

# **LONG-TERM CARBONATION PERFORMANCE OF THE CONCRETE COVERED WITH THE ELASTIC PAINT WITH HEAT DETERIORATION**

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## **ABSTRACT**

This paper is considering the influence which the elastic paint (a modified silicone resin emulsion paint, made in Japan) coated on the surface of concrete has on a long-term carbonation of concrete, and long age strength. The paint of the outside of concrete mainly deteriorates with solar heat at a long period of time.

First, elastic film of coating carried out heat deterioration, and attached this to the surface of a concrete specimens, next exposed the concrete specimens into the acceleration carbonation atmosphere. The conditions of acceleration carbonation are conditions of the temperature of 20°C, 60% of humidity, and 5% of carbon dioxide levels. In order to abolish batch differences, ready mixed concrete was used for test concrete. The water cement ratio is 0.55, the slump is 18 cm, and the aggregate maximum size is 20 mm. The 28-day strength of concrete is 24 MPa. Ordinary cement was used. The experiment examined the three kinds of heat deterioration conditions of elastic paints. It was with no heat deterioration, ten weeks about 23°C, and ten weeks about 80°C. The exam time of promotion carbonation went for a maximum of two years.

**Keywords:** Carbonation, concrete, elastic paint, ordinary cement.

## INTRODUCTION

This research examines the influence of thermal degradation of elastic paint on carbonation of concrete. First, the paint film was subjected thermal deterioration, then it was attached to the surface of concrete specimens, and the concrete specimens exposed to an atmosphere producing accelerated carbonation.

The conditions for accelerated carbonation are a temperature of 20 °C, 60% relative humidity, and 5% carbon dioxide in the air. The experiment examined three kind of the heat deterioration conditions. : 1) No thermal deterioration, 2) 23 °C for 10 weeks, 3) 80°C for 10 weeks.

The exposure time for carbonation went for a maximum of two years (114 weeks). Based on the extent of the carbonation in the concrete, the elastic paint was able to mitigate carbonation even after these deterioration at 80 °C.

## EXPERIMENTAL PROCEDURE

### Outline of Carbonation Test

**Table 1** shows the experimental plan. No.1 is the control with no cover concrete. No. 2 and No. 3 are the test concretes covered with the paint film. The coating of No. 2 was cured for 10 weeks at 23 °C. The coating of No. 3 was exposed heat deterioration for 10 weeks at 80 °C. The examination compared the carbonation depth in concrete specimens. The size of the concrete specimens was 150x150x150 mm. Depth of carbonation was measured of the following times after exposure to CO<sub>2</sub>. : 4 weeks, 8 weeks, 13 weeks ( 3 months), 26 weeks ( 6 months), 66 weeks ( 1 year and 3 months), and 114 weeks ( 2 years). A commercial modified silicon emulsion paint was used (40% of paint, 22% of a synthetic resin). The normal application rate for paint is 1100 g/m<sup>2</sup>. This results on a theoretical film thickness 786 um (micro meters).

**Photo 1** shows the state of application of the paint film to the concrete specimen. The adhesive is only around the concrete test body, and the middle is not bonded.

**Figure 1** shows the splitting position of the concrete specimens.

### Concrete Test Specimens for Carbonation Test

Test specimens were 150-mm cubes. Removal of a concrete specimens is the next day,

followed by 3 weeks of air-drying (20 °C and 60 %RH) after the underwater curing for six days. In order to abolish batch differences, ready mixed concrete was used for test concrete. The water cement ratio is 0.55, the slump is 18 cm, and the aggregate maximum size is 20 mm. The 28-day strength of concrete is 24 MPa. Ordinary cement was used. The mixture proportions and characteristics of fresh concrete are summarized in **Table 3** and **Table 4**.

### Outline of Compressive Strength Test

Outline was shown in **Table 2** and **Photo 2**. No.1 was no covering, No.2 was covering with elastic paint and No.3 are seals of all surface. Curing conditions are 20°C of 60 % humidity.

