Development of Structural Color Material Contributing to Maintenance Management of Social Infrastructure and its Application in the Civil Engineering and Architecture Fields.

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ABSTRACT

*This project constitutes of the two independent themes related with the structural color materials. (I) The one is to develop the structural color materials detecting the aging degradation of building material as the change of color. (II) The other one is to develop the educational tool made it possible to visualize and colorize the sounds. At first, we found to reveal the change of color values of structural color in CIE-L*a*b* color space during the compression process of concrete specimens. Secondary, we demonstrate the visualization and colorization of Chladni patterns created by the structural color materials.*

1. INTRODUCTION

Structural colors are responsible for many of the brilliant colors we see in nature. The blue of the sky, the rainbow of colors in an oil slick, the bright colors of peacock feathers, the brilliant blue of a Blue Morpho butterfly, the metallic colors of certain beetles, and the glimmering colors of some fish, are all due to structural color. This project constitute of the two independent themes related with the structural color materials. (I) The one is to develop the structural color materials detecting the aging degradation of building material as the change of color. (II) The other one is to develop the educational tool made it possible to visualize and colorize the sounds.

I. Development of Structural Color Material Contributing to Maintenance Management of Social Infrastructure and its Application in the Civil Engineering and Architecture Fields.

I-1 Introduction

A fifty or more years has passed since the last Tokyo Olympics. Most of the social infrastructures built at that time are rapidly progressing their deterioration. It is very important issues in Japan to construct the maintenance systems for easily diagnosing the deterioration of social infrastructures. We focus on the point that the structural color materials exhibit the remarkably change of colors by the structural damage and distortion, which cause with applying a slight external stimulus such as pressure, temperature and vibration. In this study, we tried to develop the structural color paint to diagnose the aging deterioration of buildings as the change of color.

I-2. Experimental Section

The structural color pigments (SCP) were obtained from Toyo Aluminiums K. K., called “Chromashine”. The urethane was used as the main ingredient. The weight ratios of pigment and synthetic resin were 3:97. In this project, the two-type of concrete specimen were prepared; the type (A) is directly applying SCP/urethane resin on the concrete surface, the type (B) is applying the SPS/urethane resin on a first coat of retroreflective water-based paint. In compressing the concrete by the compression tester, the color change of concrete surface was taken by using 4 K video camera. Thus, obtained photographs was converted a color value in a color space RGB to a corresponding color value in a CIE L*a*b* color space which is not depend on a device.

I-3. Results and Discussion

As show in Figure 1, both of type (A) and (B) retain the brilliant metallic color despite of the roughness of concrete surface. However, the brightness in all type B were significantly improved comparing with those of type (A). In this article, we wish to report the analysis results of the concrete specimen coated with the golden pigment, which exhibits the largest change of color values.

Figure 1. Photographs of the concrete surfaces applying various Chromashine®, type A: left specimen, type B: right one, in the same color.

Figure 2 shows the typical photographs of concrete surface coated with the gold pigments: they were taken to the state before compression (a), and immediately before (b) and after (c) cracks in concrete. Unfortunately, both of type (A) and (B) show no the remarkably change of color during the compression process. In order to quantitatively discuss the color change, image analyses were carried out using Image J program. Figure 3 shows the histograms of color values (L*, a*, b*) on type (A) and (B) to the state of

(a), (b) and (c). Type (A) exhibits to kept the identical histograms during the whole compression process.

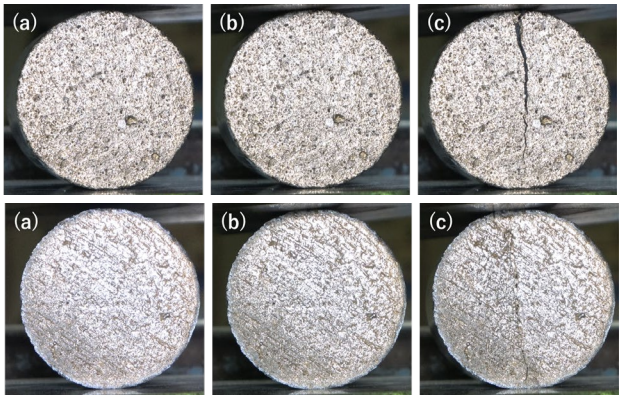

Figure 2. Photographs of concrete surface applying Chromashine® to the state of (a), (b) and (c), upper: type (A), lower: type(B) (See in text).

In contrast, type (B) was found to be changed the color values L*, a* and b* due to the compression. In particular, the chromaticity a* shifts toward the minus (green) direction, while the b* shifts to the plus (yellow) direction. This result obviously indicates to be changed the hue of type (B) by applying the compression. At this stage, however, we could not determine whether this change in hue cause to the signs of cracking or inclination of concrete specimen. Further investigations are in progress in our laboratory.

