The Effect of Chemical Admixtures on Removal of Scattered Dust

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Abstract

One of the important problems associated with building demolition is the dust generated during the work. The only way to reduce the demolition dust is to use a dust net during water spraying. However, it is difficult to supply the necessary amount of water to remove demolition dust, thus making it difficult to apply this method on a demolition site. This work attempted to find an alternative approach to dust removal by incorporating surfactant and high range AE water reducer in the water being sprayed. Through the experiment, it was found that the addition of surfactant did not contribute to the removal of demolition dust. However, the use of high range AE water reducer showed better performance than spraying plain water, indicating that some amount of demolition dust had been adsorbed on the high range AE water reducer.

Keywords : demolition, dust, surfactant, high range AE water reducer, water spraying

1. Introduction

In recent years, many buildings built in the 1970s and in the 1980s have been demolished, and it is estimated that approximately 8,900,000 aged houses will potentially be demolished after 2012[1]. Based on this estimation, the building demolition market is expected to grow rapidly to about 2.5 times its current size, from about KRW1.5 trillion to KRW 5.8 trillion by 2015. By 2025, the market value can be close to KRW11.9 trillion[1,2].

Scattered dust is produced during building demolition. However, scattered dust can cause difficulties in breathing for construction workers, obstruct the field of vision, and pollute the surrounding environment, harming residents (causing environmental issues) in the neighborhood. The number of cases associated with scattered dust has been increasing, and in addition, the laborers involved in demolition works often experience a decline in work desire and decrease in concentration due to their exposure to poor working conditions. These can be main factors that can cause safety accidents[3].

To prevent dust from scattering during demolition work, the most effective method that is currently known is to install a dust control net and to spray large amounts of water[3,4]. However, on many demolition sites it is hard to secure enough water to spray due to practical problems and economic reasons, compromising the effectiveness of the water spraying method. Despite this problem, there have been few studies conducted on an effective method of reducing dust scatter in demolition site. In a demolition job, a large quantity of scattered dust occurs in a relatively short period of time, and as such the development of an effective method to deal with the continuous occurrence of

large quantities of scattered dust is a prerequisite for safe demolition work.

Considering that the major components of concrete pollutants like scattered dust are calcium and silica, if an admixture that can increase hydrophilic property is used, the dust can be adsorbed more effectively. An admixture like surfactant can be used to remove persistent organic pollutants in soil or underground water[5] and to cleanse diesel-contaminated soil[6]. It is known that a surfactant that has both hydrophilic and hydrophobic properties is currently used to secure flowability and air entrainment in concrete. In addition, considering that superplasticizer can be well absorbed on cement particles, an admixture like superplasticizer can be also utilized to improve the absorption of scattered dust. However, there have been no studies on the effect of a surfactant or superplasticizer on removing scattered dust generated during concrete demolition.

This study aims to improve capture performance of spraying water for scattered dust. Scattered dust itself consists of hydrophilic particles, and diverse kinds of admixtures (anionic surfactant, amphiphilic surfactant, and high-performance AE water reducer) were mixed in spraying water to explore the effect of the various additives on the removal of scattered dust.

2. Experimental procedure

2.1. Preparation of scattered dust

The size distribution of scattered dust is known to be between about 0.1 μm and up to 120 μm[8]. To make the scattered dust similar to the dusts found at a demolition site, a concrete specimen, which had been exposed to the external environment for more than three years, was selected. The concrete specimen was crushed and ground using

iron mortar and pestle. The ground powder that passed the 100 um sieve was used for the experiments of this study. The particle size of the sieved dust (synthesized demolition dust) was analyzed using LS-13320 model of Beckman Coulter, and the results are shown in Figure 1. More specifically, the average particle size was 58.96μm and the size distribution varied from 0.4μm to 260μm.
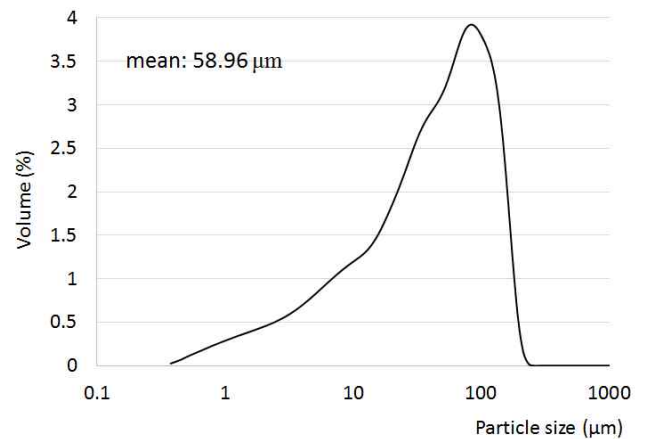

