STUDY CONSERNING THE COLORS OF TACTILE BLOCKS FOR THE VISUALLY HANDICAPPED --VISIBILITY FOR THE VISUALLY HANDICAPPED AND SCENIC CONGRUENCE FOR THOSE WITH ORDINARY SIGHT AND VISION--

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ABSTRACT

Along with the deaf and those that are hard of hearing, blind and visually handicapped persons have difficulty receiving information. They depend on sound and the sense of touch as well as limited visual information; while walking, they use such senses for people and objects around them, combining this input with the other information available. In Japan, two patterns of blocks with bumps of about 5 mm are laid in sidewalks to indicate the existence of sidewalks and provide other information through touch via the soles of the feet. The lined pattern indicates the direction in which one can walk while the round pattern warns of the end of a sidewalk and the existence of a landmark like a bus stop. However, about 80% of the visually handicapped are those with partial sight and low vision who can recognize differences in shades as well as light and darkness to some degree. They walk by recognizing the contrast between tactile blocks and neighboring paved areas. This report intends to review tactile blocks in Japan and describe the study results concerning the contrast between tactile blocks and neighboring paved areas.

1. INTRODUCTION

1.1 The actual status of Japanese tactile blocks

In Japan, to assist the visually handicapped, tactile blocks as indicated in figure1 are laid in sidewalks. As is indicated by the historical events in Table 1, the move started in 1965 and in the 35 years since tactile blocks have been laid throughout the country. Tactile blocks spread in earnest after guidelines for laying tactile blocks for the visually handicapped were issued in 1984 （an Official Notice issued in August 1985 by the Road Bureau in Ministry of Construction）. The tactile blocks for the visually

Table 1 Major events in relation to tactile blocks for the visually handicapped

Seiichi Miyake	Invention of tactile blocks	1965
Ministry of Construction	Official notice concerning the construction of sidewalks and overpasses	1973
Ministry of Construction	Study concerning guide systems on roads for the visually handicapped	1974
Japanese National Railways	Reference materials concerning facilities and equipment with use by disabled passengers considered	1975
Ministry of Construction	Design guidelines for construction and reconstruction by governmental bodies with use by the disabled considered	1981
Ministry of Transport	Guidelines for development of facilities for the disabled at public transportation terminals	1982
Ministry of Construction	Guidelines and descriptions for laying tactile blocks for the disabled	1984

handicapped were invented in Japan and reviewed by ISO, and thus, use of the tactile blocks started to spread abroad as well.

According to the guidelines, the color of the tactile blocks should be yellow as a rule. However, designers felt that they were requested to abide by this rule when possible, and therefore, tactile blocks were not always yellow.

The color plays an important role in helping the judgment of the visually handicapped person that can respond to differences in shades as well as light and darkness. However, the visibility by color contrast was not properly considered to a degree, and when tactile blocks started to be prepared, scenic factors were mainly considered in development. For example, when interlocking block (ILB) pavement was developed, the same color was often adopted for tactile blocks and neighboring paved areas.

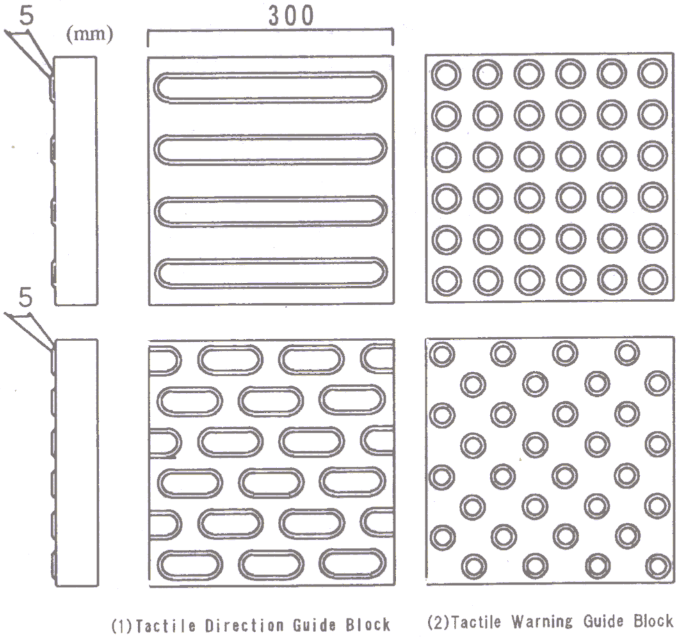

Figure 1 Patern of Tactile Block for Visual Hndicapped

Many other factors were also indicated "as a rule." For example, shapes of bumps were indicated just as examples, and therefore, blocks with bumps of various types were developed. Examples of interlocking blocks are indicated in figure 2.

