Development of a Functional Interior Material Using Scallop Shell Lime

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ABSTRACT

About 360,000 tons of scallop are unloaded in Japan now, and most of them are concentrated in Hokkaido. The illegal dumping of the scallop shell became the problem, but the recycling rate largely rose by subsidies in late years. However, subsidies are not necessarily continuing permanently.

It was found that scallop shell lime is a natural material with little environmental load and high environmental performance, such as effects of humidity control, absorbing smells and VOC, and preventing mold. In addition, water resistance was confirmed by polished finish, this performance is not appeared in general lime made from limestone.

In this paper, water resistance and environmental performances are compared between scallop shell lime and general lime.

From the result of the examination, it was found that the examination body of the scallop shell lime with polished finish could have both humidity control effect and water resistance performance. From these results, it is anticipated that the scallop shell lime with polished finish is effective as an interior material of the places such as restroom or kitchen.

In addition, in the investigation about the water resistant mechanism, a prediction that expression of water resistance is influenced by the speed of carbonation was provided.

Keywords: *indoor environmental quality, scallop shell lime, natural materials*

1. INTRODUCTION

Today, about 360,000 tons of scallops are landed throughout Japan, with almost all of that being concentrated in Hokkaido. There was previously a problem with illegal dumping of scallop shells, but in recent years subsidies have been provided, and the recycling rate has increased greatly due to use as soil improvement material, underdrainage channeling material, and in other applications. However, these subsidies will not continue forever. Also, there are substitutes other than shells for applications such as soil improvement material and underdrainage channeling material, and these applications do not make use of the special characteristics of scallop shells.

In previous research, a basic survey was carried out of environmental adjustment type building materials using scallop shell lime, and it was confirmed that this is a building material employing natural materials that has low environmental impact and good performance. It also exhibits water resistance when given a polished finish.

This report examines the use of plastering materials having the added value of environment adjustment function, while comparing between scallop shell lime and regular lime in areas such as differences in water resistance and environmental performance when given a polished finish.

2. OVERVIEW OF REGULAR LIME BASED PLASTERING MATERIALS

In this report, scallop shells ground into powder are called “scallop shell powder,” calcined scallop shell powder is called “scallop shell lime,” slaked scallop shell lime is called “scallop shell paste,” and material such as aggregate mixed with scallop shell paste is called “scallop shell plastering material.” In addition, ordinary finishing is called “mortar finishing,” and further finishing by applying pressure with a trowel is called “polish finishing.”

Quicklimes made by calcining limestone and scallop shell lime have the same ingredient (calcium oxide) aside from impurities such as minute amounts of iron, and scallop shell lime is a material which can substitute for regular lime, as shown by the fact that shell mortar was previously used as a plastering material in Japan.

3. WATER RESISTANCE TEST

3.1 Overview of test

It was thought that perhaps there are differences in the degree that water resistance is exhibited due to factors such as the temperature of the water used when slaking scallop shell lime. Three slaking conditions were established: ordinary temperature (approx. 23ºC), low temperature (approx. 10ºC), and high temperature (approx. 50ºC). Immediately after slaking at ordinary temperature, ice-chilled paste was made by cooling with ice water. A frame was attached to a 20 cm × 20 cm test specimen made using this paste, and 100 cc of water was added. Water was wiped off after 1 minute, and the water absorption rate for 1 minute was found by determining the difference in weight of the test specimen before adding water and after wiping off water.

3.3 Test result

Figure 1 shows the results of water resistance testing. It is evident that shell lime polishing exhibits higher water resistance compared to regular lime polishing. The difference between shell lime polishing 1 and shell lime polishing 2 is likely to be an error arising because the specimen was prepared by hand, rather than an effect due to the different temperatures of water used for slaking.

With regular lime polishing, there are large differences in appearance depending on whether other materials such as cellulose fiber are mixed in, and types with mixed material seem to have a stronger surface luster. However, the results showed it is unlikely that the presence/absence of mixed materials has a major effect on water resistance.

