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Properties of Cement Matrix According to Replacement Ratio of Bamboo Activated Carbon

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Abstract

Recently, China's air pollution is serious because of China's fine dust. Fine dust is a first-class carcinogen and plans are needed to reduce it. Therefore, in this study, an experiment was conducted to investigate the adsorption properties of the fine dust of the matrix by producing a matrix incorporating bamboo activated carbon. Cement and bamboo activated carbon are used as materials used, and in the case of bamboo activated carbon, harmful substances can be adsorbed. The replacement ratio of bamboo activated carbon was 0% to 40% in 10% increments, and experiments on absorption rate, density, fluidity, strength, and fine dust adsorption performance were performed. After inserting the measuring device and the air circulation device, the measurement was performed for 24 hours in 1 hour increments. As the replacement rate of bamboo activated carbon increases, the strength tends to decrease gradually. The reason is that bamboo activated carbon has a lower strength than cement, so it decreases. The absorption rate is gradually increasing as the replacement rate increases. This is because bamboo activated carbon has a property of absorbing moisture and gradually increases as the replacement rate increases. Density and table flow tend to decrease gradually as the replacement rate increases. In terms of density, bamboo activated carbon is thought to decrease gradually due to its low density. In the case of table flow, bamboo activated carbon absorbs moisture, so it gradually decreases by absorbing the moisture required for the flow. Fine dust concentrations tend to gradually decrease as the replacement rate of bamboo activated carbon increases. The reason for this is considered to be gradually reduced by the nature of adsorbing fine dust of bamboo activated carbon. The strength is lower than that of a regular finishing board, so improving it can help improve indoor air quality.

Keywords: *Fine dust, Indoor air quality, Building materials, Absorption, Finishing board*

1. Introduction

Fine dust from China's recent plant operations, coal burning, and industrial activities has spread to South Korea due to the west wind, which is a serious condition for air pollution in Korea. Korea's heavy metals in fine dust occur 87% due to Chinese influence [Figure 1]. In the OECD average fine dust level, Korea was the highest, more than twice the average. The fine dust caused the metropolitan area to come up with measures to reduce the fine dust emergency. Since March 2018, the Ministry of Environment has strengthened the 24-hour environmental standard for fine dust (PM 2.5) from 50 μm to 35 μm / m^3. It should be done at the boundary level, refraining from masking or going out.

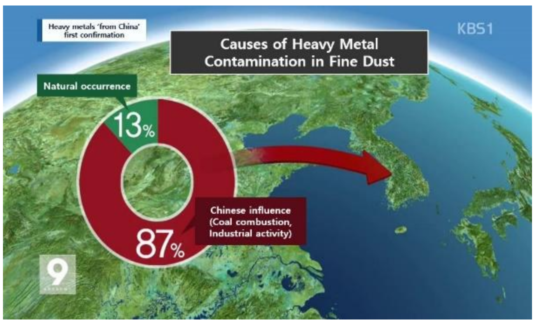

Figure 1. Causes of heavy metal contamination in fine dust By KBS news

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Such fine dust is small in size: PM 10, which is about 5 times smaller than ordinary dust, and PM 2.5, which is about 20 times smaller than hair, which is 50 to 70 μm[Figure 2]. Removing dust, but increasing the concentration of indoor contaminants, such as formaldehyde and volatile organic compounds, can also penetrate the interior even when the window is closed. Continued inhalation of teeth can cause small coughs, eye diseases and, in severe cases, lung cancer. Therefore, in this study, hard dusts with bamboo activated carbon and various pollutant adsorption performances were prepared to reduce fine dust and indoor pollutants[1-3].

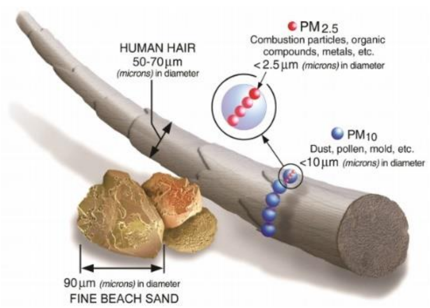

Figure 2. Fine dust particle size
By EPA(Environmental Protection Agency)

2. Adsorption mechanism of activated carbon

Activated carbon has many forms such as granular activated carbon and powdered activated carbon. Such activated carbon can be removed from the surface according to the state adsorb the indoor pollutants. Activated carbon consists of a stack of amorphous hydrocarbons and polyaromatic molecules. These crystal structures have various pore structures to allow adsorption. Activated carbon can usually be divided into micro pores and macro pores. In the case of physical adsorption, the physical adsorption process is performed by the force of van der waals. Adsorption process of activated carbon consists of a total of three stages: a transfer stage, a diffusion stage, and an adsorption stage. In the transfer step, the adsorption molecules move to the outer surface, and in the diffusion step, the adsorption molecules pass through the macro pore and the messo pore. In the case of the adsorption step, the diffused adsorption molecules are combined with the inside surface of the micro to be filled[Figure 3][4].