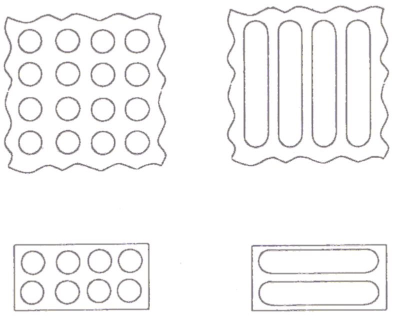

Figure 2 Example Patern of ILB Tactile Block

Some of the visually handicapped say, "The tactile blocks must be yellow." However, when the value (luminance) of the color of neighboring pavement is high -- yellow or white, for example-- yellow blocks are hard to recognize. It is therefore necessary to find an appropriate method for determining the color of blocks under such circumstances.

1.2 The actual status of the visually handicapped in Japan

The visually handicapped population in Japan totals about 300,000 people. Their handicaps are divided into six grades, from the first to the sixth. Those with severe handicaps and classified as first and second grades account for 56%. But even among those with first-grade handicaps, some have partial sight and low vision, recognizing light and colors to some degree. Those with partial sight and low vision account for 80%, while the rest are considered completely blind. In Japan, individuals over 65 years of age will account for one-third of the population in 2025, and together with the visually handicapped, it is highly possible that the number of those with visual impairments will increase. At present, the number of those losing their sight stands at between 10,000 and 15,000 people each year.

According to Yoshimoto1, information received through vision, auditory means, and through the sense of touch is respectively $1x10^6$ bit/sec, $1x10^4$ bit/sec, and $1x10^2$ bit/sec. This means that the amount of visual information is 100 times that of auditory information and 10,000 times that from the sense of touch. It is easy to understand how the visually handicapped have particular difficulties receiving information.

2. The status of the installation of tactile blocks

2.1 Patterns and colors

A study concerning the distribution of colors of tactile blocks and neighboring paved areas was conducted in 1994. For this study, 16 points in four areas within the Kanto region were selected, accounting for the frequency of use by the visually handicapped. ILB-type tactile blocks accounted for approximately 20% of the total. The types of pavement were asphalt pavement (approx. 60%), concrete plates (approx. 20%), ceramic tiles (approx. 10%), and resins (approx. 10%). Field evaluation concerning visibility for the visually handicapped was conducted at 28 points within these points.

