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Antifungal Activities of Isothiazoline/Cabamate based Organic Antifungal Agent Activated-Cement Mortars (AACM)

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Abstract

Antifungal agents are used to impart antibacterial or bactericidal properties to commodities and various articles used in industries and can be classified into two broad groups i.e organic and inorganic. Inorganic antifungal agents comprise of Ag, Zn, or Cu, etc. These elements tend to exhibit high level of antifungal activities, non-uniform dispersion in substrates, and have poor properties in expensive and cheap adhesiveness. In this study, the organic antifungal agent was used for the purpose of investigating the antifungal activity of antifungal agent activated-cement mortar (AACM) on the aspergilus niger of various fungus which can be easily discovered in the interiors and exteriors of buildings. In addition, an experiment on the basic physical properties of AACM such as compressive and flexural strength was carried out. The conclusion of this investigation revealed that a dosage increase of antifungal agent exhibits a high inhibitory effect on the aspergilus niger, and although there is a slight decrease in the strength of AACM, the strength of AACM was almost equal to that of inactivated cement mortar.

***Keywords:** cement mortar, antifungal agent, antifungal activity, inhibition zone, antibacterial, organic antifungal agent, isothiazoline/cabamate*

1. Introduction

Structural and functional demands have propelled the broad use of mortar and concrete made with Portland cement. Although these materials exhibit disadvantages such as low tensile strength, drying shrinkage or low resistance to sulfur, and the heterogeneous distribution of many solid component, they are still used widely. It is their advantage in material flexibility which attributes to the possibility of structuring concrete element into a variety of shapes and sizes, and also their natural performance such as good compressive strength, excellent water resistance, and material availability on site.[1-3)]

Hence various investigations and studies on the durability, physical and chemical properties have been carried out, and results of these investigations and studies have aided the development, performance, and serviceability of high durability concrete high fluidity concrete, and high performance concrete such as ultra high strength concrete to advanced states.[3,18,19,23)] Nevertheless, only the academic and scientific studies investigating into the influence of organisms (such as bacteria, fungus, microbial and insects) on concrete have been reported. However, the activities and influence of sulfation bacteria–aerobic bacteria oxidizing sulfuretted hydrogen(H_2S) into sulfuric acid(H_2SO_4)- has hardly been progressed in spite of the well known fact that such organisms can adversely affect concrete.[4)] Furthermore, fungus pose a threat to human-health in the sense that it could cause respiratory diseases which in turn affects the physiological, and psychological conditions of residents. Also, because there are various fungi alive and inhabiting both interiors, and exteriors of buildings, they can affect the living quality of residents.[19,22,24,25)]

The aim of this paper is to study a method of approach in preventing the problems stated above. In addition, it is an objective of this study to investigate the antifungal activities of cement mortar with organic antifungal agent presently used for paints and to present it as a basic scientific data.

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2. Experimental program

2.1 Mix constituents

For the purpose of this study, ordinary portland cement as specified in KS 5201(Specification for Portland Cements) was used in the manufacture of all mixes. The chemical compositions and physical properties of the cement are respectively listed in Tables 1 and 2. Standard sand, predominantly graded to pass a No.30(600 ㎛) and be retained on a No.50(300 ㎛) was used as the fine aggregate.

The type of organic antifungal agent, (as described in Table 3) lively used for paints were employed in this study-with the aim of probably coercing cement mortar to exhibit antifungal activity on the fungus. Aspergillus niger (shown in Fig. 1) which can extensively inhabit interiors and exteriors of buildings in the presence of humidity and available nutrition was used for the purpose of investigating the antifungal activity in specimens.[19,22,23,27)]

2.2 Preparation of test specimens

The experimental specimens were manufactured by mass of 1:2.45 of cement to fine aggregate and their W/C was fixed at 55% in order to observe and analyze the effect of antifungal agent on fluidity of the mortar. Antifungal agents were directly added into the specimens, which were measured at six levels of 0, 0.3, 0.5, 1, 2 and 5% by mass to cement. Details of the mixes used in the test program are given in Table 4.