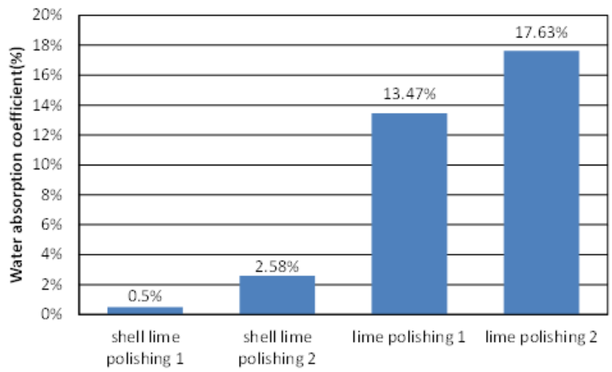


Figure 1: Result of water resistant examination

4 INVESTIGATION OF COMPOSITION VIA XRD ANALYSIS

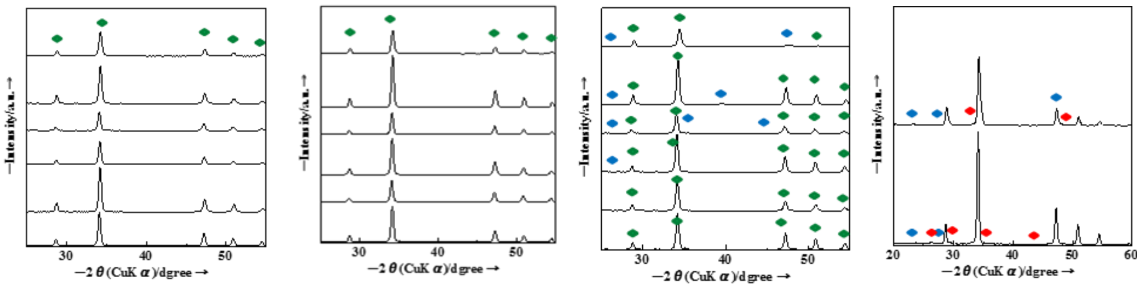
4.1 Overview

Using the paste prepared in section 3, an investigation was carried out to determine whether differences in slaking conditions have an impact on exhibiting water resistance, and whether the method of component growth during the curing stage plays a role in exhibiting water resistance. Also, as shown in Figure 2, it was thought that aragonite, a calcium carbonate component with a horizontal structure allows water to pass through less readily than calcite with its vertical structure, and this may have an effect on manifestation of water resistance. Therefore, the content percentages of aragonite and calcite were investigated through XRD analysis.

Figure 2: Crystal structure of calcite and aragonite

4.2 Test result

Test results are shown in Figure 3. The type slaked at low temperature and the type slaked at high temperature showed no appearance of calcium carbonate, and no difference was evident. The type slaked at ordinary temperature showed appearance of calcium carbonate, primarily of the calcite type. With ice chilling, there was appearance of calcium carbonate of both the argonite and calcite type, and the argonite type calcium carbonate was thought to have an effect on exhibiting water resistance, but as shown by the results of water resistance testing in section 3, there were no differences between the test specimens in terms of water resistance.



Low High Ordinary Ice

Figure 3: Result of XRD analysis

5 INVESTIGATION OF VARIOUS TYPES OF PERFORMANCE USING TEST SPECIMENS

5.1 Overview of test

Table 1 and Figure 4 provide an overview of test specimens. An undercoating and middle coating were applied to a 20 cm × 20 cm plasterboard, and this was given a mortar finish. Then a luster was brought out by applying pressure with a trowel, and the result was taken to be the polished finish.

specimen	under coat	intermediate coat			finish	
	material	material	aggregate	ratio	material	aggregate
shell lime polishing	under coat material	shell lime	shell powder	1:01	shell lime	—
lime polishing		lime	kansui	01:00.5	lime	
shell lime mortar		shell lime	shell powder	1:01	—	—
lime mortar		lime	hakuryu	01:00.5	—	—