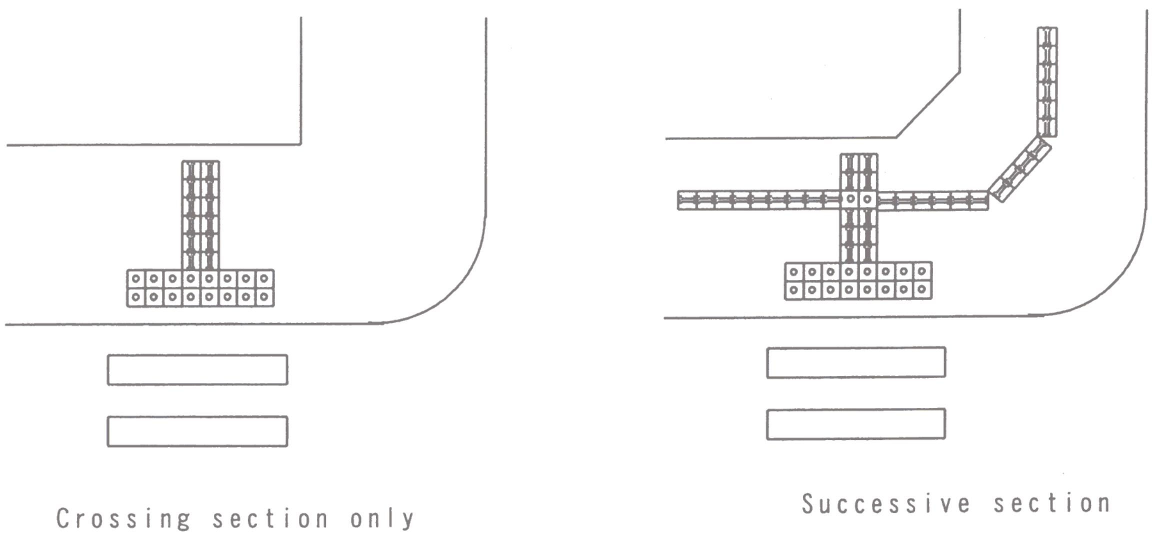

Figure 3 Tactile Block Installation Paterns

Before evaluation, the roads selected for the study were divided into two groups: crossing-section points primarily with warning blocks (where pedestrians enter a roadway from a sideway) and successive points primarily with leading blocks (a non-crossing single road). The proportions of areas with yellow blocks are indicated in Table 2. At the crossing section points, the proportion of non-yellow tactile blocks was 34.5%, higher than at the single road sections, where the proportion was 25.8%.

Table 2 Actual status of colors of tactile blocks and neighboring paved areas (28 points in the Kanto region)

tactile block color	Color of paved areas	Proportion of installment	
		Crossing section	Successive section
Yellow	Color with a similar shade	1.2	4.3
	Different color	64.3	69.9
	Subtotal	65.5	74.2
Non-yellow	Color with a similar shade	24.6	18.0
	Different color	9.9	7.8
	Subtotal	34.5	25.8
	Total	100	100

2.2 Colors used for tactile blocks

The colors of blocks used for the study are indicated in figure4. The colors for the paved portions were primarily gray (the color of concrete), dark gray (the color of asphalt), and reddish brown (colored pavement), while a few were greenish. The color for blocks was mainly yellow, but similar colors were frequently adopted for tactile blocks and paved areas, which accounted for about 20%.

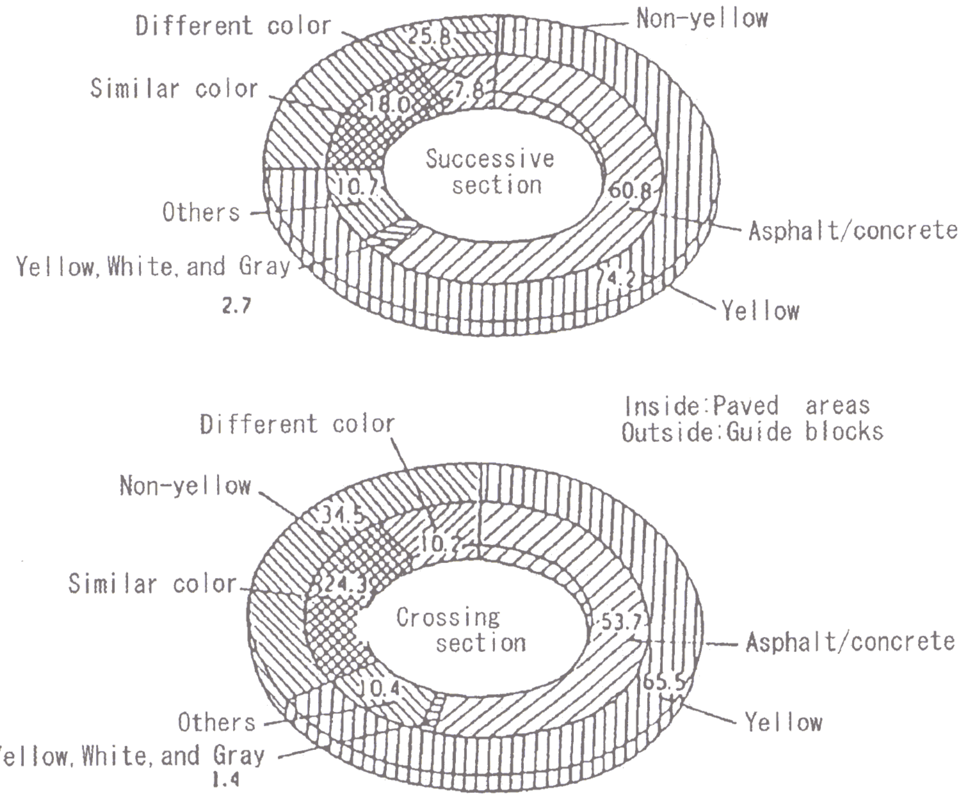

Figure 4 Examles of Colors used for Tactile Blocks (28points in Kanto Japan)

3. Visibility and incongruity of tactile blocks on actual sidewalks

3.1 Method to evaluate the contrast between tactile blocks and neighboring paved areas

As is indicated in figure5, a color is expressed with three dimensions: hue, value, and chroma. As indices to compare colors of tactile blocks and background paved areas, ratios of luminance, differences in the value (or ratios of the value), and differences in hue can be considered. According to our study, however, the ratios of luminance are most closely related to visibility for the visually handicapped. Therefore, the contrast in terms of ratios of luminance was used in this study to evaluate visibility for the visually handicapped.