The sizes of specimens used for testing antifungal activity, compressive and flexural strengths were 40 ㎜ (diameter)×5(height)㎜, and 40×40×160 ㎜ respectively.

Cement mortar was manufactured in accordance with ASTM C 305(Standard Practice for Mechanical Mixing of Hydraulic Cement Pastes and Mortars of Plastic Consistency). After placing the cement mortar into molds, a polythene sheet was used to cover the molds for a period of 24h, at 20°C ±2 in the laboratory. After 24h the specimens for strength test were removed from the molds and placed in a curing tank until measurement dates. On the other hand, the specimens for testing of antifungal activity were wrapped and sealed in polythene sheets until the antifungal activity

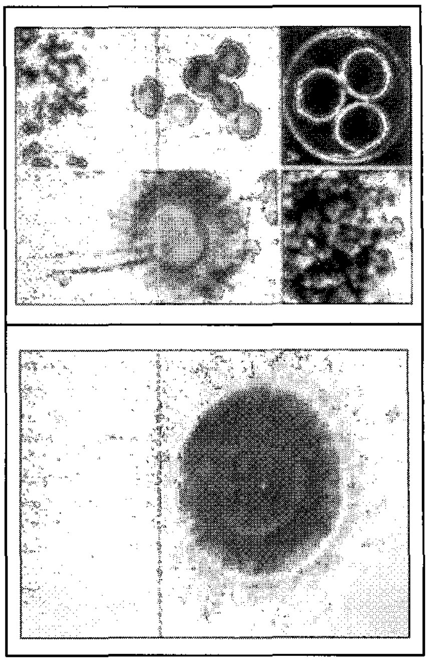

Fig. 1 Photograph of aspergilus niger

Table 3 Properties of Isothiazoline / Cabamate based antifungal agent

Composition	Isothiazoline/Cabamate
pH	4.5 ~ 7.0
Density	1.10
Appearance	white aqueous solution

Table 4 Mix design

C : S (by weight)	Antifungal agent content (wt.%, by)	W/C (%)
1 : 2.45	0	55
	0.3	
	0.5	
	1	
	2	
	5	

Table 1 Chemical composition of ordinary portland cement

CaO	SiO_2	Al_2O_3	Fe_2O_3	MgO	SO_3	Insol.	Ig. Loss	Total (%)
65.3	22.2	5.1	3.2	1.3	1.9	0.3	0.6	99.9

Table 2 Physical properties of ordinary portland cement

Density	Fineness (cm^2/g)	Setting time (h-min)		Compressive strength (MPa)		
		Initial set	Final set	3 days	7 days	28 days
3.14	3300	2-18	3-12	15.0	25.5	43.3

