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Research paper

Properties of Thermal Conductivity According to Replacement Ratio of Paper Ash of Lightweight Composite Panel Core

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Abstract

Background/Objectives: Korea, which is mostly composed of multi-family houses, is paying attention to the importance of sound insulation, insulation, and fireproofing in the environment of multi-family housing.
Methods/Statistical analysis: This study is a study on the production of lightweight composite panel core using inorganic by-product, blast furnace slag, paper ash, polysilicon sludge and vermiculite. When the paste is lightweight due to the foamability of the paper ash, the applicability of the paste as a building dry panel is examined.
Findings:As a result of the analysis of the experimental results, the fluidity shows a tendency to decrease as the replacement rate of the paper ash is increased. The compressive strength shows a tendency to decrease as the substitution rate of paper ash increases and the compressive strength shows a constant tendency with a substitution rate of more than 15%. As the substitution rate of paper ash increases, the size of bubbles on the surface of the cured product increases and the rate of bubble generation increases.
Improvements/Applications: As a result of this study, the thermal conductivity decreases as the substitution rate of paper ash increases, and further study is required for the fire resistance test.

Keywords: *Apartment house, Lightweight panel, Industrial by-product, Thermal conductivity, Inorganic insulator*

1. Introduction

With the development of the domestic industry, the government has enacted the Housing Construction Promotion Act in 1972 to solve the shortage of housing supply. Since then, the government has been continuing to supply apartment houses. According to statistical data of the Population and Housing Census conducted by the National Statistical Office, it is found that about 65% of the population in Korea is living in apartment houses. There are many problems in apartment houses because they live close to their neighbors with the ceiling, the floor and the wall in between, and the number of complaints and complaints with neighbors is increasing every year in [Figure 1]. It even leads to violent crimes such as struggle, violence, murder and arson among neighbors, and it is becoming a social issue. Therefore, the government is encouraging the construction of apartment houses with columnar structure on the condition of the increase of the floor area ratio and the score by the housing performance rating indication system when constructing new common facilities. In addition, due to the rapid growth of the national policy and remodeling market, and the continuous growth of the ramen style apartment and residential complex construction market, the market share of the dry and light wall panel market is expected to increase significantly. Since 2000, the use of lightweight wall panels has been increasing due to the shortening of the construction period, the lighter weight of the structures, the lack of professional construction workers and the solution of the problem of interlayer noise. The use of lightweight wall panels has been increasing as a result of constructing apartment houses with columnar structures in such a variable wall structure. The problem that occurs simultaneously with the increase in the usage of the wall panel is that it is a combustible material in [Figure 2, 3]. Organic materials are used as the main raw material in cement, but organic materials are harmful to people by toxic gas in case of fire and cause fire. As a result of domestic large-scale fire cases, the government implemented fire safety standards for buildings through the revision of the Building Act and Enforcement Ordinance from the first half of 2010. From December 29, 2010, not only the interior finishing materials of buildings but also the exterior wall finishing materials. It is required to improve the incombustibility and fireproof performance in the wall system which occupies the majority of the buildings by implementing the construction method imposed on the use of the building method. This research is a basic research to solve the problems presented above. It is a basic research to solve the above problems. It is a dry and lightweight product with excellent economic efficiency that can be manufactured at room temperature without using cement at high temperature and high pressure by using polysilicon sludge, vermiculite, blast furnace slag and paper ash as industrial by- It aims to develop an inorganic panel. [1, 2, 3, 4, 5]

Figure 1: House floor noise generation (http://news.gm.go.kr/news/articleView.html?idxno=7538)

Figure 2: Icheon logistics warehouse fire accident (http://www.sisapress.com/journal/article/122234)

Figure 3: Currently used wall panels (http://www.landwork.co.kr/)

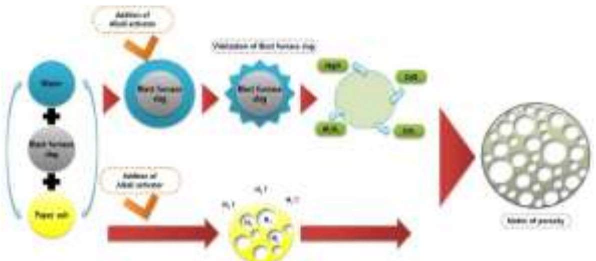

Figure 4: Alkali activation mechanism of blast furnace slag and paper ash

2.1 Experimental Plan

This study was carried out to investigate the properties of the matrix by using polysilicon sludge, paper ash and vermiculite based on blast furnace slag. The W / B was fixed at 55% and the replacement ratio of the polysilicon sludge was fixed to 8%. The paper ash was substituted with 6 levels of 0, 15, 25, 35, 45, and 55 (%). NaOH was fixed to 10% as an alkali activator and vermiculite was fixed to 12%. Thermal conductivity was measured as experimental items. The experimental factors and levels of this study are shown in [Table 1].