Table 1: Examination body summary

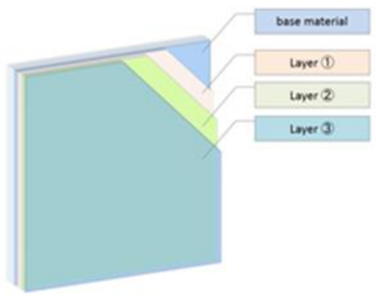


Figure 4: Cross section of the examination body

5.2 Test of moisture adsorption/ desorption performance

In accordance with JIS A 1470-1 “Determination of water vapour adsorption/desorption properties for moisture-regulating building materials — Part 1: Response to humidity variation,” the test specimen was left to stand in a constant temperature and humidity bath. The moisture adsorption process was done at 23ºC/ 75% and the moisture desorption process at 23ºC/ 50%, and in each case the process was carried out 12 hours at a time, and changes in test specimen weight were recorded.

Figure 5 shows the results combined with wallpaper data from previous research. The shell lime test specimen has performance almost on a part with regular lime, in terms of both moisture adsorption and moisture desorption rate, and result were obtained with moisture adsorption 2 times or more higher and moisture desorption 3 times or more higher than ordinary wall paper (vinyl cloth). The notable point here is the polished finish, and moisture adsorption/desorption performance on a par with an ordinary mortar finishing was confirmed, regardless of having water resistance.

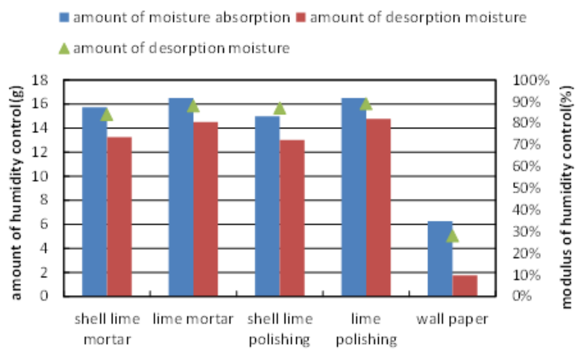
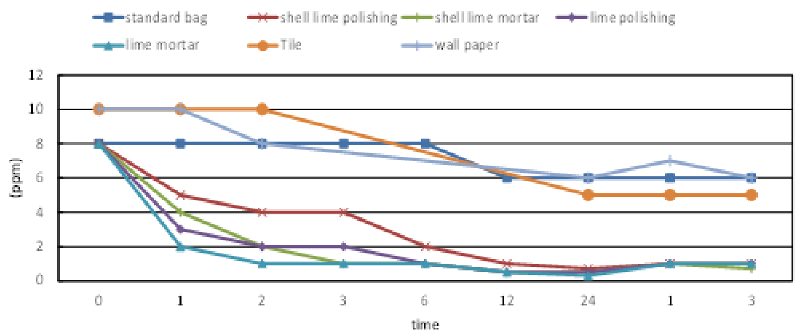


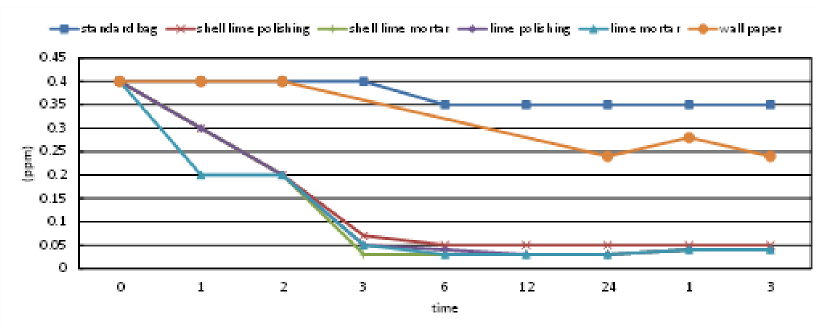
Figure 5: Structure of scallop lime

5.3 Adsorption-emission testing for ammonia-formaldehyde

Each of the test specimens in Table 1 was made into a 10 cm × 10 cm size and placed into a bag with capacity of 20 L. Ammonia was set to an initial concentration of 10 ppm and formaldehyde to an initial concentration of 0.4 ppm, and the decline in concentration over time was measured for each test specimen. As shown in Figure 6, the results showed that although there are differences in adsorption speed for both ammonia and formaldehyde, in the end adsorption up to about 1/10 or less was reached after 24 hours for both shell lime polished/mortar and regular lime polished/mortar.



