Effect of Curing Conditions on Physical Properties of Mortar Blended with Expansive Agent

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Abstract. Assuming precast concrete using expansion material, we will confirm the influence of curing conditions on the basic physical properties of mortar with regard to the free expansion coefficient, constraint expansion coefficient and strength, using two types of expansive materials widely used in Japan . As a result, it was confirmed that the higher the curing temperature, the higher the strength regardless of the addition of the expansion material. In addition, it was confirmed that both the free expansion coefficient and the constrained expansion ratio had an effect irrespective of the curing temperature of the lime type expansion material.

1 Introduction

In recent years, research results on the performance of various types of foamed concrete have been reported . It is generally known that expansion characteristics are greatly affected by curing temperature or temperature change during curing. However, knowledge on the expansion characteristics when steam curing is applied is not sufficient. For this reason, rational formulation design and curing conditions have not conventionally been determined, and setting optimum curing conditions according to the product is currently difficult. On the contrary, at the concrete product factory, the cure pattern is repeated and the quality check of the product is repeated. [1-20]

In this study, we assumed precast concrete using expandable material focusing on free expansion coefficient and expansion coefficient, and confirmed the influence of curing conditions on basic physical properties of mortar using two main materials used in Japan . [20-32]

2 Outline of experiment

2.1 Materials and formulations used

Table 1 shows the materials used in this study. Comparison was made using two kinds of ettringite type expansion material and lime type expansion material mainly used in Japan. In this test, a 1:2 mortar formulation was used to reveal the swelling effect. The amount of expansion material added was replaced by 7% of the mass of the cement.

Figure 1 shows The mixing procedure .

Pic 1 shows used mixing procedure

Figure 2 shows the curing conditions.

The kneading temperature of the mortar was 20 ± 2 ° C. in each case. The curing temperature was set at two stages of 20 ° C. and 50 ° C. and the swelling rate was measured 30 minutes after completion of curing at both 20 ° C. and 50 ° C.

Table 1. Materials used

Material		Type	Density (g/cm^2)
Cement	OPC	Ordinary portland cement	3.16
Expansive agent	CAO	Lime based expansive agent	3.19
	ET	Ettringite type expansive agent	2.93
Fine aggregate	S	River sand	2.69
Chemical admixture	Ad	High range water reducing superplasticizer	—

Table 2. Mix proportions of mortar.

No.	W/B (%)	S/B	Unit weight(kg)				Ad
			W	S	C	EX	
0	30	2	214	1427	713		C× 0.5 (%)
EX					663	50	

※Correction of the volume due to the specific gravity of the expansion material was neglected

Picture 1. Hobart type mixer.

2.2 Test items

In this study, free expansion coefficient test, restraint expansion rate test, compressive strength test were conducted. In the drop test, a columnar tinplate made of a tinplate (inner diameter 50 mm × inner size 100 mm) is used as a mold for manufacturing the test piece, and as shown in the US Department of Defense Standard Law CRD C 589, mortar freedom The displacement coefficient was simulated and measured using a laser displacement meter as a measuring device. Pic.2 and Fig.3 shows Schematic of Free Expansion Rate Test.

Pic.3 and Fig.4 . shows Schematic of restraint expansion rate test. The measurement was carried out at a curing temperature of 50 ° C. for 72 hours and at 20 ° C. for 168 hours. Restraint expansion rate test was conducted according to JCI standard JCI-S-009-2012, and initial restraint expansion rate of mortar was measured. The strain gauge used for constraint was 1 gauge 3 wire type, gauge length 2 mm and was measured at the same age as the free expansion coefficient test. Compressive strength test was conducted according to JIS A 1108.Compressive strength test was conducted according to JIS A 1108. 1, 3 days when the curing temperature was 50 ° C., 1, 3, 7 days when the curing temperature was 20 ° C. In this study,three sample were used and take average from these three sample for take certainly result

3 Experimental results and discussion

3.1 Compressive strength

FIG. 5 shows the influence of the curing temperature on the compressive strength. The compressive strength of the mortar with the added material showed about 50% higher compressive strength than the one aged at 20 ° C at the curing temperature.

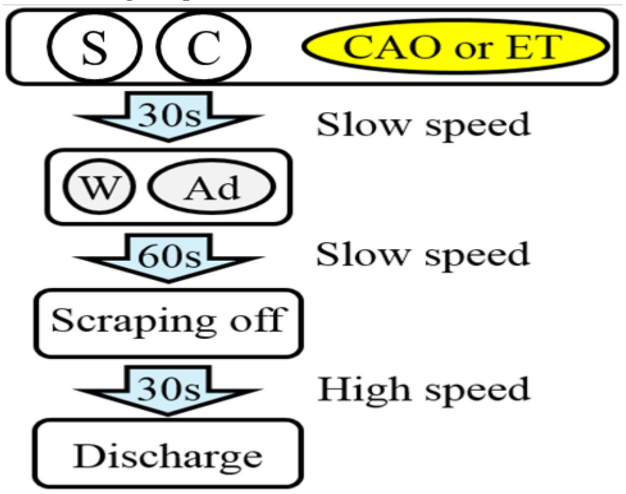


Fig.1 Mixing procedure.

