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Durability and Dynamic Properties of Lightweight Composite Panel Surface Material containing Powdery and Liquid Modified Sulfur

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ABSTRACT---- ***As fuel consumption of petroleum, natural gas and etc is rapidly increasing all over the world, there is a growing trend that production of sulfur, the industrial byproducts, increases every year and thus, durability performance of concrete becomes very important in coastal structures, industrial facilities exposed to salt and acid, and public structures with national meaning. So, this study intends to measure sulfate resistance and dynamic properties of lightweight composite panel surface material using liquid modified sulfur and powdery modified sulfur with low melting point which have excellent properties in fast hardening and corrosion resistance and then, to suggest it as basic data to practical application of modified sulfur. Surface material of lightweight composite panel is binder of inorganic material mainly made with magnesia cement without using cement. As a test result, it was shown that compressive strength and mass reduction rate pursuant to sulfur acid dip were smaller when liquid modified sulfur was added rather than powdery modified sulfur. Flowability was higher when liquid modified sulfur was used instead of powdery modified sulfur, and the flexural strength and the compressive strength showed higher strength when powdery modified sulfur was used.***

Keyword--- Powdery Modified Sulfur, Liquid Modified Sulfur, LightWeight Panel

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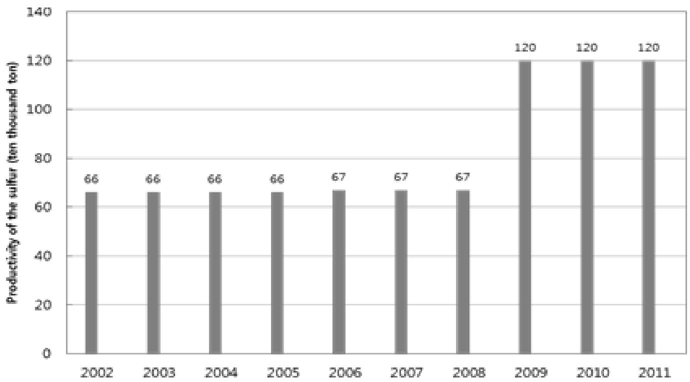
1. INTRODUCTION

Recently, durability performance of concrete has become increasingly important for coastal structures and public buildings that have significant meaning for the public. Sulfur concrete has emerged as a solution. Concrete using sulfur has the properties contributing to the freezing/thawing resistance and corrosion resistance. A growing amount of industrial sulfur has been generated amid surge in consumption of oil and natural gas, along with industrial development. Figure 1 shows sulfur generation. Industrial sulfur is likely to be generated continuously worldwide as long as the humanity use oil and natural gas. In addition, internal spatial structure of buildings is shifting towards rahmen and flat-plate structure away from wall structure for longer life of residential buildings. Contemporary consumers have a desire for interior space tailored to their personality and lifestyle, but this cannot be realized in conventional wall structure. However, the rahmen structure allows personal interior space to be redesigned easily, and for that reason, rahmen structure and construction will further increase.



2. Figure 1 Productivity of sulfur

3. EXPERIMENTAL PLANS AND METHODS

2.1 Experimental plans

To determine dynamic properties of inorganic lightweight composite panel surface material based on modified sulfur addition ratio, addition ratio of powdery modified sulfur("PMS") and liquid modified sulfur("MS") were set to 4 levels, i.e., 0%, 5%, 10%, and 15%. The water-to-binder (w/b) ratio was 55%. Addition ratio of pearlite was set to 10% while addition ratio of magnesium chloride was set to 20%.

