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Properties of Cement Matrix for Thermal Insulation using Cork

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Abstract

Currently, the development and diversification of building materials is required along with the demand for multifunctional and high-performance buildings. In addition, the standards of insulation materials have been strengthened by government policies. Accordingly, this study intends to review the cement matrix using ordinary portland cement and powdered cork (BD051) for the development of a new insulation material. As for the experimental plan, through the basic experiment, W/C was selected as 40% and the addition ratio of BD051 was 30, 32.5, 35, 37.5, 40(%). Experimental variables are to examine table flow, air content, density, absorption rate, flexural strength, compressive strength, thermal conductivity and thermal resistance. In addition, the measurement method of experimental items except for thermal conductivity and thermal resistance is conducted and analyzed in accordance with the Korean Industrial Standards (KS). Thermal conductivity and thermal resistance are conducted and analyzed in accordance with ISO 22007 standards. As a result of the experiment, the table flow decreased as the addition ratio of BD051 increased. Air content increased as the addition ratio of BD051 increased. The density decreased as the addition ratio of BD051 increased. The absorption rate increased as the addition ratio of BD051 increased. Both the flexural strength and the compressive strength decreased as the addition ratio of BD051 increased. The thermal conductivity decreased as the addition ratio of BD051 increased. The thermal resistance increased as the addition ratio of BD051 increased. Therefore, as a result of examining the properties of cement matrix using BD051, it is considered that it can be presented as basic research data. In addition, it is determined that a new insulating material can be manufactured.

Keywords: Insulation material, Cork, Building material, Thermal conductivity, Thermal resistance

1. Introduction

The development and variety of building materials are required along with the demand for multifunctional and high-performance buildings. In addition, in order to select an appropriate material, there are many matters to be considered by considering various performances, efficiencies, unit prices, and the like. Among them, the required thickness of heat insulating materials increased and the demand for heat insulating materials increased sharply in response to the government's policy of reducing energy to zero energy. As shown in [Figure 1], it affected the spread of fires such as "warehouse fires" and magnified human and property damage.[1] As a result, if the amendment of the Building Law in 2009 is for sandwich panels while passing through the Land Transport Commission, it will be necessary to proceed with the fire safety performance test of the internal insulation material, so 83% of the market based on 2018 Using EPS and polyurethane that occupy, it became non-conforming to the semi-incombustible standard.[2,3] To solve this problem, research on the development of new inorganic insulation

materials and methods is being carried out.[4,5,6] Accordingly, this study intends to examine the properties of a cement matrix using cork, which is an inorganic material and has a hexagonal honeycomb structure, in order to suppress the thickness of the insulating material and secure the thermal conductivity equivalent to the use of organic materials. After that, it is intended to determine whether it can be used as basic research data for manufacturing a new insulation material.

Figure 1. Cases of building accidents due to fire

2. Experimental plan

This study intends to examine the properties of cement matrix using powdered cork (BD051) for the development of a new insulating material.[7] The materials used are ordinary portland cement and BD051. As shown in [Table 1], the W/C is selected as 40% through the basic experiment before this experiment. The addition ratio of BD051 is selected from a total of 5 levels: 30, 32.5, 35, 37.5, and 40 (%). Curing conditions are constant temperature and humidity curing at a temperature of 20±2(℃) and a humidity of 60±5(%). Experimental variables measure table flow and air content in order to analyze the properties of the non-solidified paste. Density, absorption rate, flexural strength, compressive strength, thermal conductivity, and thermal resistance are reviewed to analyze the properties of the solidified paste.