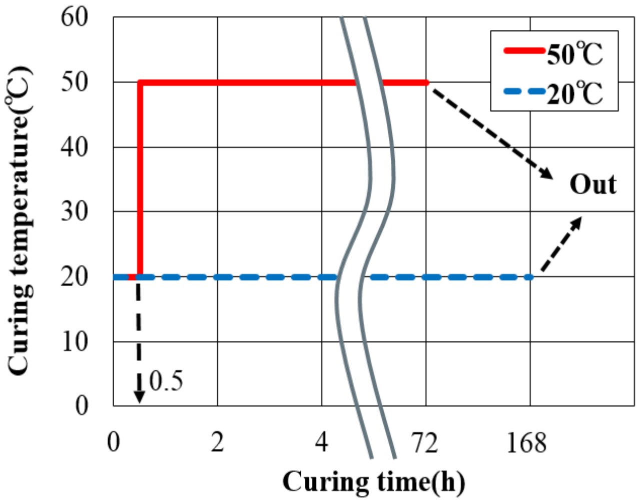
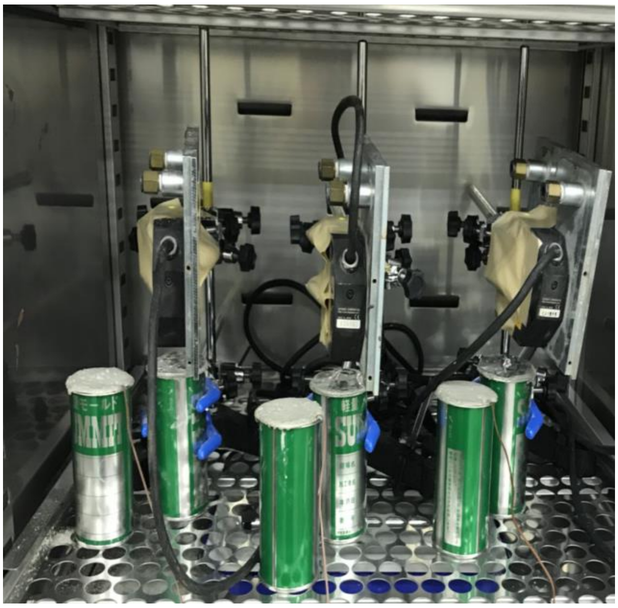


Figure 2. Curing conditionion.



Picture 2. Measurement landscape.

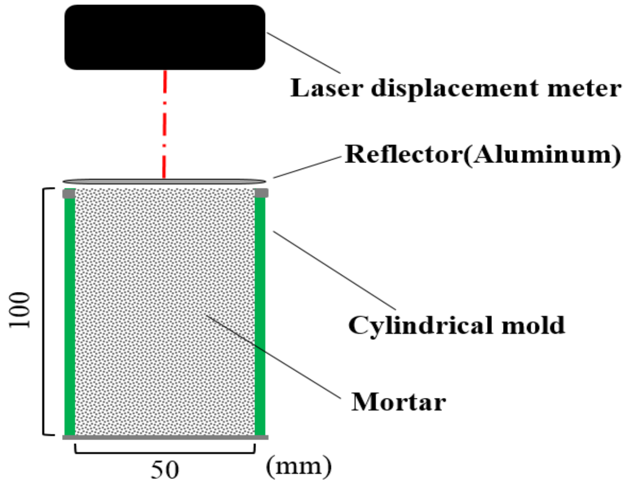


Figure 3. Schematic of free expansion rate test.

When compared at a temperature slightly higher than the curing temperature of 3 days old, 50 ° C.20 ° C. it showed high compressive strength with or without addition of expandable material.

3.2 Free expansion coefficient

Fig. 6 shows the influence of the curing temperature on the free expansion coefficient.At the curing temperature of 20°C both the lime-based expansion material and the ettringite-based expansion material showed expansion coefficients higher than 50°C. Also, as a result of comparing the difference in expansion ratio between the curing temperature of 20 ° C and 50 ° C, It was confirmed that the expansion coefficient of the lime type expansion material was larger than the expansion coefficient of the ettringite type expansion material.The reason why no additive was judged to have a high shrinkage ratio is that a lot of water came out from the mortar

3.3 Restraint expansion coefficient

Fig. 7 shows the influence of the curing temperature on the constrained expansion ratio. As a result of comparing the expansion coefficient and the temperature difference at the curing temperature of 20°C to 50° C no significant difference was found in the expansion rate due to the temperature difference between the lime-based foam and the ettringite. It was confirmed that the expansion coefficient of the lime based foam material was about 4 times the expansion coefficient of the ettringite type expansion material at any temperature of 20°C and 50°C.

