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Electrical resistivity measurement method for nondestructive evaluation of concrete segregation

*Young Hwan Bae[1)], Yu Rhee Ahn[2)] and Hong Jae Yim[3)]

[1), 2), 3)] *Department of Civil Engineering Pusan National University, Busan 46241, Korea*
[3)] yimhj@pusan.ac.kr

ABSTRACT

High performance concrete requires a highly fluid binder with sufficient segregation resistance in the fresh mixture, but, failure of mix proportion including excessive used superplasticizer can cause concrete and aggregate segregation. This study proposes a segregation evaluation method based on the measurement of electrical resistivity. After optimization of experimental setup, concrete segregation was evaluated via different types of prepared concrete using different amount of superplasticizer. Accordingly, the possibility of evaluation of static segregation was verified using electrical resistivity measurement.

1. INTRODUCTION

High performance concrete requires a highly fluid binder with sufficient segregation resistance in the fresh mixture. Its rheological properties such as viscosity and yield stress are controlled by sensitively determined mix proportioning and the used chemical and mineral admixtures. But, failure of mix proportion due to high water content, excessive dosage of superplasticizer, can cause concrete segregation. These phenomenon leads to inhomogeneity in fresh concrete mixture, which results in and potential damage including strength difference, excessive porosity and resultant high drying shrinkage, and unexpected permeability after curing. (Soshiroda 1981).

To achieve a high resistance to segregation, aggregate particles should be distributed in dimension. They need to be well distributed spatially during mixing and placing. Various methods have been proposed to evaluate segregation. Recently, the setting and hardening of cement-based materials were also evaluated using measurement of electrical resistivity via four-electrode method (Yim 2017).

[1)] Graduate Student
[2)] Undergraduate Student
[3)] Professor

2. Experimental details

2.1 Sample preparation

A total 10 concrete samples, labeled by OP, OP-1, OP-2, OP-3, OP-4, OP-5, FA, FA-1, FA-1.25 and FA-1.5 were produced. Their mix proportions were identical except the dosage of superplasticizer as reported in Table. 1. They were 0% to 5% per cement mass. In addition, the FA group was samples in which 30% of fly ash was replaced by cement.

Table. 1 concrete mixture proportion

Label	W/C (%)	Unit weight (kg/m^3)						
		Water	Cement	Sand	Gravel	Fly ash	Air Entraining Admixture	Superpla -sticizer
OP	60	219	365	1025	719	-	0.011	-
OP-1	60	219	365	1025	719	-	0.011	3.65
OP-2	60	219	365	1025	719	-	0.011	7.29
OP-3	60	219	365	1025	719	-	0.011	10.94
OP-4	60	219	365	1025	719	-	0.011	14.59
OP-5	60	219	365	1025	719	-	0.011	18.24
FA	60	219	255	1025	719	110	0.011	
FA-1	60	219	255	1025	719	110	0.011	3.65
FA-1.25	60	219	255	1025	719	110	0.011	4.56
FA-1.5	60	219	255	1025	719	110	0.011	5.48

2.2 Experiment for column test

Typically, there was method to evaluate static segregation of concrete with weight of coarse aggregate through wet sieving (ASTM C 1610 2016). This test method details are show in Fig. 1. ASTM C 1610 defines this method that measuring the coarse aggregates content in fresh concrete. Accordingly, the evaluation of static segregation was proposed by compared coarse aggregate at top and bottom section as follow:

$$S_s = 2\left(\frac{CA_b - CA_t}{CA_b + CA_t}\right) \times 100, (\%)$$

where, S_s is the static segregation ratio in percent, CA_t and CA_b is the mass of coarse aggregate in top section and bottom section of column, respectively. Result, the weight of the coarse aggregate in bottom section increased with the dosage of superplasticizer (Fig. 5 (a)).

