INFLUENCE OF MIXING METHOD ON DURABILITY OF ENTRAINED AIR IN MORTAR OF SELF COMPACTING CONCRETE

Kochi University of Technology Student Member 〇Sovannsathya Rath
Kochi University of Technology Fellow Member Ouchi Masahiro

1. INTRODUCTION

The objective of this study is to differentiate effect of mixing energy input to durability of entrained air in SCM. A number of studies have shown that entrained air improves the workability of fresh concrete while at the same time decreasing in both segregation and bleeding. However, to ensure the durability of entrained air is a complicated and difficult task especially with self-compacting concrete (SCC). Previous research shown that, in highly fluid concrete, air bubbles can move more freely which increases the bubbles coalescence and rupturing.

2. EXPERIMENT

All materials for the experiment (**Table 1**) were kept in a room with a constant temperature of 20°C where the tests were conducted. The mixing proportion of SCM was shown in the following table (**Table 2**).

Table 1: Materials used for SCM in this study

Cement (C)	Low-heat ordinary Portland cement ($3.15 g/cm^3$)
Fine aggregate (S)	Crushed limestone sand ($2.68 g/cm^3$, F. M. 2.73)
Superplasticizer (SP)	Polycarboxylic based with viscosity agent
Air entraining agent 1 (AE1)	Alkyl ether-based anionic surfactants
Air entraining agent 2 (AE2)	Vinsol resin

Table 2: Mixing proportion of SCM in this study

Water to cement ratio (W/C)	Sand to mortar ratio (s/m)	Superplasticizer to cement ratio (SP/C)	AE to cement ratio (AE/C)	
			in case of AE1	in case of AE2
45%	55%	1.4%	0.5%-3.0%	0.4%-3.0%

Two different mixing methods were performed (**Fig. 1**). It was clearly seen from the figure that mixing method B provided higher mixing energy input to the mixture than mixing method A because of the separation of mixing water into two parts in the mixing method B. The lower content of water allowed the mixture to receive higher mixing energy input in case of the mixing method B than method A. Air content test by both pressure and gravitic method were performed at 5 minutes and 2 hours, time after the start of mixing, to compare the durability of entrained air of both mixing methods.

Method A: $\xrightarrow[\text{30s}]{\text{Sand + Cement}} + \xrightarrow[\text{2min}]{\text{W + SP + AE}}$

Method B: $\xrightarrow[\text{30s}]{\text{Sand + Cement}} + \xrightarrow[\text{1min}]{\text{W1 + SP}} + \xrightarrow[\text{1min}]{\text{W2 + AE}}$

Fig.1: Mixing procedures of SCM. ($W=W_1+W_2$)

3. RESULTS AND DISCUSSION

With both types of AE, with the same variation of AE dosage, initial air content higher entrained with the mixing method A than method B (**Fig. 2**). In case of AE1, initial air content entrained from 16.0% to 25.5% for the mixing method A and from 8.8% to 12.6% for the mixing method B. In case of AE2, initial air content entrained from 10.6% to 30.0% for the mixing method A and from 5.9% to 12.5% for the mixing method B. This was resulted from higher content of water accompanying with AE during the mixing process of method A.

With both types of AE, the durability of entrained air was satisfied with the method B especially when the dosage

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Contact address: 185 Miyanokuchi, Tosayamada, Kami City, Kochi 782-8502, Japan, Tel: +81-887-57-2411

of AE was increased (**Fig. 3**). The reduction in air content in 2 hours of the method B varied from 1.0% to -0.6% for AE1 and from 1.6% to -0.9% for AE2. This was resulted from higher mixing energy input of the method B when the water was separated into two parts. In contrast, the durability of entrained air was uncontrollable with the method A. It can be seen from the figure that, with the method A, the reduction in air content in 2 hours changed unexpectedly. For example, in case of AE2, the reduction in air content was higher when the dosage of AE increased which was unexplainable. This result shown that the mixing energy input had a considerably influence on the durability of entrained air of SCM.