The value of a luminance ratio is expressed as follows:

α = Luminance of tactile blocks Y1 / Luminance of background paved areas Y2

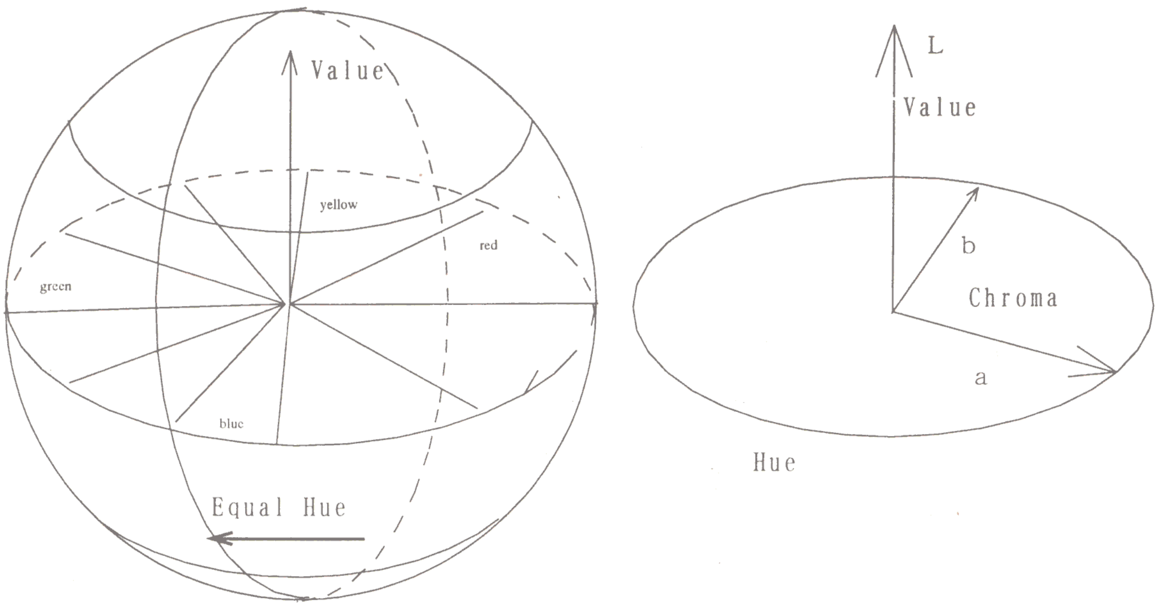

Figure 5 Factors for Color

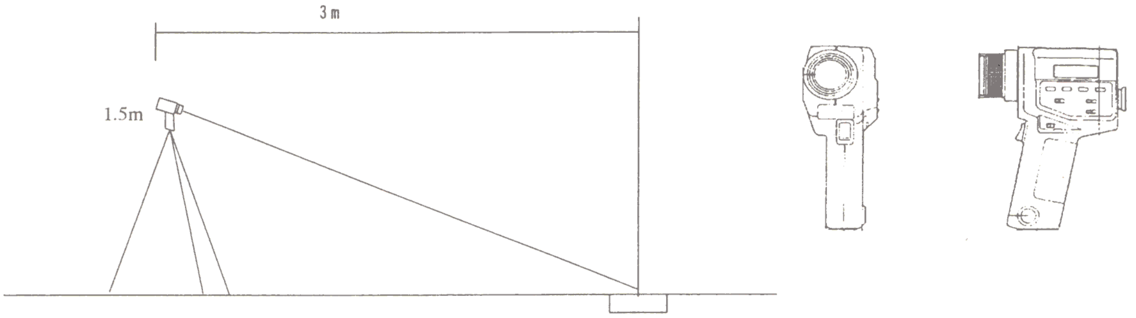

Figure 6 Method to measure luminance:Indirect Method with CS-100

When the value of colors is concerned, white is considered 100%. On the other hand, luminance is infinite, and therefore, is useful in evaluating luminous surfaces, light-reflecting surfaces, and how a road looks at night. There are two methods of measuring luminance: the contact method, in which luminance is measured under standard exposure conditions by the fixed distance from an object （a device in compliance with JIS Z8722, ISO7724/1, and DIN5033）, and the non-contact method （the color specification system for the CIE （International Commission on Illumination））. Ratios of luminance using these two methods are indicated in figure7. The non-contact method is useful from the standpoint of assisting the visually handicapped, for the method provides data for safety and, at the same time, is effective in measuring the status of road surfaces at night. Therefore, this method was adopted to evaluate the tactile blocks and a Minolta CS-100 was used. Measurement was conducted, as is shown in figure6: The luminance of the surface was measured, while the distance was fixed at 3 m and the device was tilted to the position of the eyes of a person with a height of approximately 1.5 m. The area where luminance was measured was an oval of approximately ϕ 80 × 180 mm.

