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

Toshihiro Hiejima, Hiroshi Jinnai, Tsuyoshi Moriyama, Rika Matsumoto, Mitsutoshi Okano, Noritoshi Nambu and Kazuyuki Hiraoka

Tokyo Polytechnic Univ., 1583 Iiyama, Atsugi, Kanagawa 243-0297, Japan

ABSTRACT

This project constitute of the two independent themes related with the structural color materials. (1) The one is to develop the structural color materials detecting the aging degradation of building material as the change of color. (2) The other one is to develop the educational tool made it possible to visualize and colorize the sounds. At first, we succeeded in directly applying a structural color pigment on the rough surface of concrete without primer coating. 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. (1) The one is to develop the structural color materials detecting the aging degradation of building material as the change of color. (2) 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.

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.

2. Experimental

The structural color pigments (SCP) were obtained from Toyo Aluminiums K. K., called “Chromashine”. The silicon, urethane and epoxy resins was used as the main ingredient. The weight ratios of pigment and synthetic resin were 1:10 and 1:20. In this project, the structural color paints were directly applied to the concrete surface without using additives or primers.

3. Results and Discussion

As show in Figure 1, all of pigment exhibit to retain the clear metallic color despite the roughness of concrete surface, and their color change depending on the view angle. Urethane and silicon resins could be successfully applied the pigment n the concrete surface, whereas the epoxy resin was repelled on the concrete surface, causing the color unevenness.

Figure 2 shows the typical reflectance spectra of SCP applied on the surface of concrete. The absorption bands were observed at the identical wavelength regardless of the differences of the resin. However, the maximum reflectivity strongly depends on the resins, increasing in order of urethane > silicon > epoxy resins.

Figure 1. Photographs of SCPs on the concrete surfaces, (A) Urethane and (B) Silicon resins.

In particular, it should be noted that the silicon resin retain the high transparency, indicating to be a candidate for the transparent dispersant in Section II.

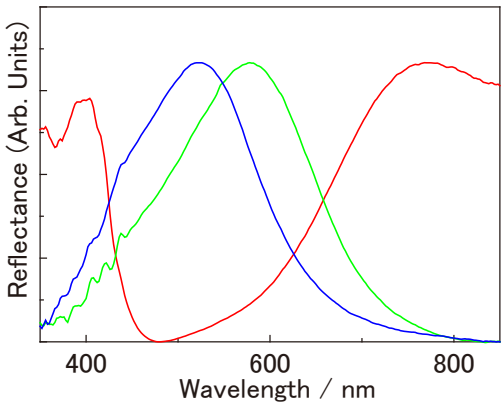

Fig. 2 Typical reflectance spectra of the SCP-urethane paint applying on the concrete surface.

Figure 3 shows the comparison of colors of SCP-urethane paints before and after destruction of concrete. Unfortunately, we could not observed the color change of pigments with generating the cracks on the concrete.

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

1. Introduction

Structural color is one of the interference 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, as shown in Figure 4.

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.

Figure 4. Chladni figures in the various frequencies [1].

2. Experimental

The sand art powder were obtained from Koeido Hobby Ltd. SCP was also used “Chromaschine®”. Silicon oil (350 cp) was used as the dispersion matrix for the SCP. The weight ratios of SCP and silicon oil were 1:20. Chladni figures were drawn on the iron plate equipped with the vibration generator and function generator.

3. Result and Discussion

As shown in Fig. 5, we succeeded in drawing the color-coded Chladni figures by using the difference of density of the sand art powder.

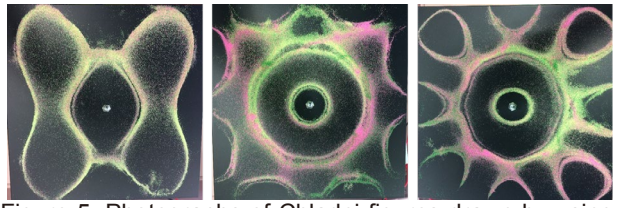

Figure 5. Photographs of Chladni figures drawn by using the sand art powders.

Applying the vibration to SCP dispersed in Silicon oil, we found to change the color tone of the optical texture with elevating the frequency, although it is not necessarily so clear (See Figure 6). In order to draw the clearer optical texture, it would be necessary to optimize the viscosity of silicone oil and concentration of SCP.

Figure 6. The variation of optical texture of SCP dispersed in Silicon oil as a function of the vibrational frequency.

4. REFERENCES

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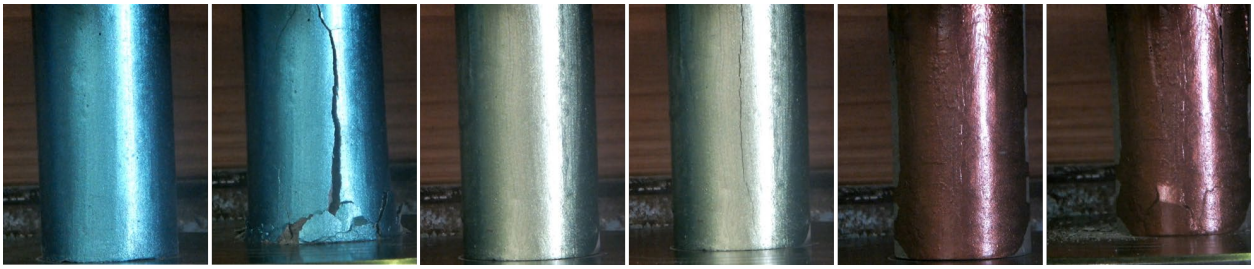

Figure 3. Comparison of colors in SCP-urethane paint before and after destruction of concrete.