2. Experimental Synopsis

This experiment was carried out to investigate the thermal conductivity characteristics of the binder according to the paper ash substitution of blast furnace slag based solids, and to select the appropriate ratio of blast furnace slag and paper ash, based on the results of this study. [Figure 4] shows the reaction mechanism between the paper ash and the alkali stimulant. Hydrogen gas is generated and the hydrogen gas is trapped in the binder by the viscosity of the blast furnace slag-based binder to form a lightweight cured product. [6,7,8]

Table 1: Experimental Factors and Levels

Experimental factor	Experimental level	
Binder	Blast furnace slag, Paper ash, Polysilicon sludge, Vermiculite	4
W/B	55 (wt.%)	1
Alkali activator(NaOH) addition ratio	10 (%)	1
Addition ratio of Vermiculite	20 (%)	1
Replacement ratio of Polysilicon sludge	8 (wt.%)	1
Replacement ratio of Paper ash	0, 15, 25, 35, 45, 55 (wt.%)	6
Curing condition	Constant temperature(20±2℃) and humidity(80±5%) curing	1
Assessment items	Thermal conductivity, Table flow, Compressive strength, Matrix surface shape	4

2.2 Experimental Materials

The chemical and physical properties of the used materials in this study are as follows. Blast furnace slag is a by-product generated during the production of pig iron, and has advantages such as improvement of long-term strength and hydration heat when used as an admixture of concrete, and it has latent hydraulic properties and consequently has a disadvantage of delayed coagulation and initial strength deterioration. The blast furnace slag used in this study was a blast furnace slag with a density of 2.91g/㎤ and a powder grade of 4,464 ㎠/g. Paper ash was used to dispose paper sludge from domestic paper mills after incineration. The chemical composition of CaO 58.7 & SiO_2 14.4% is the largest, and the particle size of papermaking ash is not more than 1 ㎛ and many particles having size of 40 ㎛ or more exist. The shape of the particles has no uniform shape and has an aggregated form. Polysilicon sludge is an industrial by-product produced during the production of polysilicon, which is used as a main raw material of solar collectors used in solar power generation. Polysilicon sludge used in this study was produced by domestic company O, [Table 2] shows. Since polysilicon sludge, which is composed of SiO_2 and CaO as main components and is a high-purity polycrystalline molecular structure, is generated in a cake state containing a large amount of water, it is dried separately and then powdered to a density of 1.75g/㎤, a powder of 6,490 ㎠/g. [Figure 5, 6, 7] are SEM images of each material, and [Figures 8, 9,10] are XRD of each material.[6,7,8,9,10,11]

Table 2: Chemical and physical properties of used materials

Chemical composition (%) Used materials	SiO_2	Al_2O_3	MgO	CaO	Fe_2O_3	SO_3	Density (g/㎤)
Blast furnace slag	35.08	13.87	3.60	41.71	0.61	2.36	2.91
Polysilicon sludge	46.60	0.57	0.69	45.16	1.78	0.16	1.75
Paper ash	12.40	6.90	3.40	58.71	8.33	1.84	2.70