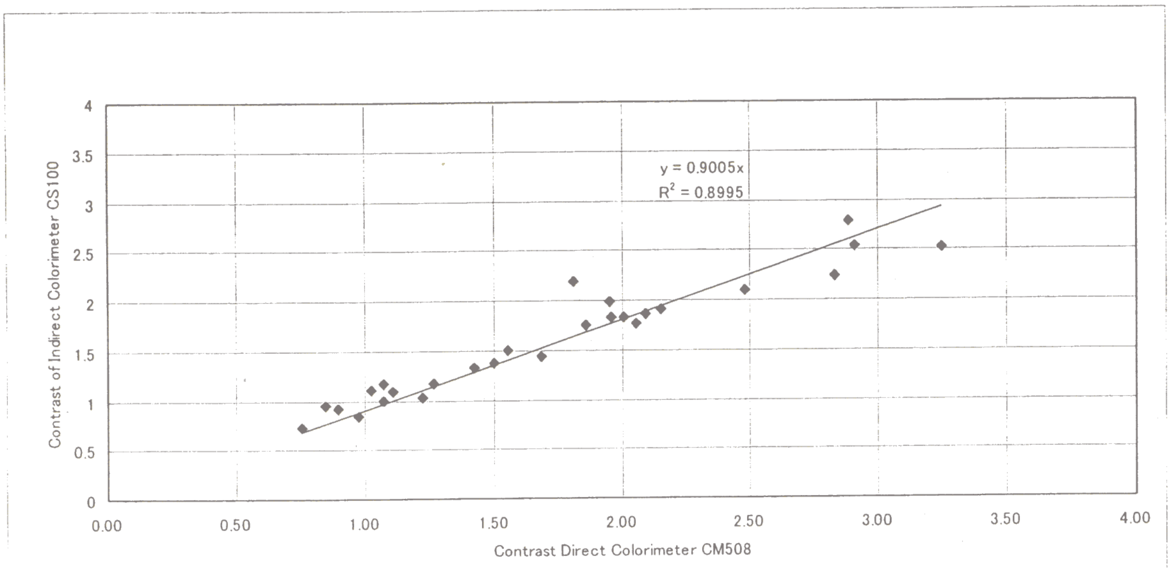

Figure 7 Contrast of Direct Colorimeter CM508 V.S. Indirect CS100

3.2 The values of luminance ratios between tactile blocks and neighboring paved areas

The distribution of the values of luminance ratios at the points examined in this study is indicated in figure8. When yellow （A） was combined with reddish brown （○） or black of asphalt concrete （□）, the values of luminance ratios range from 1.5 to 3. On the other hand, when yellow （A） was used with concrete surfaces, the values of ratios were smaller, failing to reach 1.5.

3.3 Visibility for the visually handicapped

A study was conducted to understand visibility for the visually handicapped when they actually see various tactile blocks on sidewalks. The study was conducted in the daytime from 10:00 AM to 4:00 PM for several days, excluding those with rain. The luminance on the spots selected for the study ranged from 8,000 to 32,000 lux.

There were four subjects: Three with first-grade and one with second-grade visual impairment. Each subject participated in the whole series of experiments. One of the subjects had difficulty distinguishing colors in addition to retinitis pigmentosa.