Table 1. Test Planning for carbonation test

No	Coating	Heat deterioration	Specimens
1	None	-	3 pieces×6 period
2	Done	Normal temperature (23°C ) / 10weeks	3 pieces×6 period
3	Done	Heat deterioration (80°C ) / 10weeks	3 pieces×6 period

Table 2. Test Planning for compressive strength test

No	Coating	Removable of mold	Curing condition
1	None	Removable for 2 ages	23°C 60%
2	Covering with elastic paint	With elastic paint	23°C 60%
3	Seal of all surface	Inside of mold	23°C 60%



Photo 1. Film-of-coating attachment



No.1

No.2

No.3

Photo 2. Compressive strength test specimens

Table 3. Mixture proportion (kg/m<sup>3</sup>)

W/C	Cement	Water	Sand 1	Sand 2	Gravel	Admixture
55%	314	171	342	504	963	3.14

Table 4. Characteristic of fresh concrete

Slump (cm)	Air (%)	Temperature of fresh concrete (°C)
18.0	5.4	27

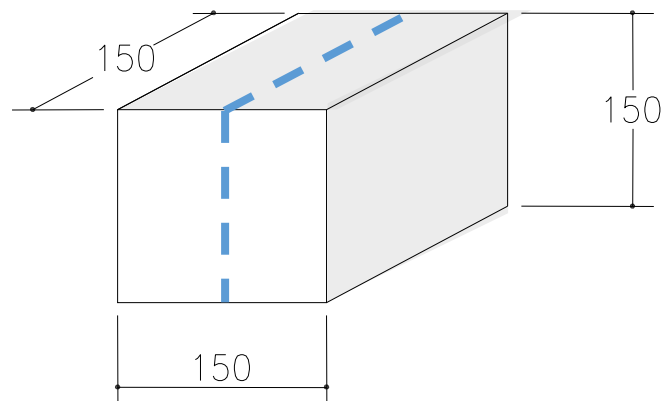


Figure 1. Carbonation depth measuring plane

### Promotion Degradation Method of Paint for Carbonation Test

Because the paint is exposed to the outdoors, the coating is damaged with heat. In the experiment, the coating was heat deterioration. The paint was applicate at rate of 1100

g/m<sup>2</sup> on the plastic plate. The paint was dry for one week. Then, the No. 2 paint for 10 weeks was stored at 23°C and No.3 paint was stored at 80°C. The paint which carried out heat deterioration was cut into a 150-mm angle, it used the epoxy resin for the end of the both sides of a concrete test piece, pasted up, and was covered.

### **Accelerated Carbonation Test Method**

The acceleration neutralization test method followed the measuring method of the neutralization depth of the concrete of JIS A 1153. The carbonation depth was measured using phenolphthalein liquid (1% concentration) for the split face. In addition, the carbonation conditions were a temperature of 20°C, 60 % relative humidity, and 5% carbon dioxide levels.

## **EXPERIMENTAL RESULTS AND DISCUSSION**

### **Carbonation Test Results**

The depth of carbonation at 114 weeks (2 years) is shown in the **Figure 2**. The progression of carbonation with time is shown in **Figure 3**.

### **Carbonation Depth of No-Thermal Deterioration & 23-Degree Centigrade for 10 Weeks**

The carbonation depth of No.1 concrete without paint was 21.2 mm in 26 weeks. Moreover, No.1 showed a 40.0-mm depth carbonation in 114 weeks (2 years). On the other hand, the carbonation depth of No.2 was 0.5 mm in 26 weeks, and was 0.4 mm in 114 weeks. To the result of having passed 114 weeks, the concrete which stuck the coat which continued normal temperature had the small carbonation depth, and the carbonation control effect was seen.