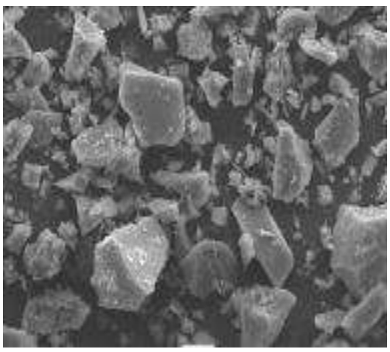

Figure 5: SEM of Blast furnace slag

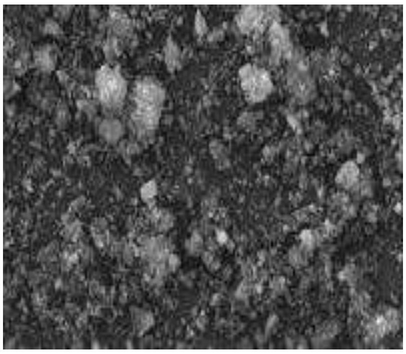

Figure 6: SEM of Polysilicon sludge

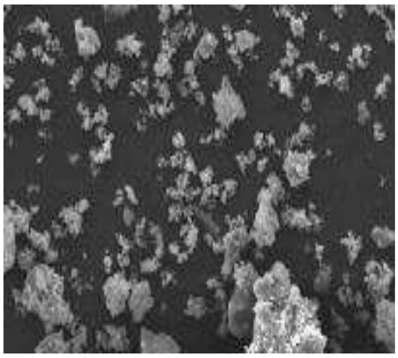

Figure 7: SEM of Paper ash

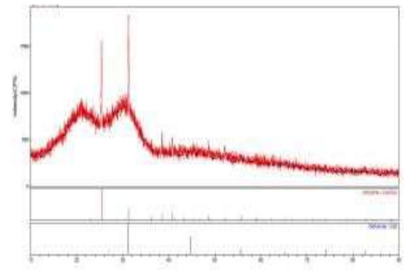

Figure 8: XRD of Blast furnace slag

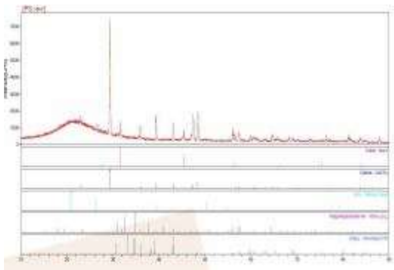

Figure 9: XRD of Polysilicon sludge

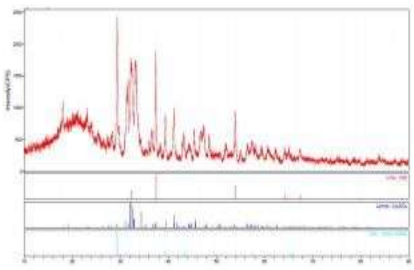

Figure 10: XRD of Paper ash

3. Experimental Results and Analysis

3.1 Table Flow

[Figure 11] shows the table flow according to the paper ash replacement ratio, which shows a tendency to decrease as the paper ash replacement ratio increases. Compared with the plain, the paperash replacement ratio of 55% showed a table flow reduction of about 40% compared to the plain, which is considered to be related to the change in properties of the binder due to bubble formation. As the replacement ratio of paper ash increased, the rate of bubble increase, and thus the fluidity was also changed.

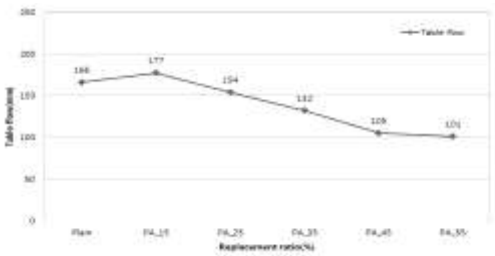

Figure 11: Table flow

3.2 Thermal Conductivity

As shown in [Figure 12], the thermal conductivity tends to decrease with increasing replacement ratio. As the replacement ratio of the paper ash increases, hydrogen generation due to paper ash reaction increases the foaming effect, and the thermal conductivity is low. In case of thermal resistance, the opposite value of thermal conductivity tends to increase with increasing paper ash replacement ratio. Plain has lower thermal resistance and higher thermal conductivity. As a result, the air layer inside matrix due to the hydrogen gas generated by the paper ash has a thermal insulation effect as a lightweight composite panel core.

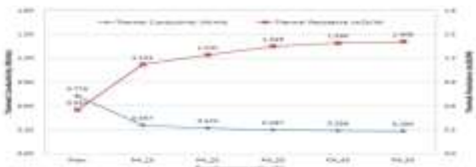

Figure 12: Thermal conductivity

3.3 Compressive Strength

[Figure 13] is a graph showing the compressive strength of the cured product according to the paper ash substitution ratio. As the substitution rate of the paper ash increases, the strength tends to converge to a certain value. As the substitution rate of paper ash increases, the cured product has a higher foaming amount, resulting in a decrease in strength. In this study, it can be seen that the tendency of the intensity value is constant from the paper ash substitution rate of 15% or more, and that the strength is lowered when the paper ash is replaced, but the difference of the strength of the initial and long age is not large.

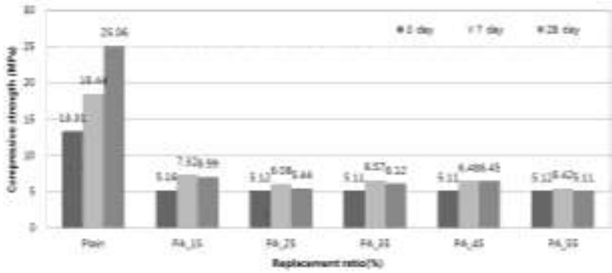

Figure 13: Compressive strength

3.4 Matrix Surface Shape

The following figures are photographs of cross sections of paper ash substituted matrix that [Figure 14]. As replacement ratio of the paper ash increases, the bubble generation or foaming performance of the cross section of the matrix increases, and it can be confirmed that inhomogeneous bubbles are formed.