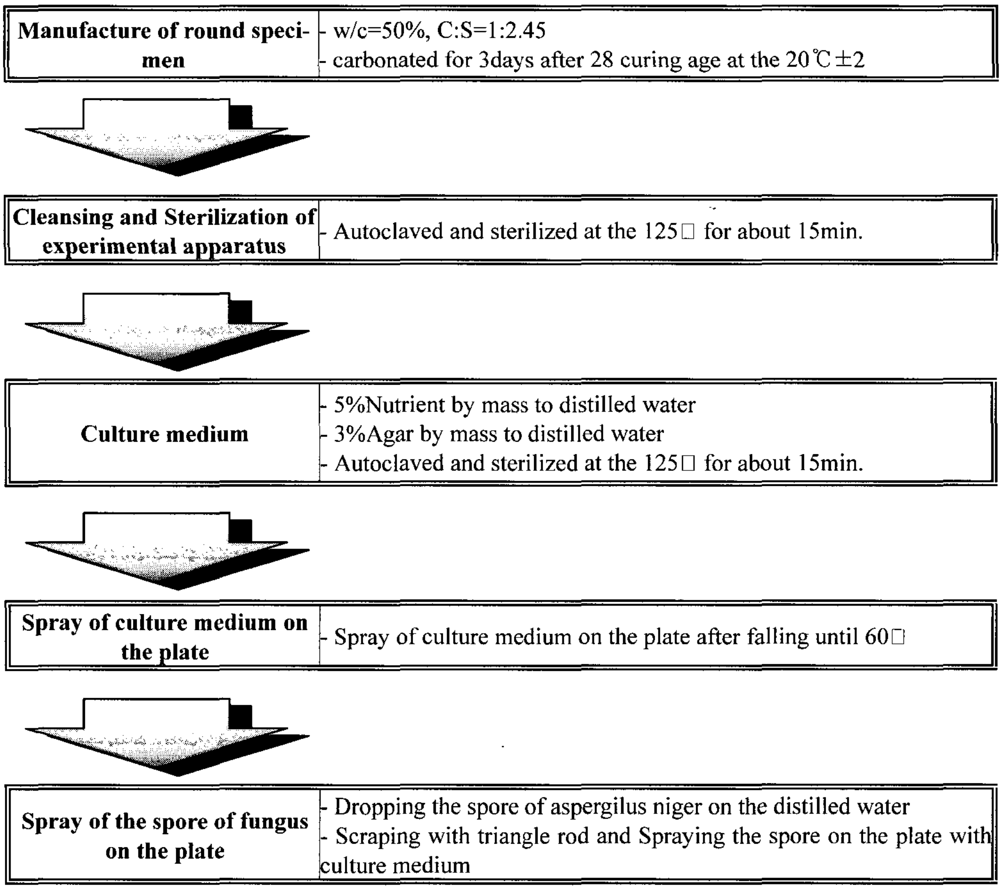

Fig. 2 Procedure of experiment for antifunal activity

in the specimens were measured; this was done because the moisture of specimens placed in water tended to disturb precise measurement of antifungal activity. Also, the specimens labeled for antifungal activity were carbonated for 3 days in the chamber set to maintain a 10% carbon dioxide concentration at 20 °C and relative humidity of 65%.

2.3 Test procedure

(1) The flow tests of specimen were performed by use of a flow table conforming to ASTM C 230(Standard Specification for flow Table for Used in Tests of Hydraulic Cement) in order to analyze and comprehend the change of consistency in accordance with addition of antifungal agent.

(2) Compressive and flexural strength

Measurement of flexural strength for the activated cement mortar produced in this study was carried out in conformance to ASTM C 328(Standard Test Method for Flexural Strength of Hydraulic Cement Mortars). Portions from broken prisms (during flexural strength test) of each specimen were used for testing compressive strength in accordance with ASTM C 349(Standard Test Method for Compressive Strength of Hydraulic Cement Mortars-Using Portions of Prisms Broken in Flexure).

(3) Measurement of antifungal activity

① Preparation of specimens for antifungal activity and Cultivation of fungus[15,16]

Round specimens made on the basis of mix design were acceleratedly carbonated in proper condition. The round specimens and the liquid state of culture medium made by admixing distilled water, 5% nutrient(by mass to water) and 3% agar(by mass to water) in the flask, were autoclaved and sterilized for about 15 minutes at 125°C, because the culture medium as well as the round specimens can probably possess the invisible fungus or spore.

The constant content of the above declared spore of aspergilus niger was equally sprayed on the culture medium in case the liquid culture medium may become a colloid after been poured into a plate. Then the round specimens were placed in the middle of the spore-sprayed plate, which were sealed and cultivated in the incubator in order to prevent the invasion of another fungus or bacterium. A more detailed and sequential procedure of measurement is shown in Fig. 2.

