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THE STUDY ON THE PROPERTIES OF Ca CONCRETE UNDER NATURAL ENVIRONMENT

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The Ca-based solidification material has neutrality so that it would be expected to be new material to reduce environmental load instead of cement in the construction field. The concrete using this material, which is Ca concrete, is useful for construction material from past research. In previous researches, we showed that the compressive strength of Ca concrete and the compressive strength of AE concrete, which contains the entrained air, had nearly equal strength under same mixture condition, and the behavior under compression loading of Ca concrete showed a tendency similar to cement concrete. Also, the compressive strength of Ca concrete obtained the stable strength when it had the curing for four weeks. Therefore, Ca concrete would be used in the same way as cement concrete for construction field. This study investigates to consider further properties of Ca concrete. Particularly, it is paid attention to the water absorbability, water retentivity, and the compressive strength under natural environment. As a result, it is clear that the Ca concrete has the higher water absorbability and the water retentivity as compared with cement concrete and the compressive strength of Ca concrete under natural exposure does not decrease even if the length of natural exposure passes for 104 weeks. Hence, the Ca concrete would apply to construction material under natural environment as one of the measures against urban heat island phenomenon.

Keywords: Exposure test, Weight ratio, Water absorbability, Water retentivity, Compressive strength.

1 INTRODUCTION

The cement concrete has some problems. For example, the cement may have the harmful effect on nature environment because the cement is alkaline, and the disposal of concrete is difficult if the concrete is discarded at the field of construction work. Also, the cement concrete may be one of the factors to urban heat island phenomenon in the urban region using many concrete structures because the cement concrete stores the heat without absorbing water such as rain. Hence, this study pays attention to the calcium-based solidification material to consider the construction material for environment loading reduction instead of cement. In our previous researches, we made the concrete using this solidification material and defined it as Ca concrete. Then, we performed some experiments to investigate the properties of this concrete. As the experimental results, we showed that the compressive strength of Ca concrete and the compressive strength of AE concrete had nearly equal strength under same mixture condition and the behavior under compression loading of Ca concrete showed a tendency similar to cement concrete (Shimabukuro and Hashimoto 2009). Besides, the compressive strength of Ca concrete obtained the stable strength when it had the curing for four weeks (Shimabukuro and Hashimoto 2013). Thus, we consider that Ca concrete would be effective material on strength as a new civil engineering material. However, we consider that the further investigations of properties of Ca concrete under natural environment are required to apply Ca concrete as the construction material because above effects are experimental results in laboratory tests. Therefore, the purpose of this study is to investigate the properties of Ca concrete under natural environment condition. Particularly, it is paid attention to the water absorbability, water retentivity, and the compressive strength under natural environment for Ca concrete.

2 CALCIUM BASED SOLIDIFICATION MATERIAL

The calcium based solidification material (Japan Conservation Engineers Co., Ltd. 2002) has the brown color like natural soil and is composed of the mineral component. The main purpose to use this material is the application to recreation trail and grass proofing at the slope. The following shows the typical characteristics examples of this material.

(1) The pH at the time of the spraying is near-neutral.

(2) This material has water absorbability and water retentivity.

Thus, the calcium-based solidification material is an attractive material for the environment instead of cement. Also, we consider that this material would be one of the effective measures against urban heat island phenomenon.

3 EXPERIMENTAL OVERVIEW

3.1 Mixture Design

In this study, we carried out the two mixture designs of cement concrete and Ca concrete. We designed the water-cement ratio of cement concrete and the water-binder ratio of Ca concrete as 60%. The coarse aggregate used crushed stone and the fine aggregate used sea sand of which the fineness ratio was 2.70. Each density of coarse aggregate and fine aggregate was 2.67 g/cm^3 and 2.60 g/cm^3. We designed the unit water as 165 kg. Here, Table 1 shows the required quantity of the above materials of cement concrete and Ca concrete in this study. We carried out the underwater curing for four weeks for the concrete specimens made from this mixture design and then carried out the following the exposure test.

Table 1. Mix proportion quantity of Ca concrete and cement concrete (unit: kg/m^3).