Table 1: Experimental factors and levels

Experimental factors	Experimental levels	
Binder	OPC[1)], BD051[2)]	2
Additional ratio of BD051[2)]	30, 32.5, 35, 37.5, 40 (%)	5
W/C	40 %	1
Curing condition	Temp. 20±2℃, Hum. 60±5%	2
Experimental variables	Table flow, Air content, Density, absorption rate, Thermal conductivity, Thermal resistance, flexural strength, compressive strength	8

1) OPC: Ordinary Portland Cement 2) BD051: Powdered Cork

2.1. *Materials*

2.1.1. OPC (ordinary portland cement)

As shown in [Figure 2] and [Figure 3], the cement used in this experiment was a type 1 ordinary portland cement with a density of 3.14 g/cm^3 and a fineness of 2,893 cm^2/g. Chemical composition is shown in [Table 2].[8]

Table 2: Chemical composition of ordinary portland cement

Chemical composition						
MgO	CaO	SiO_2	Fe_2O_3	SO_3	Al_2O_3	TiO_2
2.26	67.17	17.80	3.30	2.97	4.19	0.21

Figure 2. Ordinary portland cement

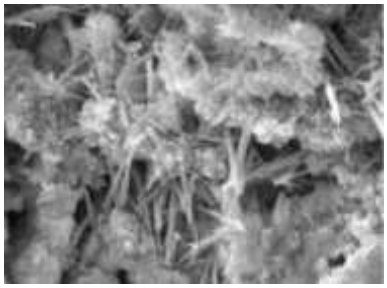

Figure 3. Microstructure of cement

2.1.2. BD051 (powdered cork)

Cork is a cell-structured material that can be obtained from the bark of a cork tree, and because it is formed by the division of the cambium, it shows a regular cell arrangement. A polymer of fatty acid called sverine is deposited on the cell wall, making it difficult for water or gas to pass through. In addition, as it has a micropore structure as shown in [Figure

4], it has excellent properties in heat insulation, sound insulation, electrical insulation, and elasticity.[9]
The cork to be used in this study is in the form of a powder as shown in [Figure 5], and its physical properties are shown in [Table 3].

Table 3: Mechanical properties of powdered cork

BD051				
Density(g/cm^3)	Absorptivity(%)	Particle size(mm)	Specific heat(J/kgK)	Thermal conductivity(W/mk)
0.05~0.06	12	0.5~1	1590	0.056~0.058

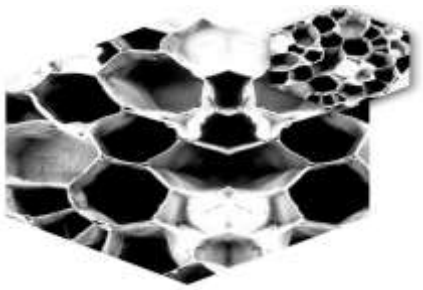

Figure 4. Structure of cork

Figure 5. BD051

2.2. ***Experimental method***

2.2.1. Table flow[10]

The table flow test of the non-solidified paste is carried out according to the standards of KS L 5111(TESTING METHOD FOR SPECOFOC GRAVITY OF HYDRAULIC CEMENT). Fill the mold on the table in three portions, and compact each 20 times. After that, the table plate is dropped 25 times for 15 seconds to a height of 1.27cm, and then the diameter of the paste is measured in 4 places to derive the average value.

2.2.2. Air content[10]

The air content test of the non-solidified paste is carried out in accordance with KS F 2409(STANDARD TEST METHOD FOR UNIT WEIGHT AND AIR CONTENT(GRACIMETRIC) OF FRESH CONCRETE).

2.2.3. Density and absorption rate[10]

Density and absorption rate test are conducted in accordance with KS F 2459(TESTING METHODS FOR BULK SPECIFIC GRAVITY, WATER CONTENT, ABSORPTION AND COMPRESSIVE STRENGTH OF CELLULAR CONCRETE). Measure the mass of the matrix in the dry state through 28 days of underwater curing. The absolute dry density is dried until there is no change in mass in the dryer and the mass is measured. Density is derived as absolute dry density/volume. Absorption rate is derived through the formula of <(surface dry density – absolute dry density) / absolute dry density>x100.

2.2.4. Flexural strength and compressive strength[10]

Flexural and compressive strength tests are conducted in accordance with KS L ISO 679(METHODS OF TESTING CEMENTS –DETERMINATION OF STRENGTH). 40x40x160(mm) and 50x50x50(mm) cement matrix are made and cured for 3, 7, 28 days. The load rate is 50±10(N/s) and the three-point method is used to measure the flexural strength, and the load rate is 2,400±200(N/s) to measure the compressive strength.