Figure 1. Particle size distribution of synthesized demolition dust made from ground concrete (3 years old)

The chemical properties of synthesized demolition dust were measured by X-ray fluorescence, using the XRF-1800 model from Shimadzu Scientific Instruments, Inc.. Table 1 indicates the chemical properties of synthesized demolition dust. As shown in Table 1, synthesized demolition particles were composed of more than 90% SiO_2, CaO, and Al_2O_3, which is almost identical to that of ordinary concrete. In terms of the particle size distribution and chemical properties of the synthesized demolition dust, the synthesized demolition dust showed almost identical properties to that of actual scattered dust, and thus was used for the experiment.

Table 1. Chemical compositions of 3 year old concrete

Composition	Amount
SiO_2	41.74%
CaO	41.46%
Al_2O_3	6.55%
K_2O	3.25%
SO_3	2.03%
MgO	1.93%
Fe_2O_3	1.87%
Na_2O	0.65%
TiO_2	0.25%
P_2O_5	0.14%
MnO	0.08%
SrO	0.04%
ZnO	0.04%

2.2. Selection of chemical admixtures

This study aims to increase the capturing performance of spraying water for scattered dust. Since both water and scattered dust are hydrophilic, an admixture that has good capture ability with hydrophilic property is required. A surfactant consists of hydrophilic and hydrophobic group. Based on the assumption that a surfactant with longer hydrophilic chain could better absorb scattered dust, several types of surfactants were selected. The types of surfactants include anionic, cationic, amphiphilic, and nonionic surfactants. Table 2 indicates the types of surfactants used in the experiment and the chemical formula of the hydrophilic group.

For the surfactants used in the experiment, the surfactants made of natural ingredients that were harmless and hypoallergenic to humans were selected. The non-ionic, anionic, and amphiphilic surfactants were LP-1046, LES and Cocobetain from MW, respectively. Cationic surfactants usually include quaternary ammonium and are harmful to

humans, and for this reason were excluded from the test. High range AE water reducer also has hydrophilic molecules, and it was selected based on the rationale that it might have the effect of removing scattered dust. High range AE water reducer used for this experiment was Megad 601PC from KMB.

Table 2. Surfactants used for the experiments

Types	Hydrophilic group	Hydrophobic group
Non-ionic	$-OH$, $-O-$ or $-O-CH2-CH2-OH$	Long chain hydrocarbon
Anionic	$-COO^-$, $-SO3^-$ or $-OSO3^-$	Long chain hydrocarbon
Amphiphilic	mostly $-COO^-$, and $R4N^+$	Long chain hydrocarbon

2.3. Fabrication of the measuring space

To perform the test for the removal of scattered dust, an identical quantity of dust should be spayed at an identical pressure and for the same time span in a certain area of space. . To do this, the measuring space was fabricated to have the dimensions of 600mm×600mm×1800mm. Figures 3 and 4 are views of the space from outside and inside, and show the locations of the diverse equipment for measurement.

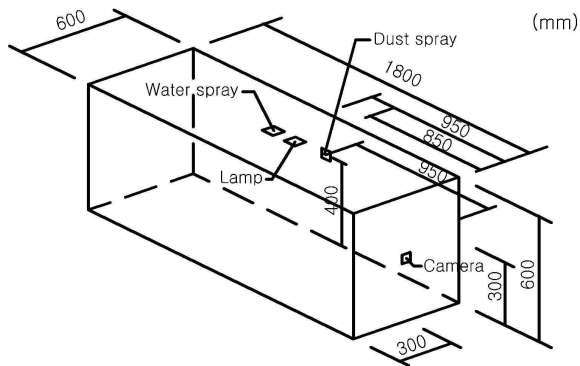Figure 3. Photographic images of the testing box

Figure 4. Dimensions of the testing box

PM-10, a device that can measure dust quantitatively, could not be used in this experiment[7] because after spraying water with an admixture, the scattered dust could be adhered to the device, making it difficult to get experiment results and possibly causing damage to the device. Therefore, as shown in Figures 3 and 4, the level of reduction of dust scatter after admixture-contained water was sprayed was investigated using RGB values of the picture taken inside the space. To effectively spray and measure dust scatter, several trial experiments were performed and then the measuring device was placed at a location that was determined to be the most effective (see Figure 4).