	Water	**Binder**	**Sand**	**Gravel**
Ca Concrete	165	275	810	996
Cement Concrete	165	275	814	1001

3.2 Exposure Test

We defined the investigations of the both specimens put in these two places as the exposure test regarding the weight change and the compressive strength. We placed the both specimens there to measure the weight change for about 20 weeks. Also, we located the both specimens there to investigate the compressive strength for about 104 weeks. Here, Figure 3 shows the average temperature and rainfall in this region during this test, which was given from the

Automated Meteorological Data Acquisition System (AMeDAS) of the Japan Meteorological Agency.

We place the Ca concrete specimens in two natural places to observe the behavior of Ca concrete under natural condition. We also located the cement concrete specimens in the same place to compare and investigate experimental results of Ca concrete and cement concrete. Figure 1 and Figure 2 show the situation putting in each concrete, respectively. The Place A shown in Figure 1 was high humidity due to shaded place all the day. Thereby, many liverworts existed in the Place A. On the other hand, the humidity in the Place B shown in Figure 2 was not so high because of more sunshine than Place A.

Figure 1. The exposure test in the Place A.

Figure 2. The exposure test in the Place B.

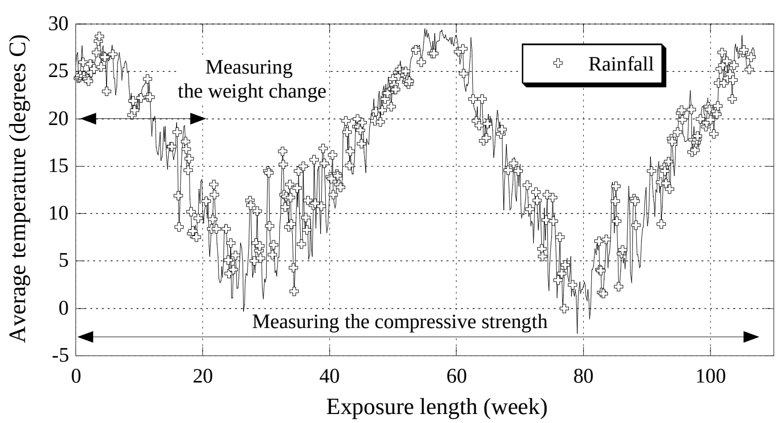

Figure 3. Weather condition during measuring.

3.3 Compressive Strength Test

We carried out the compressive strength test for the both concrete specimens with exposure length of 13 weeks, 26 weeks, and 104 weeks after the underwater curing for four weeks. The compressive loading method for this test applied the displacement control. The velocity of displacement was $0.5*10^{-2}$ mm/sec. We kept the compressive loading until the specimens were completely fractured. We calculated the compressive strength from the maximum load.

4 EXPERIMENTAL RESULT AND CONSIDERATION

4.1 The Property of the Weight Change from Exposure Test Result

We estimate the properties of the weight change from the weight ratio calculated by Eq. (1).

$$W_R = \frac{W_M}{W_F} \tag{1}$$

Here, W_R: the weight ratio; W_M: the weight of the measurement day; W_F: the first weight when the specimen was placed in the Place A and the Place B.

Figure 4 and Figure 5 show the relationship between the weight ratio and exposure length in two places for the both concrete specimens, respectively. The considerations in two places are as follows.

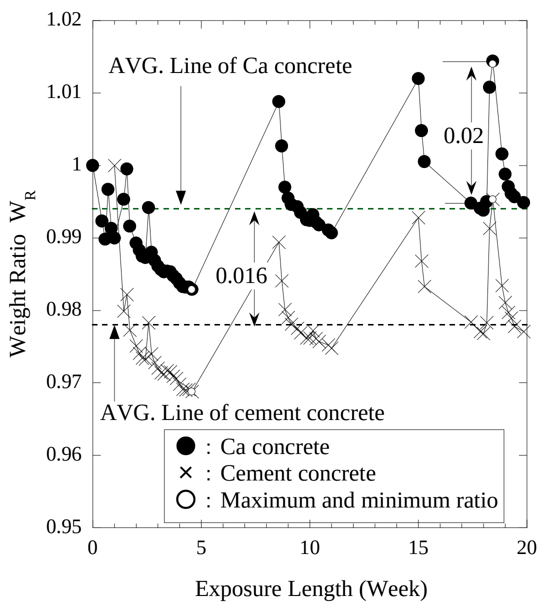

Figure 4. The relationship between the weight ratio and exposure length at the Place A.