Table 1 Experimental factor and level

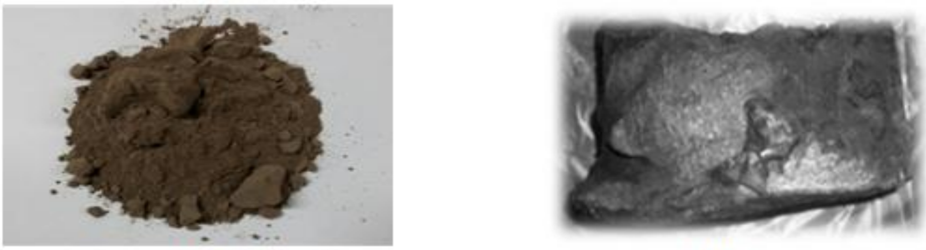
Factor	Level	
Binder	·Magnesium Oxide	1
W/B	·55%	1
Powdery and Liquid Modified Sulfur Addition Ratio	·0, 5, 10, 15 (wt.%)	4
Pearlite Addition Ratio	·10 (wt.%)	1
Magnesium Addition Ratio	. 20 (wt.%)	1
Curing Condition	. Temperature (20±2)℃, Relative humidity (80±5)%	1
Test Item	. Table Flow, Density, Water Absorption, Compressive Strength, Flexural Strength, Sulfate Resistance	6

2.2 Experimental methods

Test piece was made by using the flexural strength test form(40㎜×40㎜×160㎜) in accordance with KS L ISO 679. Table flow test was performed as per KS L 5111. Water absorption ratio was measured as specified in KS F 2459. Flexural strength was measured by using the center-point loading test machine. To minimize the test error, measurements of 3 test pieces(40×40×160(mm)) were averaged. Meanwhile, compressive strength was measured within the range of KS L ISO 679 standards.

2.3 Used materials

The modified sulfur developed by Company H was used. When carrying out the experiment, the modified sulfur was heated to 65±5℃ into a liquid state before being used. The powdery modified sulfur was made by pulverizing semi-solid modified sulfur in separate grinding equipment and blender. The liquid modified sulfur had a density of 2.01g/㎤, while powdery modified sulfur had a density of 2.09g/㎤



Powdery Modified Sulfur   Liquid Modified Sulfur

Figure 2 Modified Sulfur

Table 2 Chemical component of liquid modified sulfur

Chemical component (%)						
S	Si	P	Fe	Cu	Zn	Ti
97	0.319	0.101	0.0534	0.0065	0.0117	0.0344

Table 3 Chemical component of powdery modified sulfur

Chemical component (%)						
SO_3	SiO_2	Al_2O_3	Fe_2O_3	CaO	K_2O	MnO
53.30	30.00	9.94	2.58	1.25	0.93	0.02

2.4 Production process
Modified sulfur is manufactured through polymerization of sulfur and dicyclopentadiene ("DCPD"). U.S. Bureau of Minesand TSI announced the results of itsevaluation of sulfur concrete under 56 types of corrosive environment. It relates to the method for producing modified sulfur by adding 2.5% DCPD and 2.5% cyclopentadiene.