To evaluate the visibility of tactile blocks in outdoor conditions, the visually handicapped subjects stood on the blocks and evaluated whether the blocks were recognizable at first sight by selecting one of four levels: 1-Very easy to recognize, 2-Relatively easy to recognize, 3-Hard to recognize, and 4-Impossible to recognize.

The average point of the visibility evaluation （a 4-level evaluation） was considered to express visibility. The relationship between visibility and the values of luminance ratios is indicated in figure9. With the increase in the values of luminance ratios, the visibility increases. When the value exceeds 2, the visibility reaches the maximum point level, which means that all subjects evaluated the area as a level 4 （Very easy to understand）. However, according to the present study （figure8）, even when the tactile blocks were yellow, the values of luminance ratios sometimes failed to reach 2, depending on the combination. In other words, it is difficult in actuality to always ensure a value of 2. Therefore, when it is impossible, a visibility of 2.5 -- the intermediate value between level 3 （Recognizable after some time） and 2 （Recognizable if told） -- was determined to be the lowest necessary level for ensuring that the visually handicapped could recognize tactile blocks if observing

Color for tactile blocks	Color for paved areas
A : Yellow B : Gray C : Whitish gray D : Reddish gray E : Bluish gray	No mark : Light gray (Concrete) ○ : Reddish brown □ : Blackish gray (Asphalt concrete △ : Greenish

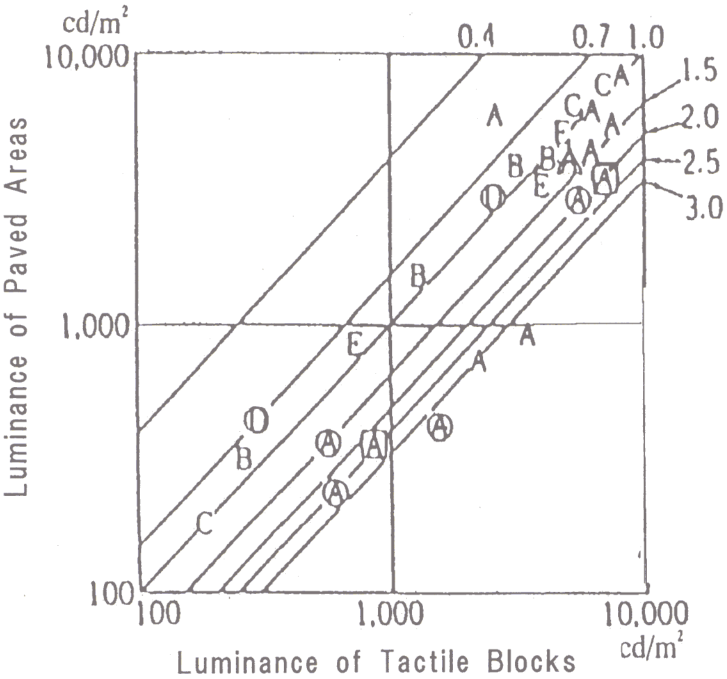

Figure 8 Luminance and Values of Luminance Ratios for Tactile Blocks and Background Paved Areas

(p1) and the visibility of 2.5 (y1) was found, and as a result, a luminance ratio of 1.5 (x1) was determined to be the minimum value of the luminance ratio that should be ensured.

3.4 Incongruity for those with ordinary sight and vision

3.4.1 Method of evaluation

It is a common view, particularly among designers, that sidewalk spaces with yellow tactile blocks are incongruous to those with ordinary sight and vision from a scenic standpoint. Therefore, a questionnaire was conducted where subjects answered what they felt when they were shown slides of scenery with tactile blocks. The subjects were 92 workers and students (39 males and 53 females) recognized to have ordinary sight, a regular visual field, and color vision. They saw the slides in a room for a certain period and evaluated incongruity of the scenery according to seven levels: -3 = Very incongruous, -2 = Congruous, -1 = A little incongruous, 0 = Can't say, +1 = Not so incongruous, +2 = Not incongruous, and +3 = Not incongruous at all. Then, the average figures were calculated. The 80 slides used in the experiment were based on the 25 on-the-spot pictures and developed by