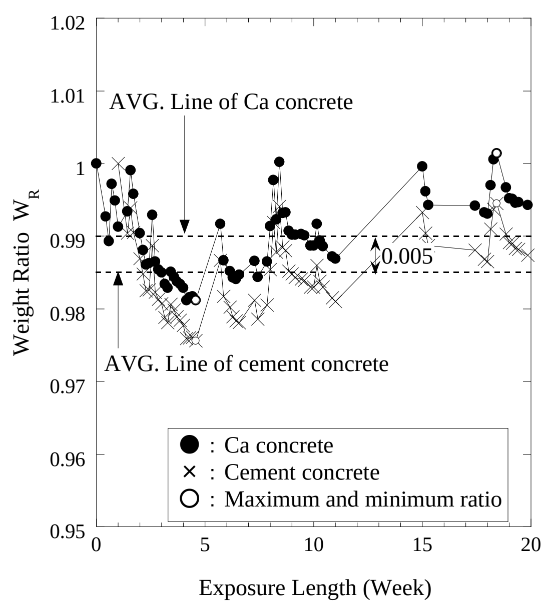

Figure 5. The relationship between the weight ratio and exposure length at the Place B.

Figure 4 shows the relationship between the weight ratio and exposure length at Place A. In this figure, the weight ratio of Ca concrete shows 1.0 or more, but the weight ratio of cement concrete shows less than 1.0. It shows that the weight of Ca concrete became more the weight than the first weight by absorbing water. Also, the maximum weight ratio of the Ca concrete is greater than the cement concrete, and the difference of the weight ratio between the both specimens is about 0.02 after natural exposure. It shows that the Ca concrete absorbed water more than cement concrete. Therefore, we consider that the Ca concrete substantially absorbed water under high humidity environment like the Place A. Moreover, the average of the weight ratio of Ca concrete is greater than cement concrete. It shows that Ca concrete retained water than cement concrete under high humidity environment. From this result, we consider that the Ca concrete also retained water than the cement concrete. Hence, the Ca concrete is the material, which has high water absorbability and water retentivity under high humidity environment.

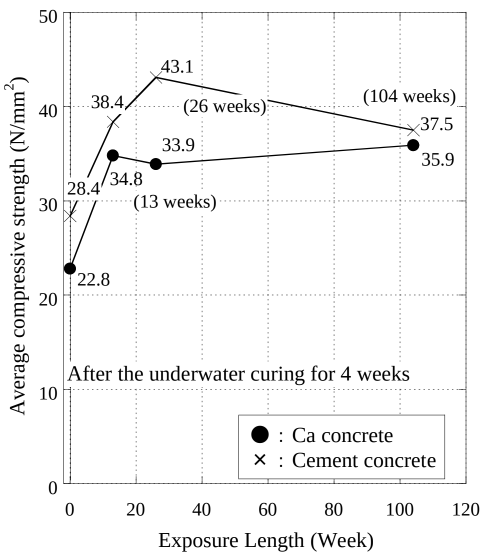

Figure 6. The relationship between the compressive strength and exposure length at the Place A.

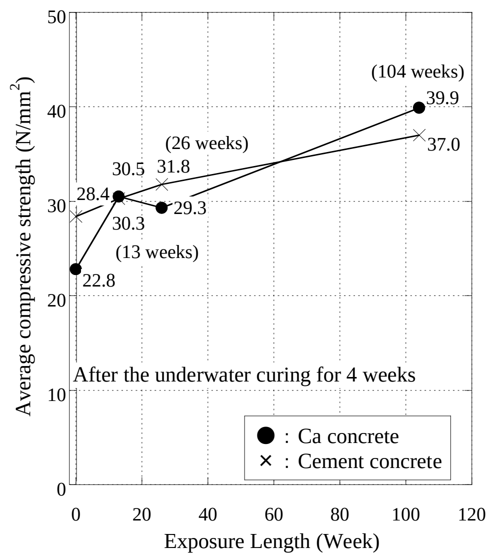

Figure 7. The relationship between the compressive strength and exposure length at the Place B.