4. Conclusion

From the experimental results, this experiment was conducted to investigate the physical and mechanical properties of the matrix according to the replacement ratio of paper ash. The fluidity shows a tendency to decrease as the substitution rate of paper ash is increased. This is considered to be the foaming performance by the paper ash. The thermal conductivity tends to decrease with increasing substitution rate of paper ash. It is considered that the bubble generation due to the foaming performance of the paper ash produced a large number of bubbles in the cured body and the thermal conductivity decreased. Compressive strength tends to decrease as the substitution rate of papermaking ash increases and the compressive strength shows a constant tendency at a replacement rate of 15% or more. As the substitution rate of paper ash increases, Size and bubble generation rate are increasing. So, as the substitution rate of paper ash is increased by analyzing the surface morphology of the matrix, the size of bubbles on the surface of the matrix and the incidence of bubbles increase.

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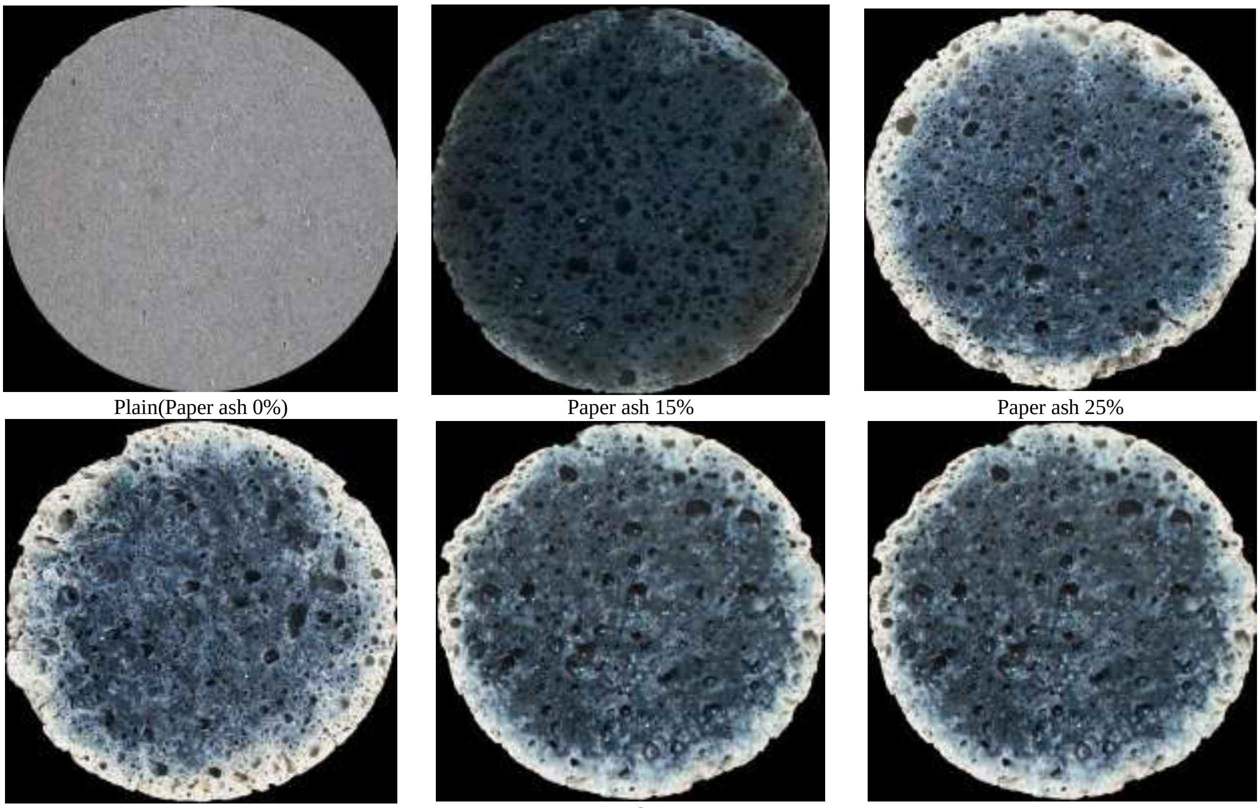

Plain(Paper ash 0%) Paper ash 15% Paper ash 25%

Paper ash 35% Paper ash 45% Paper ash 55%

Figure 14: Matrix surface shape