1, G, and B models in high-rise residential area ; the GY-1 and PB models in the rural area ; and the Y-2, GY-1, GY-2, and G models in the city park area. Among these, there were some color models which improved both evaluations in a certain land-use area, such as the PB model in the business-use area, the BG model in the low-rise residential area, and the GY-1 model in the high-rise residential, rural, and city park areas.

Conclusion

According to the above analysis, the N (monochromatic grey) and GY-2 models were given the highest overall landscape evaluations accross the board. In contrast, these same models were given low landscape accent evaluations, which suggested that inconspicuous colors can be used on huge structures such as evaluated freeways to make them seem less oppressive. However, this may not be the way to improve the landscape quality of urban landscapes, which already tend to be monotonous in terms of color.

In land-use areas where man-made materials predominate, warm and neutral colors hardly appear as all, while monochromatic grey are common. The business-use area and low-rise residential area fit this description, and in these areas cool color models were given the highest overall landscape evaluations. On the other hand, according to landscape accent evaluations, the same cool color models received high ratings in these two land-use areas, especially the PB model in the business-use area and the BG model in the low-rise residential area. From this, it is concluded that monotonous landscapes dominated by monochromatic greys can be improved by painting elevated freeways in harmonious cool colors and contrasting them with their greyish surroundings by means of differing value (brightness). On the other hand, in settings with few man-made materials but great expanses of blue sky and water and green vegetation--namely high-rise residential, rural, and city park areas--neutral color models tended to be given the highest overall landscape evaluations. According to landscape accent evaluations, the GY-1 model was given a high rating in all three of these land-use areas. From this, it is concluded that landscape dominated by neutral colors can be improved by painting evaluated freeways the same basic hue as their surroundings. An attractive contrast can be achieved by means of differing chroma.

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