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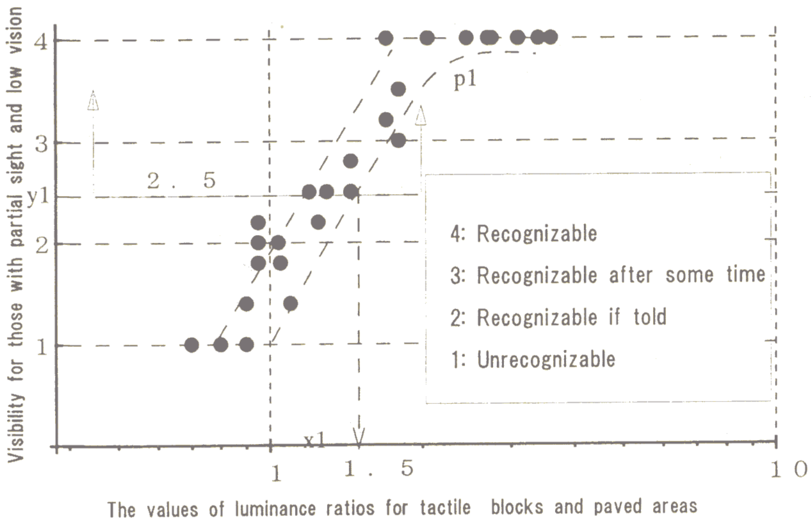

Figure 9 Relationship between the Visibility of Tactile Blocks for the Visually Handicaped and the Values of Luminance Ratios

other colors with computer graphics so that all of the colors in a hue circle might be included.

3.4.2 Results of the incongruity study

The relationship between the incongruity reported by the subjects with ordinary sight and vision (7-level evaluation) and the values of luminance ratios and hue differences is indicated in figure 10. As regards the relationship with the values of luminance ratios, the points gathered around a value of 1. Incongruity tended to increase with the increase in luminance ratios, but they were not strongly correlated. Rather, the incongruity felt by the subjects was considered to be dependent on other dimensions. When other indices were examined, it was found that there was a correlation between hue differences and incongruity, as indicated in figure11. With the decrease in hue differences, the sense of incongruity diminished.

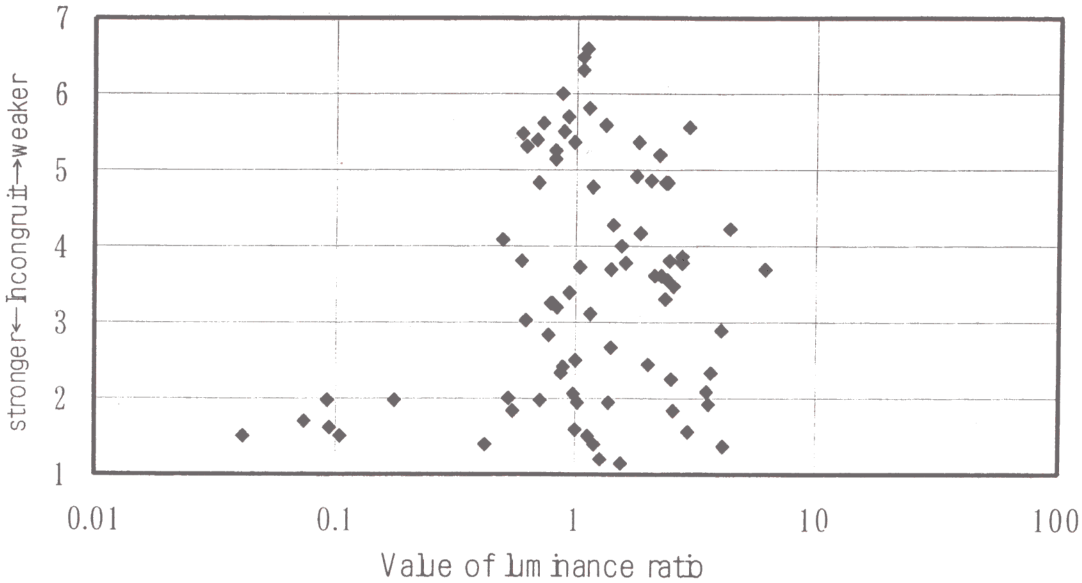

Figure 10 Incongruity for Those with Ordinary Sight and Vision and the Values of Luminance Ratios