② Assessment of antifungal activity

The evaluation criteria of the inhibition zone, as shown

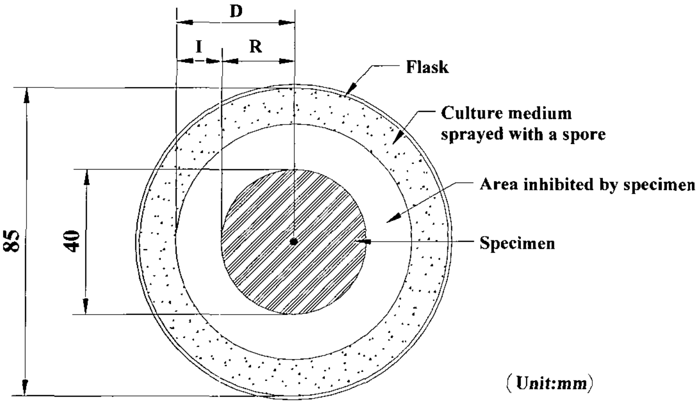

Fig. 3 Measurement of Inhibition zone

in Fig. 3 and Eq. 1, was presented as the length given by subtracting the radius of round specimen from the distance between the end of inhibition zone and the center of the round specimen in order to quantify the antifungal activity of activated cement mortar. The detailed size of the inhibition zone is calculated from Eq. 1 as follows.

The major axis $I_l = (D_l - R_l)$

The minor axis $I_s = (D_s - R_s)$

$$I = (I_l + I_s)/2 \quad \text{--------------------}(1)$$

where, I : Inhibition zone(㎜)

D : Distance between the end and the end of inhibition zone(㎜)

R : Radius of round specimen(㎜)

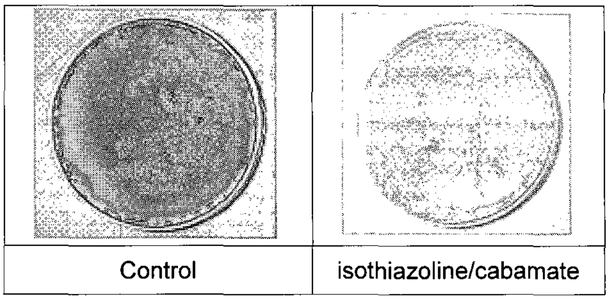

Fig. 4 Photograph of antifungal activity of agent used

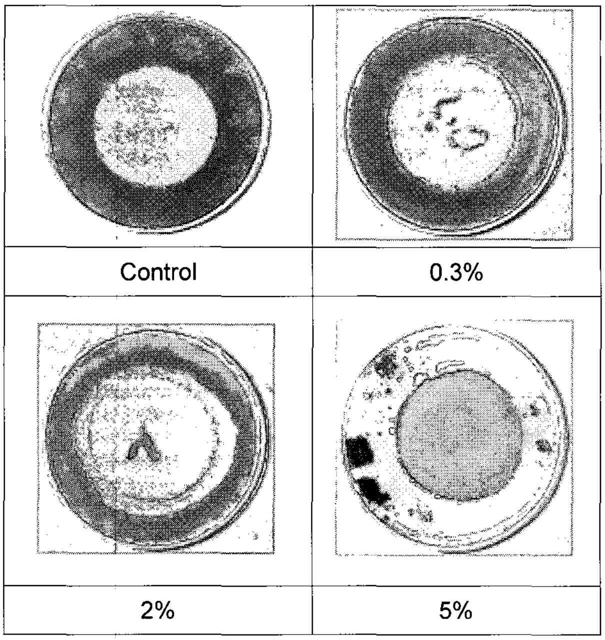

Fig. 5 Photograph of antifungal activity of cement mortar activated by Isothiazoline/cabamate based agent

3. Results and discussion

3.1 Antifungal activity

3.1.1 Natural antifungal activity of antifungal agent

Fig. 4 shows the natural antifungal activity exhibited by introducing drops of antifungal agent on the culture medium containing spore of aspergilus niger. Also, it was observed that the type of the antifungal agent used in this study exhibited excellent antifungal activity on aspergilus niger. Hence the experiment confirmed that the antifungal activity of the antifungal agent was naturally eliminated (as shown in fig. 4).