To block the light from the outside, the measuring space was made as a darkroom using form black colored foam boards and pinewoods. The inside of the space was illuminated with a lamp with a certain level of luminous source. In such a space, it is possible to measure the effect of spraying water on the removal of dust scatter using the reflection effect of illuminated light according to the volume of scattered dust. The illumination source used in the test was HQI-TS 150W/NDL EXCELLENCE, a metal halide lamp, which has white light and 12500lm speed of light.

The reason why the light was installed in the center is to reduce the amount of light reflected from the back wall. If the light is reflected from either the front or the back wall, the brightness of the light goes up, which can lead to a distortion of the RGB analysis. The length of specimen was set as 1.8m, which is rather long, to minimize the light reflection from each of the walls.

To measure dust scatter using images, pictures of the light source were taken with a camera. A Nikon DSLR D7000 camera and a Nikkor MF 50mm F1.4 lens were used. Since the image was taken as a snapshot, the shutter speed was maximized, and a bright prime lens with a low aperture value was selected to get a clear image. The camera was set at the exact center of the front wall. Since the pictures were taken inside of a dark space, a fixing device and a remote controller were used in order to avoid camera shake. The photographing conditions were fixed at 1/80 second for the shutter speed and F4.0 for the aperture value and ISO 1600.

2.4. Testing procedure

The test was conducted through the following process. At the beginning of the test, 5g of dust was sprayed for the first 10 seconds using an air blower (30 mmHq wind pressure and 72m^3/hr air volume, located in the right of the specimen box). No activity was done during 30 seconds to allow the dust to settle. At 40 seconds after dust spraying, the picture of dust scatter inside of the measuring space was taken, which was set as the initial value. About 500ml water with the 20:1 ratio of water to an admixture (weight ratio) was sprayed for 90 seconds, and 9 pictures were taken at 30-second intervals. A total of 10 pictures were taken, including the first picture. The details of the testing procedure are shown in Figure 5.

Figure 5. Testing procedure (left to right; spraying demolition dust, waiting for 30 seconds, water spraying)

2.5. Measurement on the amount of dust scatter (RGB analysis)

To assess the effect of mixing of a chemical admixture in water to increase the capturing performance for scattered dust, the RGB analysis was used. Figure 6 illustrates the details of the RGB analysis procedure. The images taken were imported using Adobe Photoshop CS5, and the center part of the picture was divided into 2000*1280 Pixels. The volume of scattered dust was quantitatively assessed using the average RGB value of each pixel.
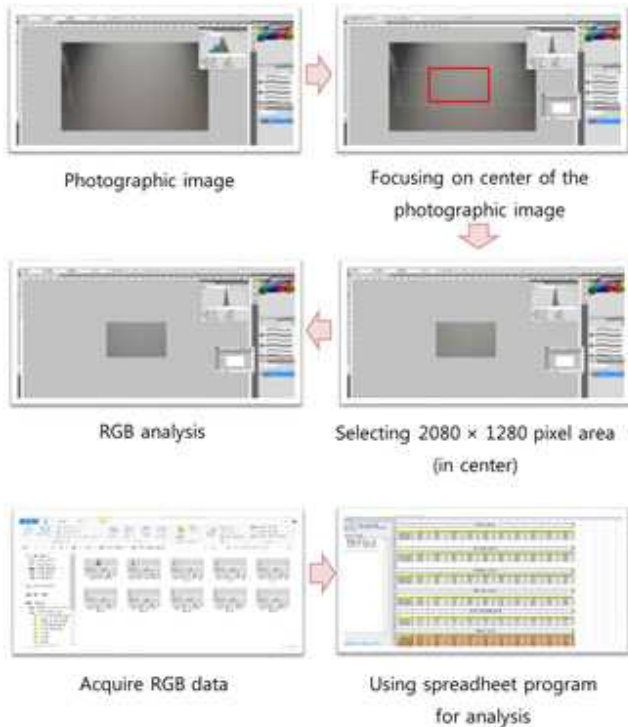

Figure 6. RGB analysis procedure

The RGB values of the images taken are distributed from 0 to 255. Here, the lower the RGB value, the darker the color, and vice versa. More specifically, when the RGB value is 0, the color is black, and when the RGB value is 255, the color is white. When the light is reflected by scattered dust, it gets brighter, and the RGB value in return gets higher. Therefore, the average RGB values of the images taken were compared, and the image that had the lower average RGB value was assessed to have greater capture performance.

