Improvement of Fireproof and Formaldehyde Adsorption Ability of Charcoal Board Mixed with Calcium Hydroxide

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Abstract

Recently, many kinds of unused woody resources, such as thinner timber and scrap wood, have been generated from sawmills in Japan. How to use these resources has become a big issue. At the same time, the formaldehyde contained in materials of furniture considered as the cause of sick house syndrome. Therefore, charcoal board that adsorbs formaldehyde was developed by Sumiya Ltd. for solving these two problems. This charcoal board has high adsorption ability of formaldehyde and its bending strength is stronger than that of plaster board which is generally used in Japan, but the board does not have sufficient fireproof ability and cannot be used in public houses. If the charcoal board that has high fireproof ability is developed, the board can be used for public houses. We were trying to develop charcoal board mixed with calcium hydroxide for improving board's fireproof ability. As a result, this charcoal board mixed with calcium hydroxide has high fireproof ability and the same quality of bending strength as plaster board when the board is reacted with carbon dioxide gas. Moreover, the charcoal board mixed with calcium hydroxide has high adsorption ability of formaldehyde.

1. Introduction

Many kinds of unused woody resources, such as thinner timber and scrap wood, have been generated from sawmills in Japan. Most of these resources have been burnt up, but recently it is impossible to burn them up for the sake of environmental protection. Therefore, how to use these resources has become a big issue. At the same time, the formaldehyde contained in materials of furniture is considered as the cause of sick house syndrome. For this reason, the installation of ventilators has been required inside houses. Then, charcoal board that adsorbs formaldehyde was developed by Sumiya Ltd. for solving these two problems. If this charcoal board is used as a building material, ventilator usage will be decreased and electricity cost will become lower. Moreover, these things will signify energy saving. However, the board does not have high fireproof ability and cannot be used in public houses. Therefore, we are trying to develop charcoal board mixed with calcium hydroxide for improving the fireproof ability of the board.

Building materials have to satisfy JIS (Japanese Industrial Standards) for bending strength and fireproof ability. Therefore, this paper reports the present condition of the bending strength and fireproof ability of the board. Moreover, the adsorption ability of formaldehyde is reported in this paper.

2. Experimental

2-1. Producing Samples

High temperature charcoal powder that was carbonized at 1200℃ and low temperature charcoal powder that was carbonized at 600℃ were used as basic ingredients. High temperature charcoal – low temperature charcoal ratio was 7 - 3. First, 83wt% calcium hydroxide, 17wt% charcoal and 0.01wt% water were mixed using an agitator for 3 minutes. Second, the mixed powder was put into a columnar mold sized 100×100×40mm and 0.02wt% calcium powder was sprinkled on the surface. After that, the samples were pressed at 20MPa for a minute using a Press Machine. Next, the samples were taken out of the mold, put into closed container and reacted with carbon dioxide gas of flow rate 30ml/min.

2-1-1. Samples for Bending Strength Test

The samples that had changed carbonation rate and calcium hydroxide – charcoal ratio were used for the bending strength test. The carbonation rate was changed into 7.3, 36.7, 78.6, 88.9% and the calcium hydroxide – charcoal ratio was changed into 63wt% - 37wt%, 73wt% - 27wt%, 83wt% - 17wt%. The size of the samples was 100×100×4mm.

2-1-2. Samples for Fireproof Ability Test

The samples in which calcium hydroxide – charcoal ratio was changed into 63wt% - 37wt%, 73wt% - 27wt%, 83wt% - 17wt% were used for the fireproof ability test. The size of the samples was 100×100×4mm.

2-1-3. Samples for Adsorption Ability of Formaldehyde Test

The samples were put into a Drying Machine that was set at 60℃ for a day. After that, the samples were cut to 33 ×50×10mm using a Diamond Cutter.

2-2. Evaluation

2-2-1. Bending Strength Test

The bending strength test was done conforming to JIS A 1414 that if the bending strength is more than 5N/mm^2, it can be used in a house. First, the ultimate load was measured by the Bending Strength Machine. Next, the bending strength was calculated by the bending strength formula (i.e., Figure 1.).

$$\sigma_{b3} = \frac{3PL}{2\omega t^2}$$

P: ultimate load (N), L: supporting point length (mm),
ω: width (mm), t: thickness (mm)

Figure 1. Bending Strength Formula

2-2-2. Fireproof Ability Test

The fireproof ability test was done at Japan Testing Center for Construction Materials. The test samples were heated in the furnace for 20 minutes, and then if the total calorific value is less than 8MJ/m^2, the board can be passed the test.

2-2-3. Adsorption Ability of Formaldehyde Test

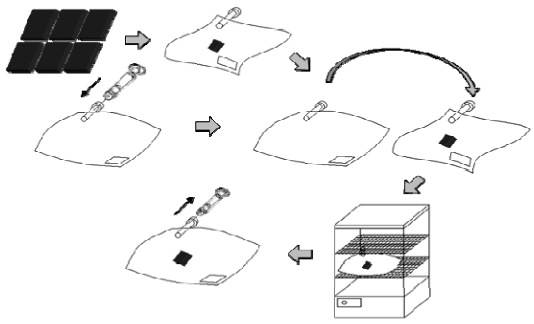

Figure 2. Methods of Adsorption Test

Air and formaldehyde gas of the same temperature and humidity were put in a tetra bag whose value is 10L, and the tetra bag was put in the constant temperature and humidity zone for a day. Next, the board's samples were put in another tetra bag and the gas mixture of air and formaldehyde was flowed in the tetra bag that contained the board's samples. After that, the concentration of formaldehyde was constantly measured using a Kitagawa style gas detecting tube (i.e., Figure 2.).