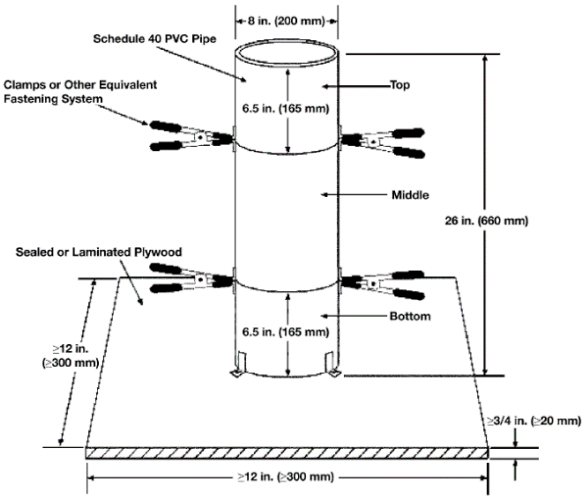


Fig. 1 Column type mold for evaluation of concrete static segregation

2.2 Experiment for electrical resistivity measurement

The column type mold for measuring electrical resistivity was made according to ASTM C 1610. This mold inner diameter and height were 150mm and 540mm, respectively (Fig. 2). A total of 12 brass electrodes are regularly installed, and the length of electrode was 70mm and the diameter was 5mm. The electrical resistivity was then averaged with the twelve rotating at 30℃ sequentially. Experimental setup and schematic of the four-electrode method (square configuration) are shown in Fig. 3. Before evaluating concrete segregation, pretest for feasibility and limitation of proposed method was performed using combined mixture, which mixture is layered half-and-half as concrete sample OP from bottom to midpoint of cylinder mold and as mortar from midpoint to top of mold (Fig. 4). Result of this experiment, the electrical resistivity of bottom section increased according to the dosage of superplasticizer (Fig. 5 (b)).

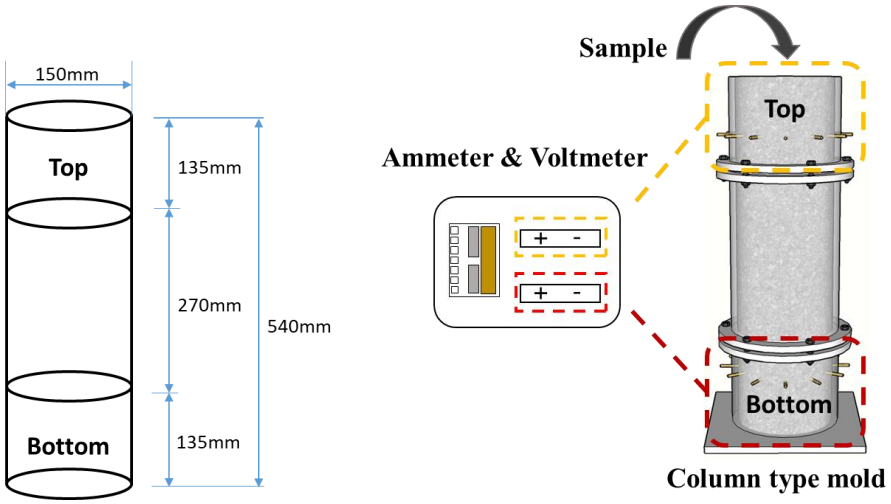


Fig. 2 Electrical resistivity measurement mold for evaluation of concrete segregation