The initial RGB value obtained after the analysis (taken at 40 seconds; the value before admixture-contained water was sprayed) was related with the number of sprayed particles to the center. Since the particles were distributed irregularly, the values were similar but not constant. For a comparative analysis, the relative values were determined by dividing the RGB value of each timeframe by the initial RGB value at 40 seconds.

3. Results and discussion

3.1 RGB value with water spraying

Figure 7 shows the changes in RGB value after water spraying. When the RGB value of the initial image at 40 seconds was set at 100, the RGB value decreased after spraying water without admixture. The lower the RGB value, the darker the image, which means that the method has a better capture performance of scattered dust. According to the test results in Figure 7, the volume of scattered dust was significantly reduced at 130 seconds, at which time the water spraying was finished. This indicates that a considerable volume of scattered dust was removed by water. Therefore, when assessing test results, the result at 130 seconds after water spraying can be considered the most important.
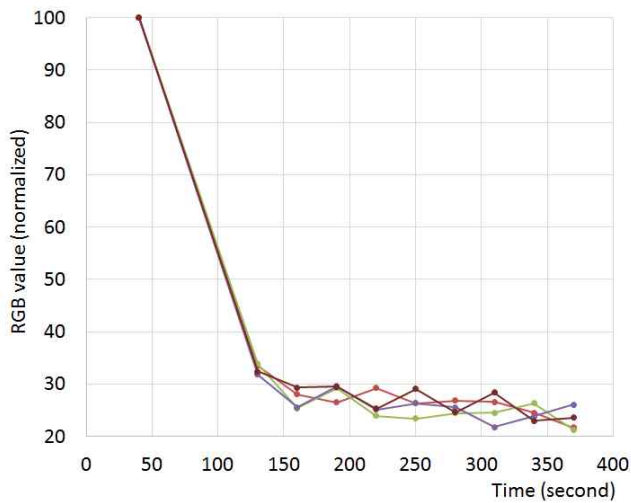
Figure 7. Normalized RGB value from water spraying

The RGB values measured subsequently were shown to be similar but had a slight distribution. The scattered dust that had not yet been removed can move randomly in the test space, which is be-lieved to have affected the RGB values on the measuring part (the exact center of the testing box). As shown in Figure 7, the standard deviation of the RGB values measured after water spraying (after 130 seconds) was shown to be less than 3 within the whole timeframe. Considering that the average of all the RGB values measured after 130 seconds was 26.56, the test method is proven to have considerable reliability. It is found that al-though a comparison of RGB values is a qual-itative method, if the testing procedure is strictly controlled, reliable data can be obtained. For this reason, the RGB analysis could be applied to a surfactant and high-performance AE water reducer.

3.2 RGB value with the addition of surfactants

Figure 8 shows the RGB values when spraying surfactant-containing water. Compared with the RGB value at 40 seconds, the addition of surfac-tant containing water decreased the RGB values after 130 seconds. However, when a non-ionic

surfactant was mixed, the RGB values were similar with those without surfactant (plain water). When either natural or amphoteric surfactant was mixed, the RGB values were much higher compared with those without surfactant. This implies that natural and amphoteric surfactants were not effective for removing scattered dust.
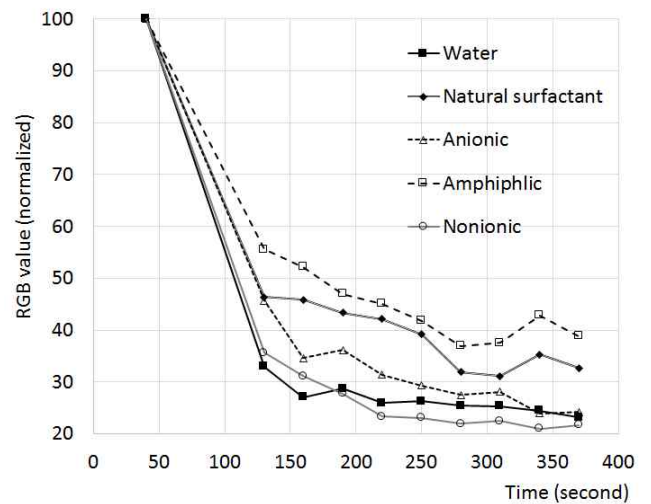