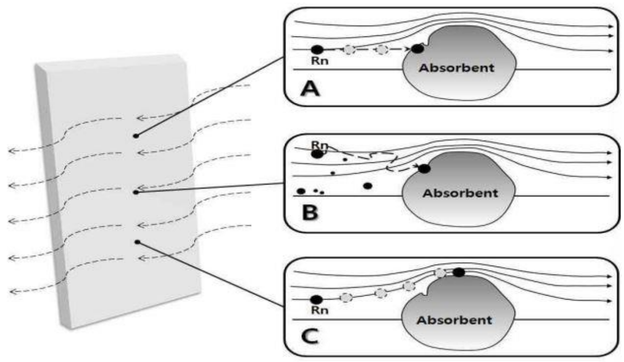

Figure 3. Physical adsorption

3. Experimental plan

3.1 Materials

• Portland cement

Portland cement is most commonly used for cement, which accounts for over 75% of the total cement. The main raw material is composed of silica, lime, iron oxide and the like[Table 1]. The density of cement is about 3.15g / cm^3 and the specific surface area is 3,120cm^2 / g. The Setting time is shown in [Table 2]. The manufacturing process is divided into three stages. The first stage is the crushed limestone in the raw material process, through the first and second grinders, the raw materials such as clay, limestone and iron oxide are mixed in suitable proportions and transferred to silos. Thereafter, in two stages, the unmilled mixed materials are fired in a rotary kiln from 1,400℃ to 1,500℃ through a preheater and discharged in the form of clinker. In the final third step, an appropriate amount of gypsum is added to the clinker, which is then crushed by a cement

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grinder into a cement grinder, which produces cement[5,6].

Table 1. Chemical components of cement

Chemical composition						
SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	Ig. loss
19.88	4.87	3.11	61.56	2.95	2.82	2.93

Table 2. Physical components of cement

Physical composition			
Dencity (g/cm^3)	Specific surface area (cm^2/g)	Setting time(min)	
		Initial set	Final set
3.15	3,120	4:30	6:40

• Bamboo activated carbon

In this study, bamboo activated carbon produced through the activation process was used as the adsorbent. Bamboo activated carbon was used as a powder. SEM photographs of bamboo activated carbon show many fine pores. As physical chuck adsorption is performed through these pores, indoor harmful substances are adsorbed. The specific surface area of bamboo activated carbon is about 1,300m^2 / g and has a large specific surface area.

In addition, ammonia adsorption power is high as 70%. Due to this property, bamboo activated carbon has 50 times higher adsorption performance than ordinary charcoal and lasts for more than 1 year[Figure 4,5][7,8].

Figure 4. Bamboo activated carbon

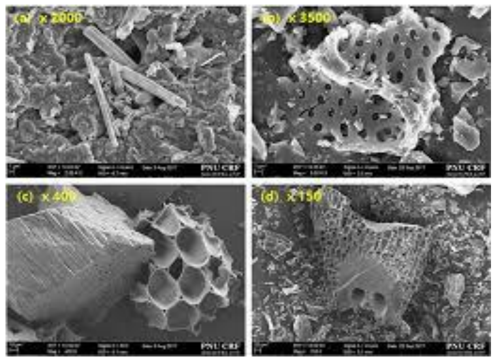

Figure 5. Bamboo activated carbon SEM

Table 3. Physical components of bamboo activated carbon

Specific surface area (m^2/g)	Filling density (g/mL)	Lead adsorption (%)	Ammonia adsorption (%)
1,300	0.3	60	70

3.2 Experimental plan

In this study, paste experiments were performed to investigate the properties of matrix cement substituted with bamboo activated carbon. As test items, compressive strength, flexural strength, water absorption, density, table flow and fine dust adsorption performance were evaluated. As an experimental method of fine dust adsorption performance, a fine dust source, a fine dust measuring device and an air circulator were placed in a closed chamber. In the case of compressive strength and flexural strength, the experiment was conducted according to KS L ISO 679 through the universal material tester. For the rest of the experiment, the experiment was conducted based on KS criteria. The replacement rate of bamboo activated carbon was 0%, 10%, 20%, 30% and 40%. W / B was fixed at 35%, the curing method was constant temperature and humidity, temperature was 18-22 ℃, humidity

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was 75-85%. Table 4 shows the experimental factors and levels [9,10].