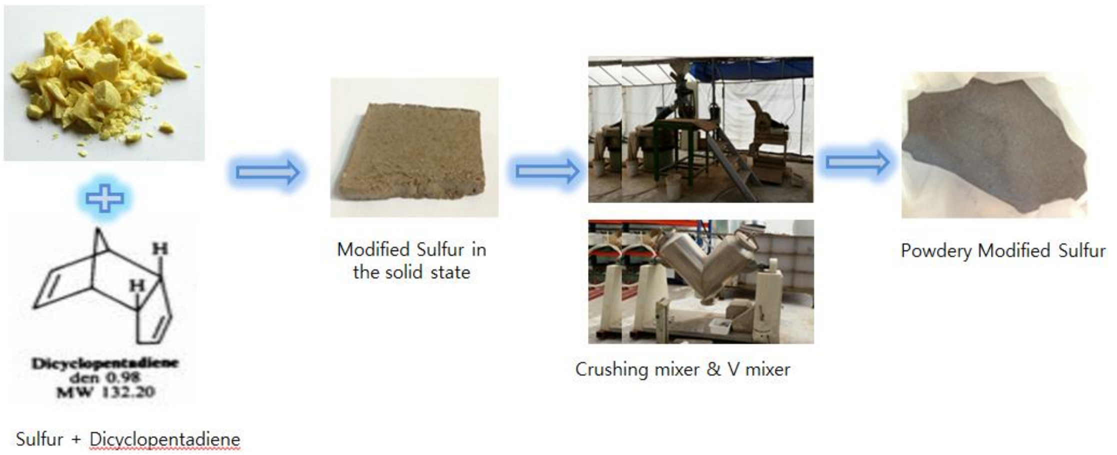


Figure 3 Production process

4. RESULTS AND ANALYSIS

3.1 Table Flow
Figure 3 shows the table flow test results. The results of table flow measurement suggested that the table flow tended to decrease as addition ratio of modified sulfur increased. Table flow decreased sharply when powdery modified sulfur was added, rather than liquid modified sulfur. As liquid modified sulfur will quickly solidify with the elapse of time, pre-hardening workability should be taken into consideration.

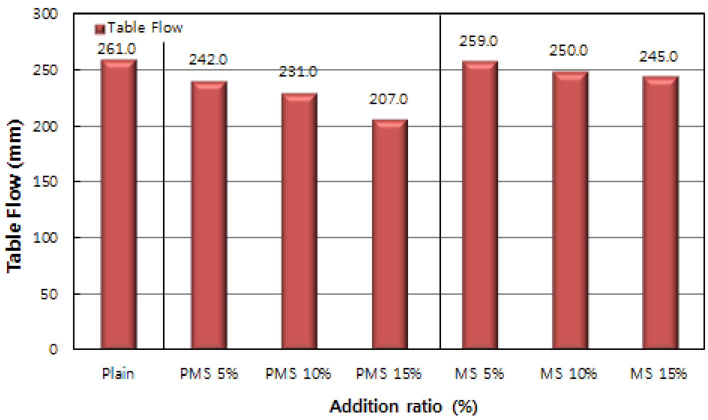


Figure 4 Table Flow

3.2 Density and Water Absorption
Figure 4 shows the results of density and water absorption ratio test. The results of density test suggested that the density tended to increase as the addition ratio of modified sulfur was higher. Powdery modified sulfur exhibited higher density than liquid modified sulfur. The results of water absorption ratio test suggested that water absorption ratio tended to fall as the addition ratio of modified sulfur increased. Powdery modified sulfur showed higher water absorption ratio than

liquid modified sulfur. That is considered attributable to fact that liquid modified sulfur become packed in the mixing process and consequently is not uniformly distributed, making water absorption ratio higher.

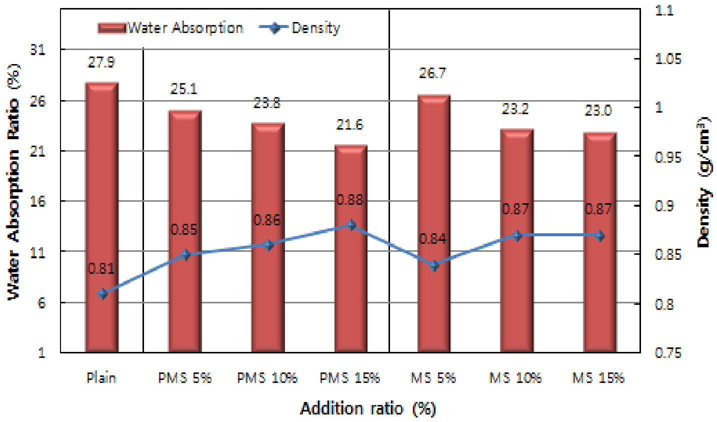


Figure 5 Density and Water Absorption

3.3 Compressive Strength

Figure 5 shows the test results of compressive strength and flexural strength. The strength improved more when powdery modified sulfur was added, rather than liquid modified sulfur. The lightweight matrix added with powdery modified sulfur showed greater strength development because liquid modified sulfur became packed in the mixing process, resulting in weaker strength, and powdery modified sulfur had slightly higher density than liquid modified sulfur. The strength tended to increase as liquid modified sulfur and powdery modified sulfur were added more. However, the strength began to decrease when addition ratio was above 15%. Flexural strength showed a tendency similar to that of compressive strength.