Figure 8. Normalized RGB value from solution (using additives) spraying

When mixed with an anionic surfactant, the RGB value was considerably high immediately after the water was sprayed, but converged to a similar level to that of the water without surfactant. As shown in Figures 7 and 8, considering that most of the scattered dust was removed after water spraying, the RGB values for the first 130 seconds can be interpreted as the most important. The value of non-ionic surfactant was shown to be higher than that of water with no admixture, which indicates that the water with non-ionic surfactant is less effective than the plain water.

3.3 RGB value when using a superplasticizer

Figure 9 shows the RGB values when high range AE water reducer was added to the water being

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sprayed. As shown in Figure 9, when the water with high range AE water reducer was sprayed, the RGB values were lower than that from the plain when water, from 40 seconds to the end of the test. There were no significant differences in RGB values, but when it comes to the standard distribution (expressed as an error bar of each datum in Figure 9), the RGB values were located at the outside of the distribution range, which indicates that the difference in RGB values is significant.
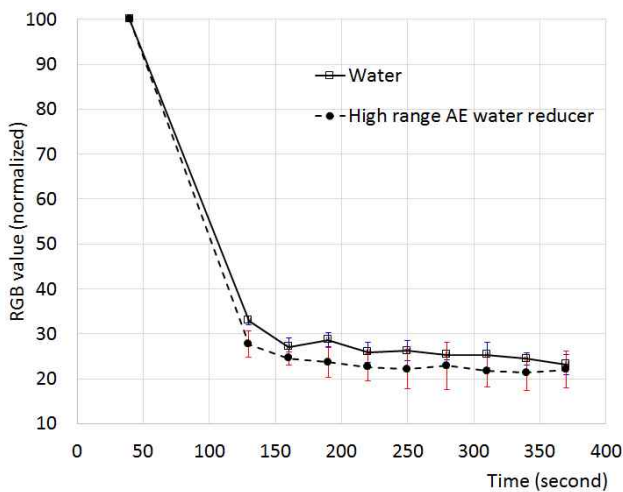

Figure 9. Normalized RGB value with and without high range AE water reducer

There are two types of poly-carboxylate high range water reducers: one consists of hydrophilic carboxylate (-COOM: M indicates H or alkali metal such as Na) polymers and the other consists of hydrophilic carboxylate with hydrophobic ester chains (copolymer). The latter was used in this study. In this case, when poly-carboxylate polymers are absorbed into cement, they develop a negative charge, and ester type physically makes a distance between particles, in turn increasing the flowability of cement paste.

A similar phenomenon can be applied to the absorption of scattered dust. However, to improve the absorption of poly-carboxylate high-performance water reducer, the number of hydrophilic molecule should be higher. The high range water reducer used in this experiment is for commercial use only, so the ingredients of the water reducer could not be controlled because it is a proprietary formula.

4. Conclusion

This study aims to improve capture performance of scattered dust by adding chemical admixtures to water. However, while the RGB analysis used in this study is a quantitative method, and the analysis results were found to be significant, the dust reduction effect could not be expressed in an absolute quantity of gram. Future study should prepare a measuring method to obtain quantitative data in order to improve the current test regime. The results from the RGB analyses can be summarized as follows:

1) The capture performance of amphiphilic and anionic surfactants (Cocobetain and LES, respectively) were significantly less effective compared to that of the water without chemical admixture, while the capture performance of the non-ionic surfactant (LP-1046) was similar to that of water without admixture.

2) Through the RGB analysis of the water without chemical admixture and the water with high range AE water reducer, it was found that the average RGB value of water with high range AE water reducer consistently showed lower RGB value. This indicates that the capture performance of the water with high range AE water reducer was higher than the plain water.

Acknowledgement

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