Table 4. Experimental factors and levels

Experimental factor	Experimental level	
W/B	35 (wt.%)	1
Binder	C[1)]	1
Adsorbent	BAC[2)]	1
BAC replacement ratio	0, 10, 20, 30, 40 (wt.%)	5
Curing condition	Constant temperature-Humidity curing (Temp. 20±2℃, Hum. 80±5%)	1
Test items	Compressive strength, Flexural strength, Water absorption, Unit weight, Table flow, Fine dust concentration	6

1)C : Cement 2)BAC : Bamboo activated carbon

4. Results and discussion

4.1 Compressive strength and flexural strength

The compressive strength and flexural strength tend to decrease gradually as the replacement ratio of bamboo activated carbon increases. In the case of the compressive strength, about 28 MPa, the reduction was about 30 MPa from 54 MPa to 22.3 MPa at 40% replacement ratio [Figure 6]. In the case of flexural strength, the 28-day strength-based plain decreased 6MPa from 11.5MPa to 5.5MPa at 40% replacement ratio [Figure 7]. The reason for the decrease in strength is that bamboo activated carbon has a property of absorbing moisture, and thus, it is considered that sufficient curing has not been achieved by absorbing moisture necessary for curing as the replacement ratio increases. In addition, since bamboo activated carbon has a weaker strength than cement, it is believed that the strength decreases as the replacement ratio increases.

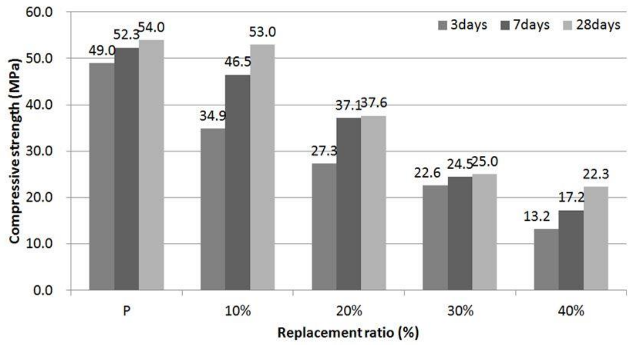

Figure 6. Compressive Strength

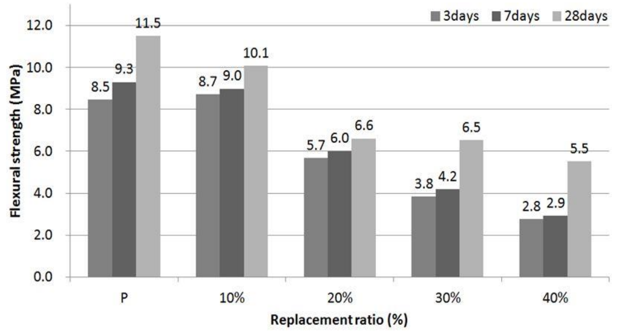

Figure 7. Flexural Strength

4.2 Water absorption and unit weight

As the replacement ratio of bamboo activated carbon increases, the water absorption tends to increase gradually, and the unit weight tends to decrease gradually. The reason for the absorption is that bamboo activated carbon has a property of adsorbing moisture, so the absorption rate gradually increases as the replacement ratio increases. In terms of unit weight, bamboo activated carbon has a lower unit weight than cement, and thus, it seems to decrease gradually as the replacement ratio increases[Figure 8].