General favoring of colors depending on individuals and the fact that the subjects were young should be also taken into account. However, from among value, chroma, and hue, hue was found to relate to the scenic congruence of sidewalks. The result that colors with small hue differences were felt to be less incongruous was taken to mean that combinations of similar colors would be favored. Even when colors are similar, they can be in contrast with each other. Namely, a color of the same hue can be changed vertically and horizontally in terms of chroma and value. Thus, the resulting variations fall under the same hue regardless of value and chroma and have no difference in terms of the hue. Yellow ranks high in terms of value and has a quality of attracting attention as well as white. Therefore, yellow tactile blocks are considered useful in attracting the attention of people around as well. Then, it is necessary to find a method to select the color of pavement after the color of tactile blocks has been determined. When the color of tactile blocks is determined to be yellow, a dark yellowish or reddish color is assumed to be favored as the color of pavement, for such colors are similar or close to yellow in terms of hue. It is, of course, possible to find other colors while maintaining the necessary value of the luminance ratio.

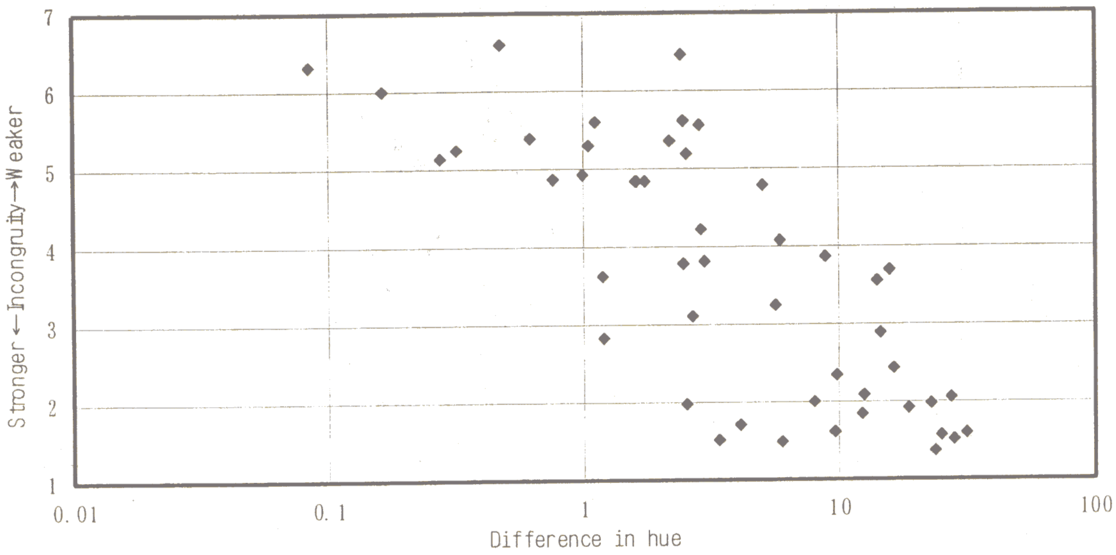

Figure 11 Incongruity for Those with Ordinary Sight and Vision and Differences in Hue

4. CONCLUSION

This report concerns tactile blocks for the visually handicapped that are laid in the center of sidewalks and include ILBs. The status of these blocks in Japan has been reviewed and a study concerning the relationship between the color of the tactile blocks, which is said to affect the scenic congruence for those with ordinary sight and vision, and visibility for the visually handicapped was conducted. Results indicate that the value of the luminance ratio should be over 1.5 or, even better, over 2.0. This result has been confirmed by other researchers that conducted experiments with larger number of subjects2.
Results of an experiment with subjects that have ordinary sight and vision indicated that, as the hue differences between tactile blocks and neighboring paved areas grow smaller, the scenic incongruity diminishes. Such combinations should be possible while maintaining the necessary contrast of luminance. Another result was that when cement concrete including ILBs was used for pavement, it was sometimes difficult to ensure a sufficient value for the luminance ratio, even with the yellow tactile blocks. In such cases, the necessary value of the luminance ratio could be obtained by making the color of the blocks darker. In concluding, the authors would like to express their sincere gratitude to Mr. Yoshihiko Sasagawa, vice-chairman of the Japan Federation of the Blind, who assisted throughout this study as one of the visually handicapped subjects by telling us the actual status and selecting the subjects. The authors are also deeply grateful to Mr. Hiroyuki Tada, director of the Road Management Technology Center, and Mr. Hiromi Yamashita, former director of Nippon Road, for indicating the appropriateness of this study during the initial stages3.

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