Fundamental Study on Colored Concrete for Structural Building Members

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ABSTRACT

Focusing on the mortar portion, which determines the color of colored concrete, the author experimentally investigated color development and color changes over time. This investigation led to the following two conclusions. 1) It is possible to manufacture colored mortar with high compressive strength that can be used to construct high-rise RC buildings of 40 to 60 stories, and 2) the color of colored mortar changes as the result of drying after demolding, but the denser the structure of the mortar and the greater its compressive strength, the less pronounced the color change.

1. INTRODUCTION

Reinforced concrete buildings are often clad with tiles or the like as a cosmetic exterior material. However, accidents such as tiles coming off walls due to aging deterioration are far from infrequent. Therefore, the author decided to conduct research to develop technology for the construction of major structural members such as columns and beams of buildings using pigment colored concrete that does not require exterior cladding materials.

2. COLORED CONCRETE USED IN THIS STUDY

本Colored concrete is originally defined as a mixture of cement, pigment, coarse aggregate, fine aggregate, and water. However, depending on the type of experimental data that are desired, there are cases where the use of coarse aggregate and fine aggregate in the mix is not required for experiments. Thus, in this study, cured cements mixed with pigments are collectively referred to as colored concrete, and colored cement paste and colored mortar are treated as types of colored concrete.

3. EXPERIMENT 1

In Experiment 1, the compressive strength and color changes of mortar to which pigment was added were investigated. In all, four colors, namely pigment-free white, as well as pigmented blue, green, and yellow, were used. The dosage of pigment was that recommended by the manufacturer. The water-binder ratio (W/B: ratio of the mass of water to the mass of cement) of mortar was set to four levels: 0.2, 0.3, 0.4, and 0.5.

Mixing was carried out in a room with temperature of 20 ±3℃. Next, the specimens for the compressive strength test underwent sealed curing in a curing room at 20℃, and the specimens for color measurement were stored in a

Photo1 Colored Concrete (Colored Cement paste)

Photo2 University logo mark made from colored concrete (Colored mortar)

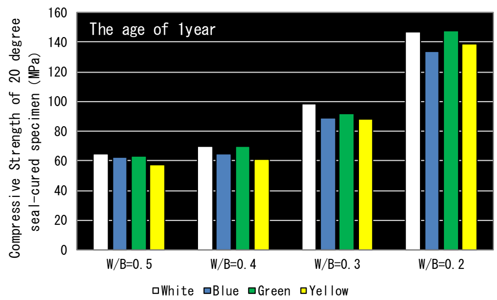

Fig. 1 Compressive test results of Colored concrete (Colored mortar)

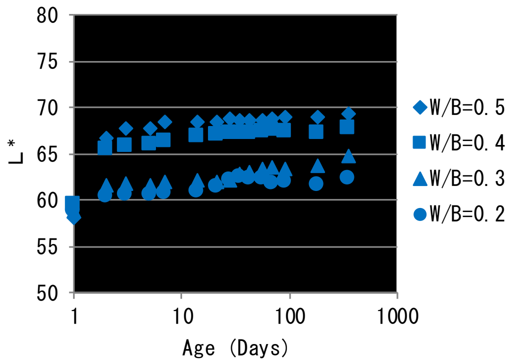

Fig. 2 Example of color changes over time (Blue specimen: L* value)

curing chamber at the temperature of 20℃ and humidity of 60%.

The results of the compressive strength test of colored mortars at the age of 1 year as shown in Fig. 1. While the colored mortars to which pigment was added had slightly lower strength than basic white mortar, compression strength of about 140 MPa was achieved. This level of strength is sufficient for the construction of high-rise RC buildings of 40 to 60 stories.

As an example of the measurement of color changes over time, Fig. 2 shows the L* value measurement results for the blue specimen. In the L*a*b* color space, the L* value represents the lightness of the color, with 0 indicating black and 100 indicating white. In L*a*b* measurement, the color immediately after demolding was almost the same regardless of the water-binder ratio for any of the specimens. On the other hand, as time passed after demolding, the color changed due to drying, and in specimens with large water-binder ratio, which are more prone to drying, the increase in L* value was remarkable.

4. EXPERIMENT 2

In Experiment 2, the influence of the amount of pigment used was investigated. Three dosages of additive were used, using the manufacturer recommended dosage as the base. Two water-binder ratios, 0.2 and 0.5, were adopted for each mortar.