Ammonia



Formaldehyde

Figure 6: Result of ammonia and formaldehyde adsorption examination

5.4 Fungus resistance test

Fungus was sprayed onto each type of test specimen: shell lime polished, shell lime mortar, regular lime polished, regular lime mortar, wall paper, plaster board, wood, and earth wall. The inside of the sealed container was set to a humidity of 90% or more, and growth of fungus was observed. The results showed that fungus grew in a condition like white cotton on the plaster board, wood and earth wall, but no growth of fungus was evident on the shell lime and regular lime test specimens.

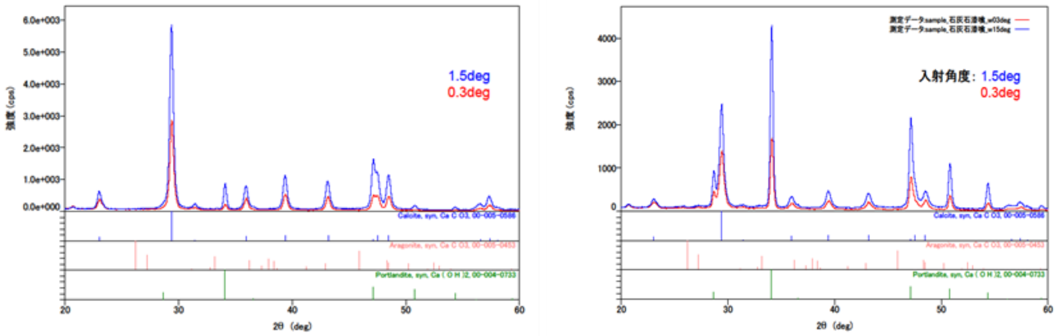
6 XRD DIFFRACTION IN POLISHED PLASTERING MATERIALS

6.1 Overview of test

Among the items prepared in Table 2, those used as test specimens were: polished finish plastering material made with ice chilled scallop shell paste (shell lime polished), and for comparison polished finish plastering material made from regular lime (regular lime polished).

6.2 Test results

Figure 7 shows the test results. In the shell lime polished specimen, the surface layer is almost entirely calcium carbonate, and in the regular lime polished specimen it is calcium hydroxide. It was confirmed that carbonization progresses more quickly with the shell lime polished specimen. In general, the density of calcium carbonate is 2.7 g/cm³, and the density of calcium hydroxide is 2.2 g/cm³. The results suggest the possibility that the difference between these components covering the surface relate to manifestation of water resistance.



Shell lime Lime

Figure 7: Result of XRD diffraction in polished plastering materials

7 CONCLUSION

In investigating various types of environmental performance using test specimens, it was confirmed that shell lime has moisture-regulating, gas adsorption and anti-fungal performance on a par with regular lime. Also, in water resistance testing, it was confirmed that water resistance typical of scallop polishing is exhibited, and in investigation of the water resistance mechanism, the results indicated that perhaps the high speed of carbonization compared to regular lime has an effect on manifestation of water resistance.

Plastering material using scallop shell lime has outstanding environmental performance, and is an environmentally-friendly building material because it reuses waste. In addition, it exhibits water resistance when given a polished finish, and has potential for use in settings involving plumbing. Even when polished, environmental performance such as adsorption-desorption performance does not degrade, and can be realized together with water resistance performance, and thus there is potential for applications such as wall material in plumbing-related setting such as toilets where odors are a particular worry.

REFERENCES

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