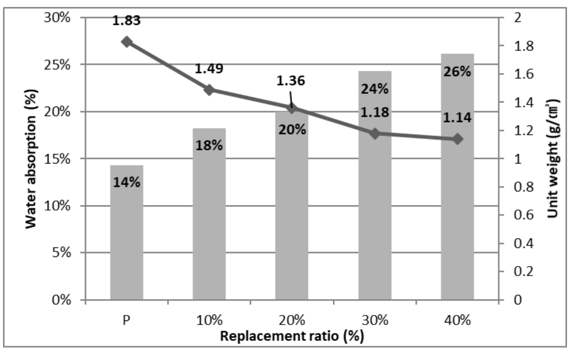

Figure 8. Water adsorption and unit weight

4.3 Table flow

Table flow shows a tendency to decrease gradually as the replacement ratio of bamboo activated carbon increases. It is measured at 198mm in plain and shows a decrease of 83mm to 115mm at 40% replacement ratio. The decrease in table flow is due to the fact that bamboo activated carbon absorbs water, and as the replacement ratio increases, it absorbs more water, which reduces the flowability[Figure 9][11].

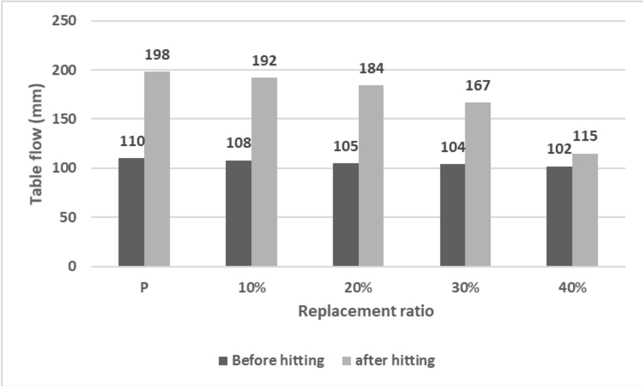

Figure 9. Table flow

4.4 Fine dust concentration

In the case of fine dust concentration, as the replacement ratio of bamboo activated carbon increases, it tends to decrease gradually. It is judged that all concentrations in the chamber were adsorbed in the case of 40% replacement ratio compared to 230 for 12 hours. The reason for this is that bamboo activated carbon has a property of adsorbing fine dust, so it is judged to decrease gradually as the replacement ratio increases[Figure 10].

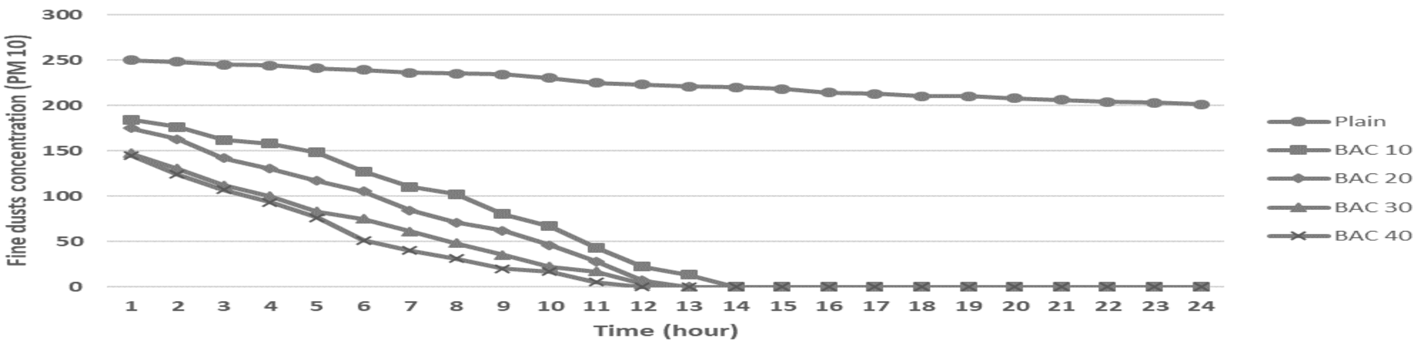

Figure 10. Fine Dust concentration

5. Conclusion

This study is the basic research to manufacture fine dust adsorption board. The properties of the cured product according to the replacement ratio of bamboo activated carbon were evaluated.

Flexural strength and compressive strength decreased gradually as the replacement ratio of bamboo activated carbon increased and the density also decreased. Table flow also tends to decrease gradually as the replacement ratio of bamboo activated carbon increases or decreases. However, the absorption rate tends to increase gradually as the replacement ratio of bamboo activated carbon increases, and the fine dust adsorption performance also tends to increase gradually. In view of strength, water absorption, and fine dust adsorption performance, it is determined that the replacement ratio of bamboo activated carbon is the most suitable replacement ratio.

6. Acknowledgment

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