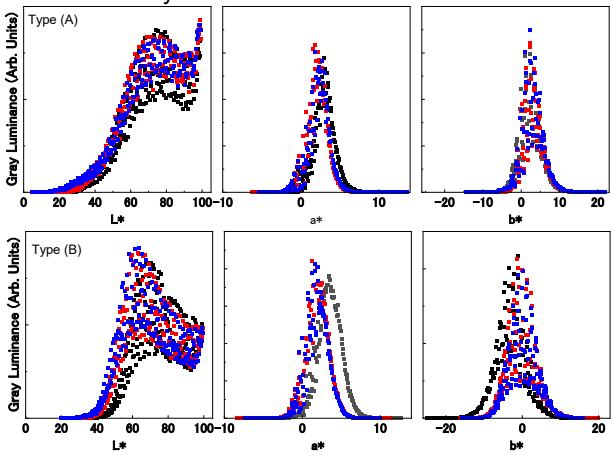

Figure 3. Histograms of color values (L*, a*, b*) on type (A) and (B) to the state of (a): ■, (b): ■ and (c): ■, (See in text).

II Development for Coloring of the Mysterious Geometric Pattern "Chladni Figure" Made by Sound with Using the Structural Color Materials

II-1. Introduction

Structural color is one of the interferences of light; it arises through the reflection of light from complex nanostructures found in the feathers of birds or the hard-outer shell of beetles. These multi-layered structures produce iridescence, whereby the color appears to change depending on the angle of view. In contrast, Chladni figures are one of the resonance phenomena of sounds; it reveals the various shapes or patterns characteristic of the vibrational mode of sounds.

If we can make Chladni figures colorized by using the structural color materials, it could be an extremely effective educational tool not only in experiencing scientific interest but also on understanding in both of the interference of light and the resonance of sounds for Japanese high school students. In this study, we wish to demonstrate the Chladni figures changing optical patterns according to the frequency of sound and the angle of view.

II-2. Experimental Section

Chromashine® and silicon oil (1.5 cp) were added to a square (20 x 20 mm^2) iron plate container with a thickness of 1 mm, vibrating by using a vibration generator equipped with a function generator. The weight ratios of Chromashine® and silicon oil were 1:20. Fig. 4 shows the experimental equipment in Col.lab Gallery.

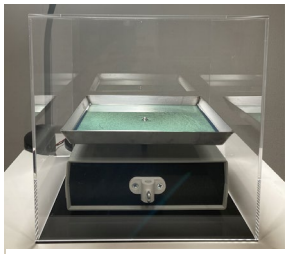

Figure 4. Experimental equipment for sound image (Chladni figure).

II-3. Result and Discussion

The Chladni figure strongly depends on not only the pigment type but also the material and size of the container, can only resonating at a specific frequency. When chromashine® of green was used, the most vibrant chladni figure was observed in all of pigments. As show in Fig. 5, we finally succeeded in finding the specific frequencies where reveal mysterious optical texture. We have put the works of sound image on display at 6th Exhibition at the Col.lab Gallery, so please have a look at them.

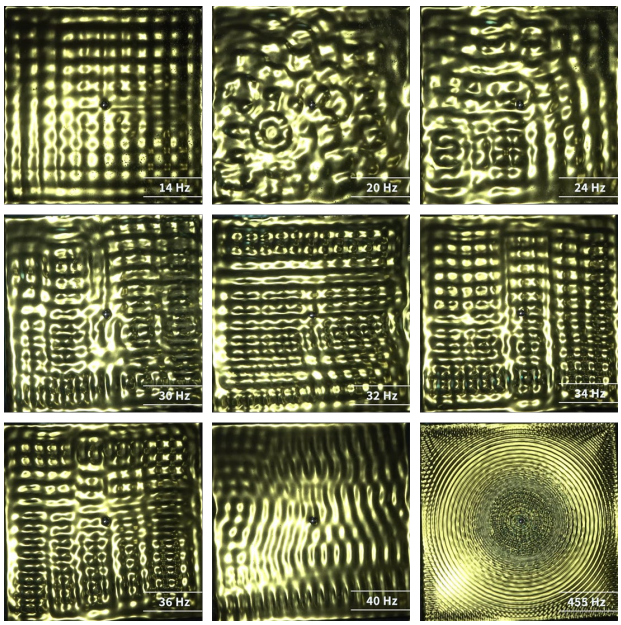

Figure 5. The optical textures in Chladni figures at the specific vibrational frequencies.