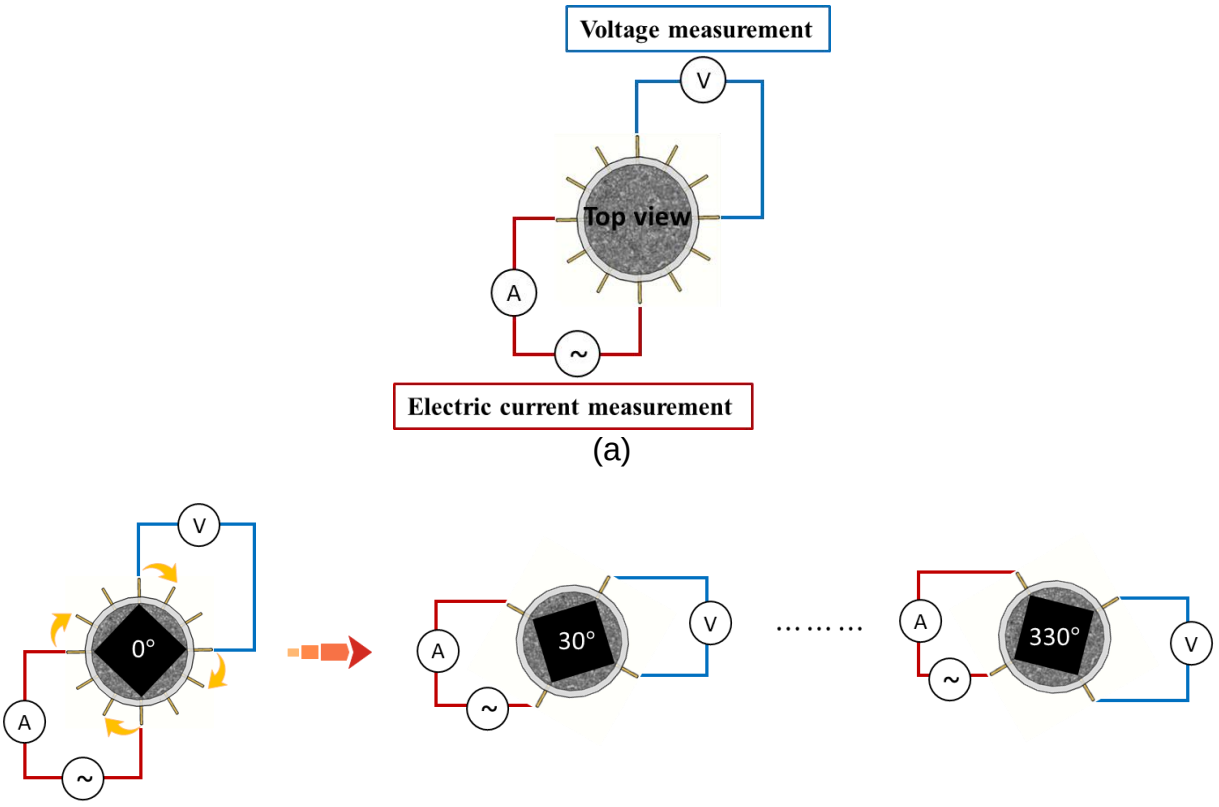
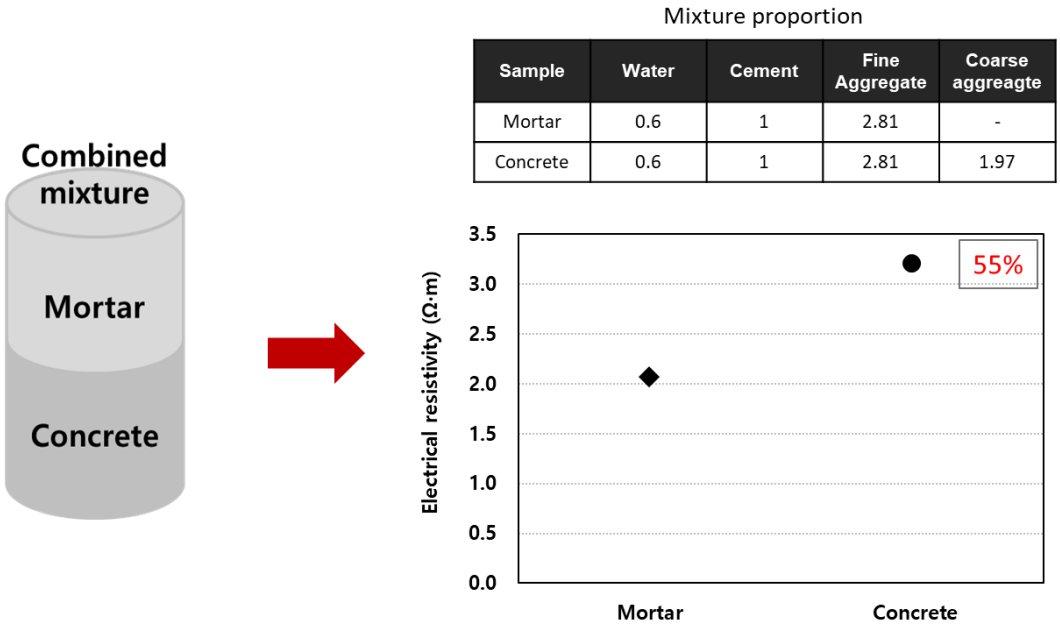