The experiment parameters are shown in Fig. 3. The pigment dosages were the manufacturer recommended dosage, one half of that dosage, and one quarter of that dosage. Photos 3 and 4 show pictures showing the actual test specimen placed in the same positions as in Fig. 3. Photo 3 was taken immediately after demolding 1 day after pouring, i.e. at the material age of 1 day. Photo 4 was taken after six months of storage in a curing chamber at the temperature of 20℃ and humidity of 60%.

As long as the base mortar is white, mortar of a beautiful color can be achieved even when reducing the pigment dosage to about one-fourth of the manufacturer recommended value. Further, looking at the 1/4 pigment blue specimens indicated by the red arrows, we can see that the color of the specimens with W/B of 0.5 is darker than that of the specimens with W/B of 0.2 at the age of 1 day. However, as the specimen with W/B of 0.5, which is more prone to water loss, dries as the days pass, its color depth becomes lesser than that of the specimen with W/B of 0.2. These results show that the results obtained in Experiment 1 are reproducible.

5. CONCLUSIONS

1) It is possible to manufacture colored mortar with high compressive strength that can be used to construct high-rise RC buildings of 40 to 60 stories.
2) The color of colored mortar changes as the result of drying after demolding, but this tendency is less pronounced the denser the structure of the mortar and the greater its compressive strength.

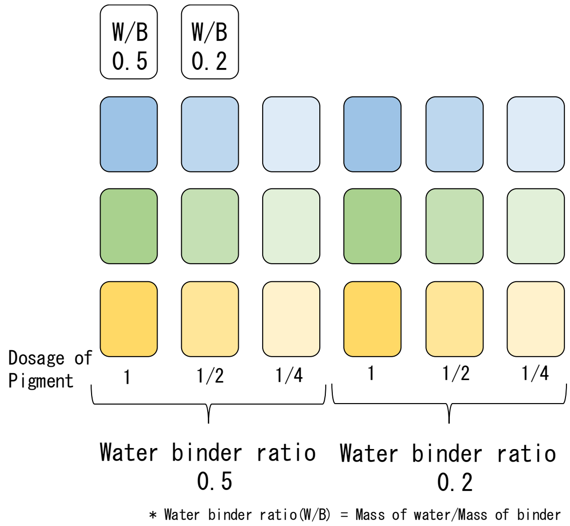

Fig.3 Parameter of experiment

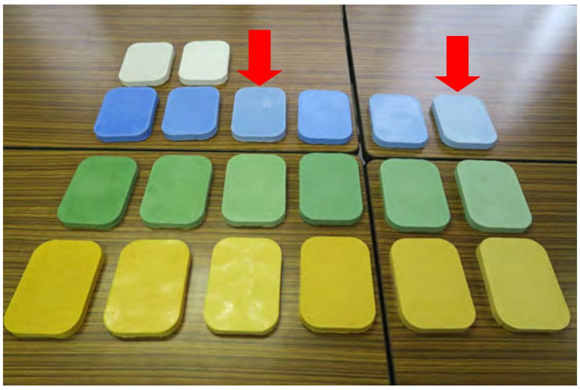

Photo3 Colors of specimens at the age of 1day
(Comparing the colors of the specimens with 1/4 of the manufacturer recommended pigment dosage, which are indicated by the red arrows, the specimens with W/B of 0.5 are darker in color than the specimens with W/B of 0.2.)

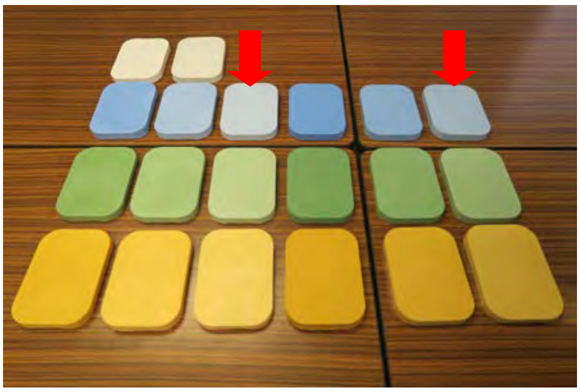

Photo4 Colors of specimens at the age of 6 months
(Comparing the colors of the specimens with 1/4 of the manufacturer recommended pigment dosage, which are indicated by the red arrows, the specimens with W/B of 0.5 become lighter in color than the specimens with W/B of 0.2 over time)