3.1.2 Antifungal activity of activated cement mortar

Fig. 5 shows the antifungal activity of cement mortar activated by isothiazoline/cabamate based organic antifungal agent on aspergilus niger. Antifungal activity of the cement mortar activated by antifungal agent of isothiazoline /cabamate increased with increase in the dosage of the agent. Figs 6 and 7 present the antifungal activity of cement mortar activated by Isothiazoline/cabamate based mortar on aspergilus niger from the period of exposure to the fungus-active environment for 2 days and 7 days respectively. In the case of cement mortar activated by Isothiazoline /cabamate based antifungal agent, the effect of antifungal activity was enhanced (almost linearly) according to the increased addition ratio of Isothiazoline/cabamate based antifungal agent. And also, antifungal activity at the exposed period of 7 days was almost equal to the antifungal activity at the exposed period of 2 days. Because of that, it was found that Isothiazoline/cabamate based antifungal agent preserve the antifungal activity of specimen irrespective of exposed period to the fungus-active environment.

3.2 Physical properties of antifungal agent-activated cement mortar

3.2.1 Effect of antifungal agent on consistency of activated cement mortar

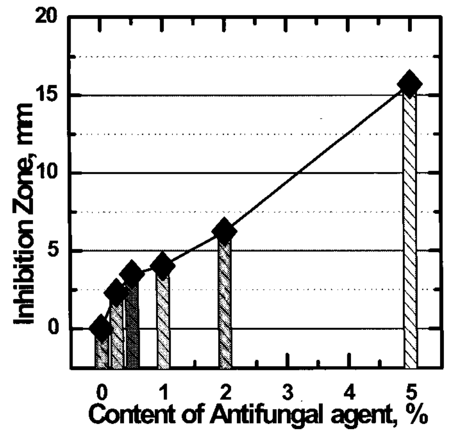

Fig. 6 Inhibition zone according to content of antifungal agent after 2days

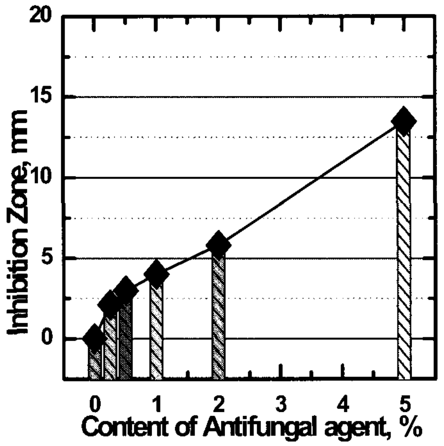

Fig. 7 Inhibition zone according to content of antifungal agent after 7days

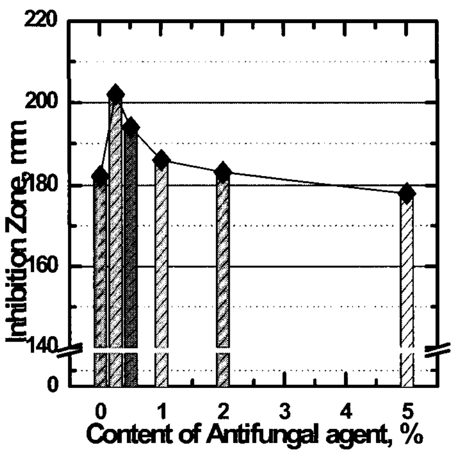

Fig. 8 Flow according to content of antifungal agent

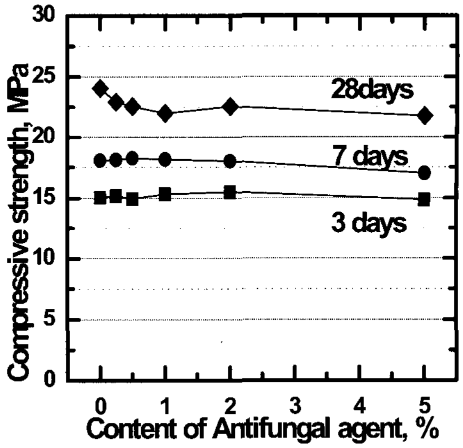

Fig. 9 Compressive strength according to content of antifungal agent

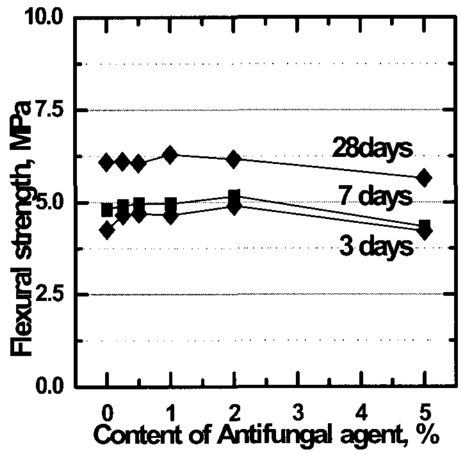

Fig. 10 Flexural strength according to content of antifungal agent

Fig. 8 represents the flow of cement mortar activated by the isothiazoline/cabamate based antifungal agent according to the content of antifungal agent to cement. It is revealed that the flow of cement mortar activated by antifungal agent was the highest when 0.25 percent antifungal agent were added into the specimen. This is probably due to the reaction of a little surfactant present in the antifungal agent. Also, the flow of specimen with antifungal agent was relatively excellent in comparison with non-activated cement mortar, but the flow decreased with increase in the dosage of antifungal agent after it recorded the highest peak at the content of 0.25%.

From the experimental result of the flow of specimen, it is possible that excessive usage of antifungal agent for activation of cement mortar may cause loss in consistency cement mortar and can act adversely from the standpoint of consistency in cement mortar.