### **Carbonation Depth of 80-Degree Centigrade for 10 Weeks**

The carbonation depth of No.3 which carried out heat deterioration of the paint at 80°C was 0.4 mm in 26 weeks, and was 0.6 mm in 114 weeks. This result was in the same situation as No.2, and was the result of seeing the carbonation control effect, even if 114 weeks pass.

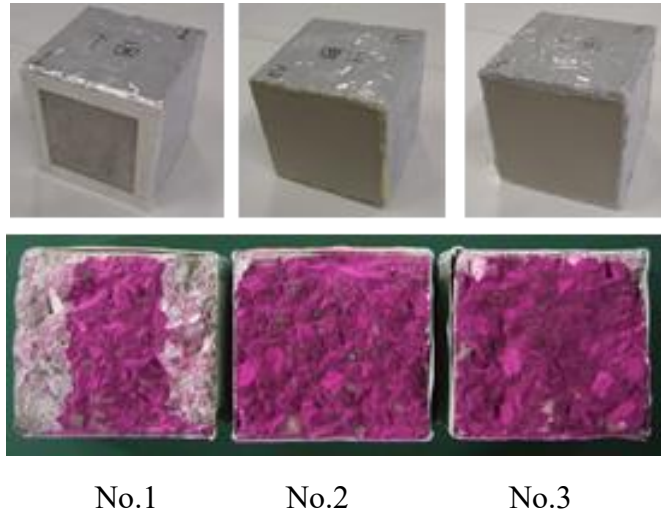


Figure 2. Accelerated carbonation test result, 114 weeks

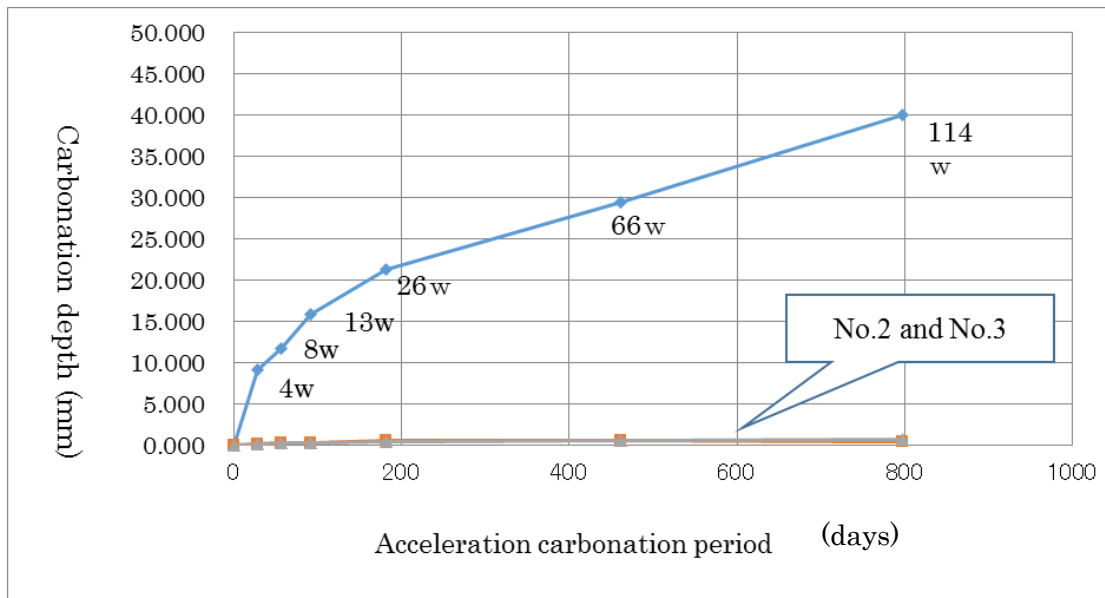


Figure 3. Accelerated carbonation depth

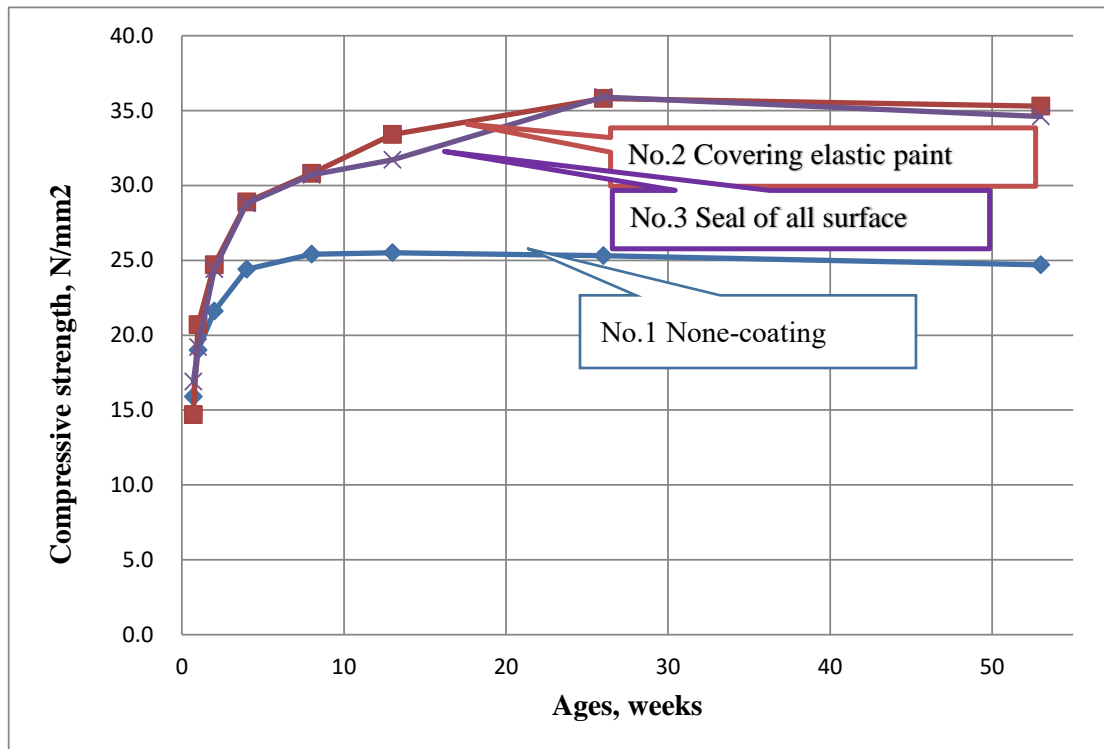


Figure 4. Compressive strength test

### Compressive Strength Test

The result of compressive strength test was shown in **Fig. 4**.

The specimens which carried out the covering of the elastic paint (No.2) was same strong as the specimens of seal of all surface (No.3). The reason why the compressive strength of the uncoated concrete is lower than that of the coated concrete is the usual aerial curing with the curing condition of 20 ° C. and 60% humidity, so it is conceivable that concrete dried and curing differed.

### CONCLUSIONS

A conclusion is the following as a result of this test.

The examined elastic paint (modified silicon resin emulsion paint) had the excellent carbonation control effect.

Compressive strength of concrete specimens coated with paint is higher than that of no coating.

## REFERENCES

Masashi SUGIYAMA, et al. Fundamental study on durability improvement of the housing base concrete, Part 1~16, Proceeding of Architecture Institute of Japan, 2010-2018.

Jinzhi Tang, Jin Wu, Zhenghao Zou, Anyi Yue, Andrea Mueller, Influence of axial loading and carbonation age on the carbonation resistance of recycled aggregate concrete, *Construction and Building Materials*, Volume 173, 10 June 2018, Pages 707-717

Jian Wang, Han Su, Jinsheng Du, Influence of coupled effects between flexural tensile stress and carbonation time on the carbonation depth of concrete, *Construction and Building Materials*, Volume 190, 30 November 2018, Pages 439-451