Figure 5 shows the relationship between the weight ratio and exposure length at Place B. As with Figure 4, the weight ratio of Ca concrete shows slightly more than 1.0, and the weight ratio of cement concrete shows less than 1.0. It shows that the weight of Ca concrete in the Place B also became slightly heavier than the first weight by absorbing a little water even under lower humidity condition than Place A. Also, the maximum weight ratio of the Ca concrete is greater than the cement concrete. Therefore, we consider that the Ca concrete absorbed water even under lower humidity environment than Place A. Moreover, the average of the weight ratio of Ca concrete is also greater than cement concrete as with Place A. However, comparing that average difference between Figure 4 and Figure 5, that difference reduces to 0.005 from 0.016. It shows that the water retentivity of Ca concrete depended on humidity. Hence, the Ca concrete is the material, which has water absorbability and water retentivity even under lower humidity environment than Place A.

From the above, we consider that the Ca concrete is the favorable material as one of the measures against urban heat island phenomenon because this material has the water absorbability and the water retentivity from these experimental results of the Place A and the Place B.

4.2 The Property of Compressive Strength under Natural Exposure

Figure 6 and Figure 7 show the compressive strength results about each specimen under natural exposure. The compressive strengths at zero weeks in both figures are the values immediately after the underwater curing for four weeks. Those results show the average values of three specimens.

Figure 6 is the result in the Place A. It shows that the average strength of Ca concrete is lower than that strength of cement concrete but is greater than the original strength of zero weeks even for long natural exposure. Also, the strength difference of zero weeks and 104weeks is about 13 N/mm^2 in Ca concrete. On the other hand, the corresponding strength difference of cement concrete is 9.1 N/mm^2. It shows that the strength increase of Ca concrete is higher than the value of cement concrete. Therefore, we consider that Ca concrete retains and increases the compressive strength even if we locate the Ca concrete under high humidity condition for long natural exposure.

Figure 7 is the result in the Place B. It shows that, as with Figure 6, the average strength of Ca concrete is greater than the original strength of zero weeks even for long natural exposure and the strength increase of Ca concrete from zero weeks to 104 weeks is higher than the value of cement concrete. Also, comparing Figure 7 with Figure 6, the average strengths of Ca concrete in Figure 6 are greater than the values in Figure 7 until 26 weeks. However, the average strength at 104 weeks in Figure 7 is higher than the value at 104 weeks in Figure 6. We consider that the humidity affected those results. The Place B was lower humidity than the Place A. Since the past study showed that the strength development of Ca concrete occurred by atmospheric moisture without requiring so many moistures (Shimabukuro and Hashimoto 2013), the strength of the Place B in lower humidity is greater than the value of the Place A. Therefore, we consider that Ca concrete retains and increases the compressive strength even if we locate the Ca concrete under lower humidity condition than the Place A for long natural exposure. Besides, we consider that the humidity substantially influences the strength increase of Ca concrete.

From those results, the average strength of Ca concrete is smaller than that strength of cement concrete in each place. However, the average strength of Ca concrete with the long natural exposure does not decrease from the original strength under either of high or low humidity condition. Therefore, we consider that the Ca concrete would apply to construction material under natural environment because the strength of Ca concrete does not decrease for a long time natural exposure.

5 CONCLUSIONS

In this paper, we investigated the further properties of Ca concrete under natural environment. As a result, the knowledge obtained in this study is the following:

(1) Ca concrete has the higher water absorbability and the water retentivity as compared with cement concrete. Also, the water absorbability and the water retentivity of Ca concrete depend on humidity environment.

(2) The compressive strength of Ca concrete under natural exposure increases from the original strength even if the length of natural exposure passes for 104 weeks. Besides, the strength increase of Ca concrete also depends on humidity environment.

(3) Because Ca concrete has the water absorbability and the water retentivity and the strength of Ca concrete does not decrease from the original strength, Ca concrete would apply to construction material under natural environment as one of the measures against urban heat island phenomenon.

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