4 Conclusion

In the scope of this research, the following findings were obtained regarding the influence of curing conditions on basic physical properties of mortar mixed with expanding

Picture 3. Measurement landscape

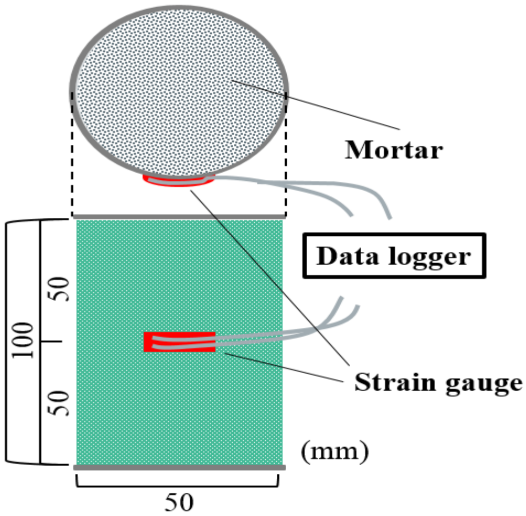


Figure 4. Schematic of restraint expansion rate test.

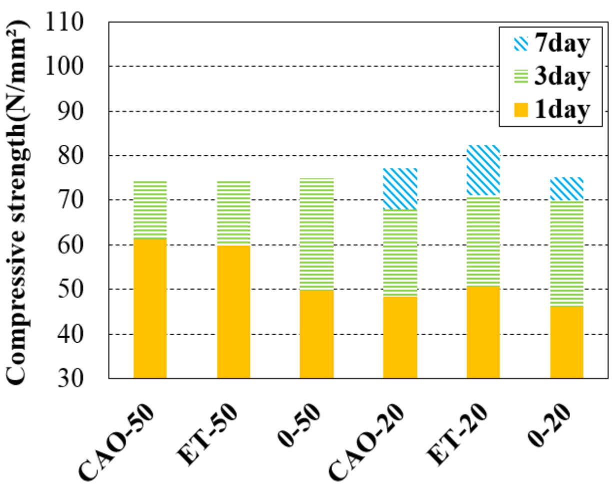


Figure 5. Relation of curing temperature to compressive strength.

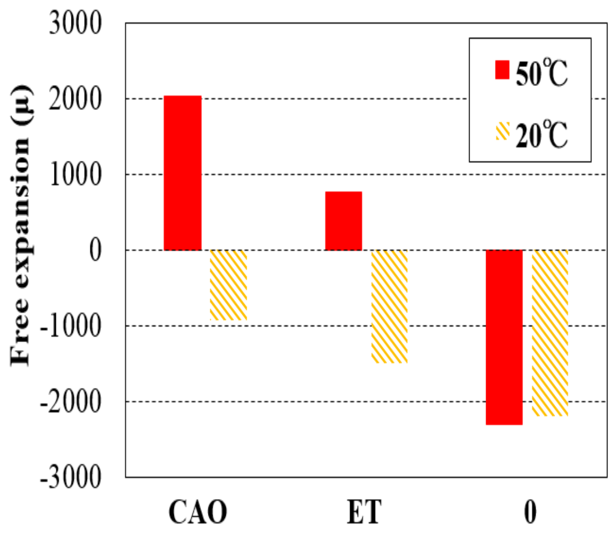


Figure 6. Free expansion by maximum curing temperature.

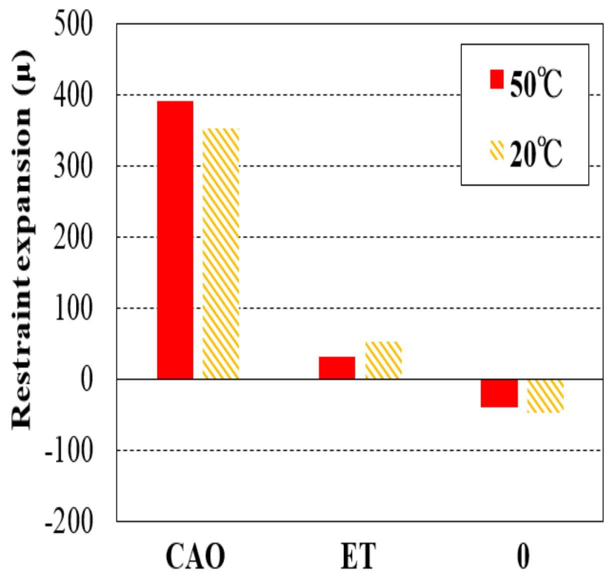


Figure 7. Restraint expansion by maximum curing temperature.

material. By applying the curing temperature (50 ° C.), the initial strength of the mortar to which the expansion material is added increases. With the free expansion coefficient, it was confirmed that the higher the temperature, the higher the expansion coefficient when comparing the curing temperature of 20 ° C and 50 ° C. Both the free expansion coefficient and the confining expansion coefficient showed that the expansion coefficient of the lime type expansion material was larger than that of the ettringite type expansion material. It is considered that an effect can be obtained by adding a low-lime type expansion material in order to obtain the same expansion coefficient as compared with the ettringite type expansion material.

Acknowledgment

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