3. Results and Discussions

3-1. Bending Strength Test for Changing Carbonation Rate

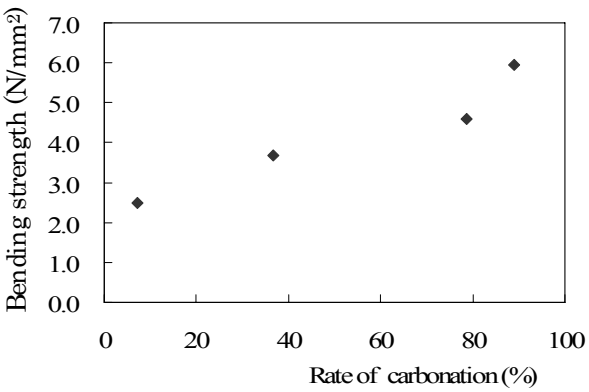

Figure 3. Relationship between Bending Strength and Rate of Carbonation

Figure 3. shows the relationship between the bending strength and the rate of carbonation. The bending strength increases more when the rate of carbonation increases more. Moreover, when the rate of carbonation is more than 85%, the board can pass JIS A 1414.

3-2. Bending Strength Test for Changing Calcium Hydroxide- Charcoal Ratio in the Board

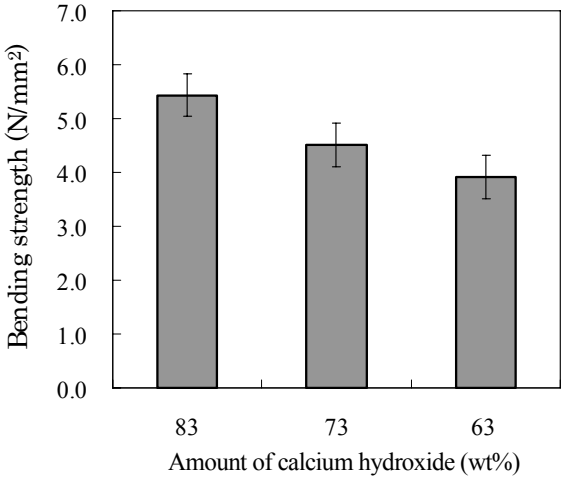

Figure 4. Relationship between the Bending Strength and the Amount of Calcium Hydroxide in the Board

Figure 4. shows the relationship between the bending strength and the amount of calcium hydroxide in the board. The bending strength increases more when the amount of calcium hydroxide in the board increases more, and when the calcium hydroxide - charcoal ratio is 83wt% - 17wt%, the board has been able to pass JIS A 1414.

3-3. Fireproof Ability Test

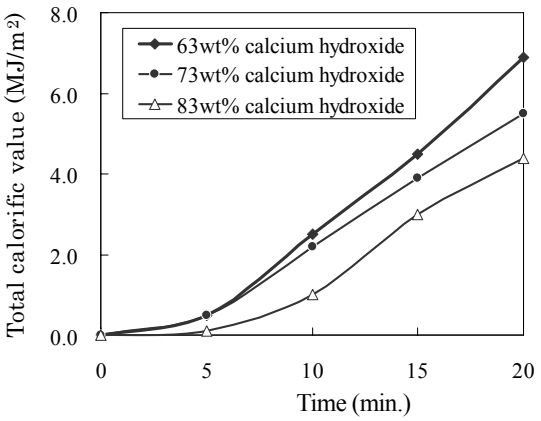

Figure 5. Total Calorific Value of the Board

The total calorific value was measured when the amount of calcium hydroxide in the board was changed. The result is shown in figure 5. The total calorific value is lower when the amount of calcium hydroxide in the board increases more. Moreover, all of the samples have been able to pass the fireproof ability test.

3-4. Adsorption Ability of Formaldehyde Test

We found that the bending strength and fireproof ability of the board can pass when the calcium hydroxide – charcoal ratio is 83wt% - 17wt%. Therefore, the board's adsorption ability of formaldehyde was measured. The result is shown in figure 6. The concentration of formaldehyde has decreased with time, and the Ministry of Health's environmental guide states that if the concentration of formaldehyde in a house is less than 0.08ppm after 24 hours, the board is safe.

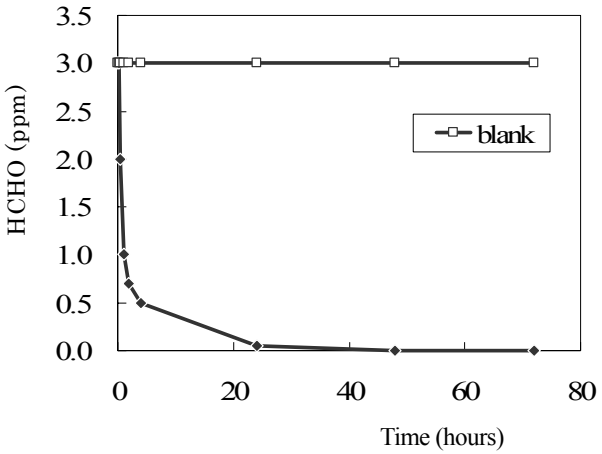

Figure 6. Changing the Concentration of Formaldehyde

4. Conclusion

When the board has the ratio of more than 85% calcium hydroxyde, the board has been able to pass the fireproof ability test. Moreover, the board has been able to pass the fireproof ability test, and has sufficient adsorption ability of formaldehyde. Thus, we have succeeded in developing a new building material which has high fireproof ability, the same quality of bending strength as plaster board and has sufficient adsorption ability of formaldehyde.

As a result, it is possible that ventilator usage will decrease and electricity costs will become lower,and these things will also signify energy saving.