3.2.2 Effect of antifungal agent on strength of activated cement mortar

Figs. 9 and 10 present the compressive and flexural strength of activated cement mortar according to the addition ratio of antifungal agent. As shown in Fig. 9, the compressive strength of activated cement mortar with change in the content of antifungal agent exhibited about 22 to 23Mpa at 28 curing ages and was almost equal to that of non-activated cement mortar although there was a slight decrease of about 1 to 3MPa at 28 curing ages. The flexural strength of activated cement mortar amounted to about 6MPa at 28 curing ages within the addition of 2%, and also was almost similar to that of non-activated cement mortar.

Hence, it is presumed that there is no adverse effect of isothiazoline/cabamate based antifungal agent on the strength of activated cement mortar.

4. Conclusions

Based on results obtained from the basic investigation on antifungal activity and physical properties of activated cement mortar manufactured by changing types of anifungal agents, and the ratio of antifungal agent addition, the following conclusions were reached.

1) A small quantity of isothiazoline/cabamate based antifungal agent enhanced the antifungal activity of cement mortar so much to a point that its inhibition zone may amount to about 15 ㎜ in case of the addition ratio of 5% to cement.

3) Antifungal activity of cement mortar activated by isothiazoline/cabamate based antifungal agent continued to increase almost linearly according to increase in the ratio of antifungal agent addition irrespective of the 2days and 7days exposed period to the fungus-active environment.

4) Consistency of cement mortar activated by isothiazoline/cabamate based antifungal agent was dependent on the content of antifungal agent. It was the highest at the addition ratio of 0.25% to cement and after that, it continued to decrease with increase in the dosage of antifungal agent. Nevertheless, Consistency of cement mortar with antifungal agent was better than non-activated cement mortar.

5) The effect of isothiazoline/cabamate based antifungal agent on strength such as compressive and flexural strength of cement mortar was negligibly insignificant; that it might be about as equal to that of non-activated cement mortar.

6) This study focused on antifungal activity and so far have shown the efficient application of antifungal agent to cement mortar in spite of the dependence on the type of antifungal agent. But further investigations to assess the precise effect of other types of antifungal agent such as inorganic and natural agent etc. and to comprehend the action principle are likely to be required in order to present basic and scientific data on the antifungal activity of cement mortar in application.

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