Fig. 3 (a) Electrical resistivity measurement system using electrode square configuration (b) Twelve rotating system for averaged electrical resistivity



Sample	Water	Cement	Fine Aggregate	Coarse aggreagte
Mortar	0.6	1	2.81	-
Concrete	0.6	1	2.81	1.97

Fig. 4 Result of combined mixture (preliminary experiment)

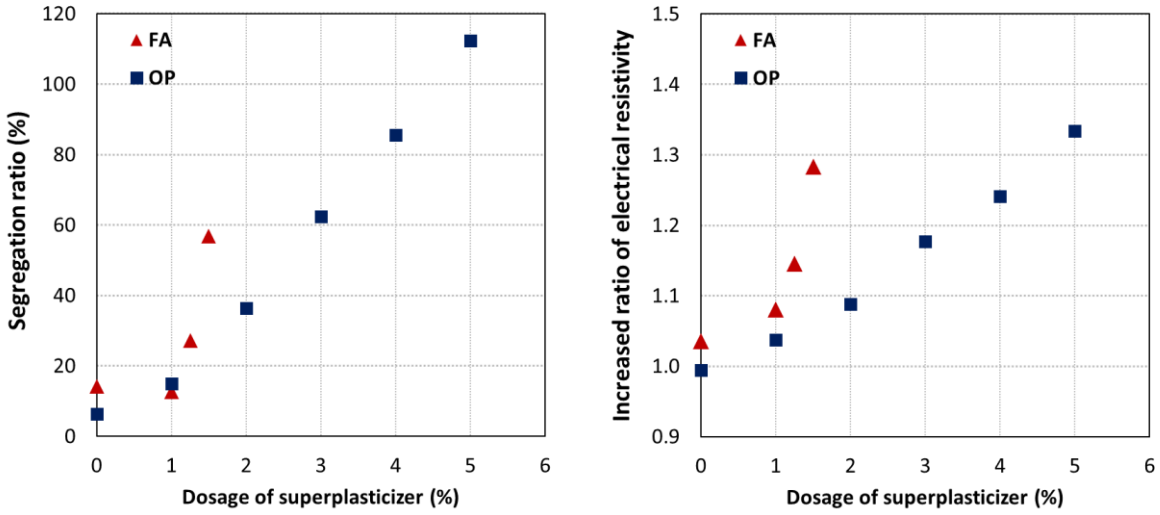


Fig. 5 (a) Increased ratio of electrical resistivity by dosage of superplasticizer
(b) Segregation ratio by dosage of superplasticizer

3. CONCLUSIONS

This study presents a nondestructive method for static concrete segregation. The proposed column type mold measures the electrical resistivity of the top and bottom of the specimen. Segregation ratio was derived as maximum 112% in the bottom section as the dosage of superplasticizer increased. The measured electrical resistivity increases a maximum 33.4%. Through comparing the results of segregation ratio and electrical resistivity, it can be concluded that the proposed method can evaluate static segregation.

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