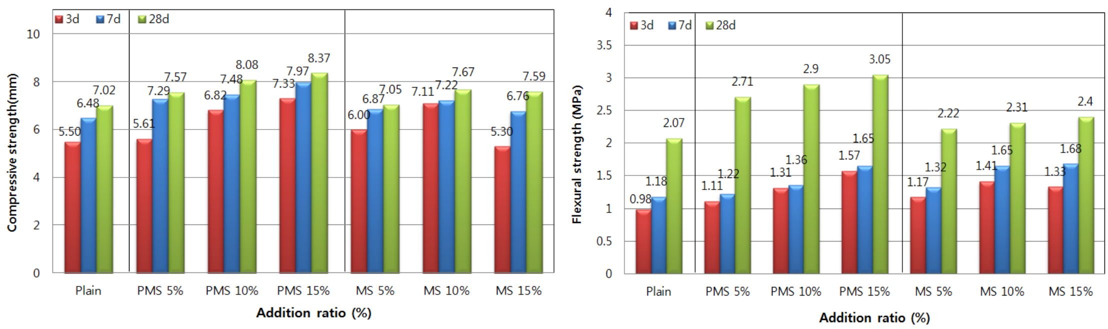


Figure 6 Compressive Strength and Flexural Strength

3.4 Sulfate Resistance

Figure 7 shows the test results sulfate resistance. The results of test suggested that mass reduction rate decreased in test pieces across all ages when addition ratio of powdery and liquid modified sulfur rose. Compressive strength ratio increased as the mass reduction rate of test piece fell. Liquid modified sulfur and powdery modified sulfur exhibited similar compressive strength ratio and mass reduction rate.

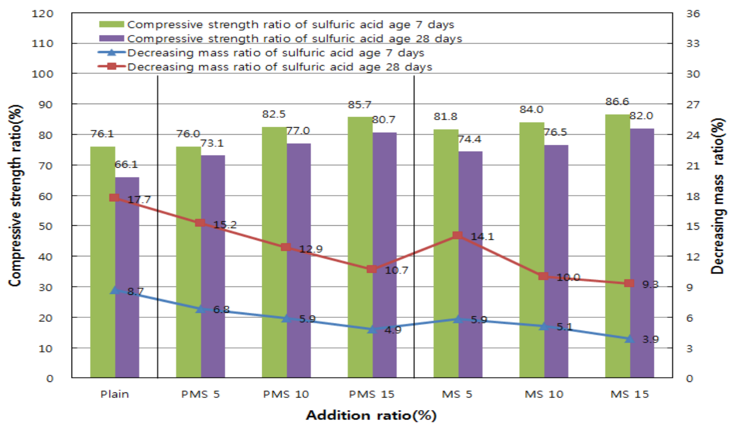


Figure 7 Sulfate Resistance

5. CONCLUSION

In this study, dynamic properties of lightweight composite panel surface material added with liquid modified sulfur and powdery modified sulfur were found to be as follows:

1) The results of table flow measurement showed that table flow decreased as addition ratio of modified sulfur increased. Powdery modified sulfur showed greater reduction of table flow than liquid modified sulfur did.
2) The results of density measurement showed that density increased as addition ratio of modified was higher. Powdery modified sulfur showed higher density than liquid modified sulfur did.
3) The results of water absorption ratio measurement showed that water absorption ratio decreased as addition ratio of modified sulfur was higher. Liquid modified sulfur showed higher water absorption ratio than powdery modified sulfur did.
4) The results of strength measurement suggested that the strength increased as addition ratio of modified sulfur was higher. However, the strength tended to decrease when addition ratio was above 15%. Powdery modified sulfur exhibited higher strength.
5) The results of sulfate resistance measurement suggested that mass reduction rate decreased as addition ratio of sulfur was higher. Compressive strength showed an increasing tendency. Liquid modified sulfur had higher compressive strength ratio than powdery modified sulfur did.

Thus, optimal strength and sulfate resistance properties are considered achievable with addition ratio of 10%. It will be easier to use powdery modified sulfur that provides convenience to work, rather than using liquid modified sulfur.

6. ACKNOWLEDGEMENT

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