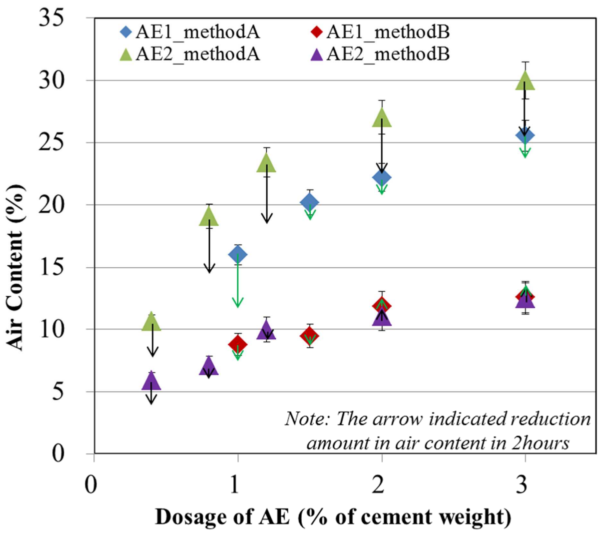

Fig. 2: Influence of mixing energy input on air content

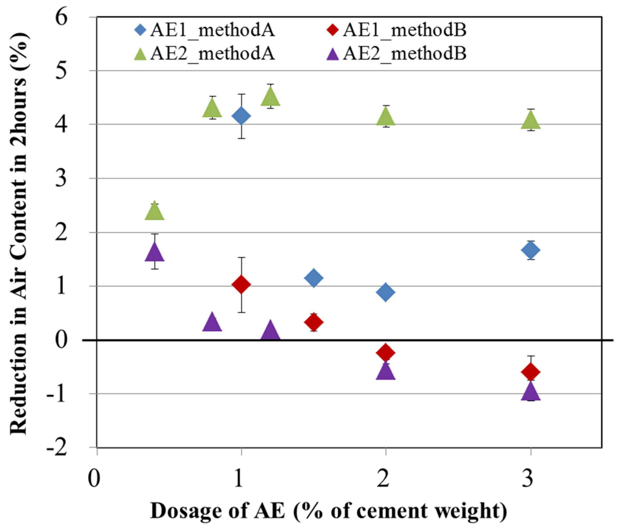

Fig. 3: Reduction in air content in 2hours

In case of AE2, to get similar initial air content, with the mixing method B the dosage of AE of 2.0% of cement weight was required whereas only 0.4% was needed in case of the mixing method A (points circled in **Fig. 4**). However, the air content obtained from the method B was more durable than the method A. It can be seen from the **Fig. 4** that, the redution in air content in 2 hours was 2.4% and -0.6% for the mixing method A and method B respectively. This can be explained that with higher mixing energy input, higher dosage of AE was also required to entrain the same air content.

The correlation between the intial air content and the reduction in air content in 2 hours was good in case of the mixing method B but this was not the case for the mixing method A (**Fig. 4**).

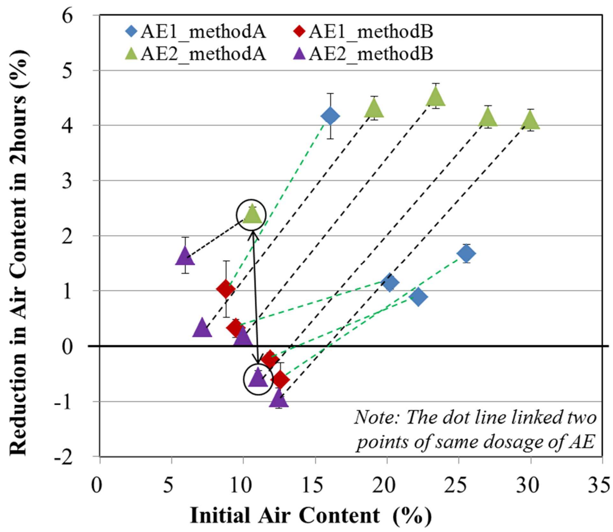

Fig. 4: Influence of mixing energy input on the durability of entrained air

4. CONCLUSION

Based on this experiment result, conclusion can be written as the following:

(1) Increasing the mixing energy input resulted in reduction in the initial air content but improved the durability of entrained air.

(2) In method of higher mixing energy input, higher dosage of AE was required to obtain the same initial air content.

(3) In method of higher mixing energy input, the reduction in air content in 2hours was mitigated with the increased dosage of AE.

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