2.2.5. Thermal conductivity and thermal resistance

Thermal conductivity and thermal resistance tests are conducted in accordance with the standards of ISO 22007. The TPS method measures 80 seconds by placing the sensor between the 50x50x50(mm) hardened cement.

3. Experiment results and Analysis

3.1. ***Table flow***

As shown in [Figure 6], as the addition ratio of BD051 increased, the table flow after hitting showed a tendency to decrease. In addition, as the addition ratio of BD051 increases, the difference between before and after hitting decreases, and as the amount of cork used increases, the effect of hitting becomes weaker. It is judged that the table flow decreases because the cork has a low density as well as a large number of voids, which increases the number of units absorbed inside.

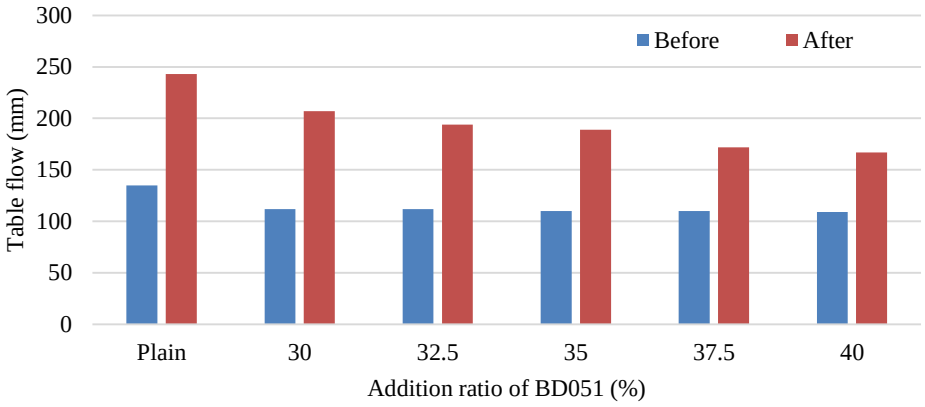

Figure 6. Table flow

3.2. *Air content*

As shown in [Figure 7], when BD051 was not added, a low value of 2.1% was derived. However, when BD051 was added, air content was significantly increased. It is considered that air content increased due to the porosity of BD051 during mixing. In addition, when the addition ratio of BD051 is increased by 2.5%, air content is increased by about 0.3~0.5(%), so the difference is insignificant.

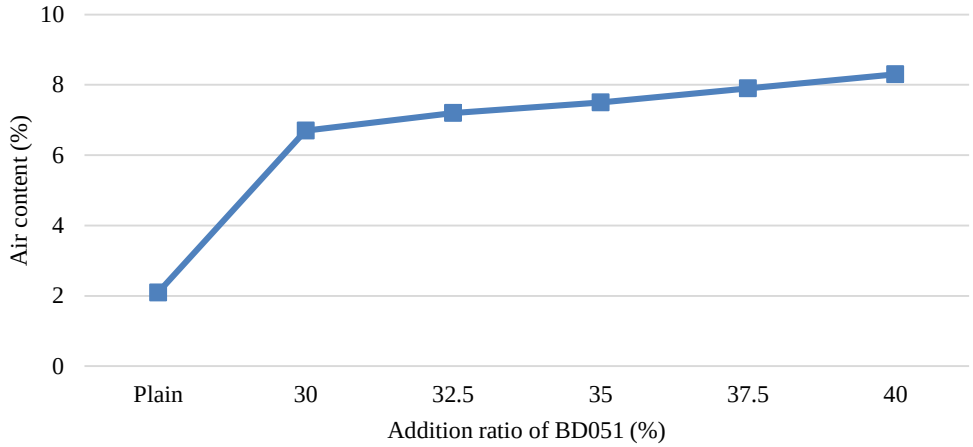

Figure 7. Air content

3.3. *Density and Absorption rate*

As shown in [Figure 8], as the addition ratio of BD051 increased, the density showed a tendency to decrease. In addition, a significant difference was observed when compared with the cured product to which BD051 was not added. The absorption rate increased as the addition ratio of BD051 increased. This is because the BD051 material itself has a low density and is porous, so it is judged that the absorption rate increases as the density decreases as a large number of pores are formed in the matrix.

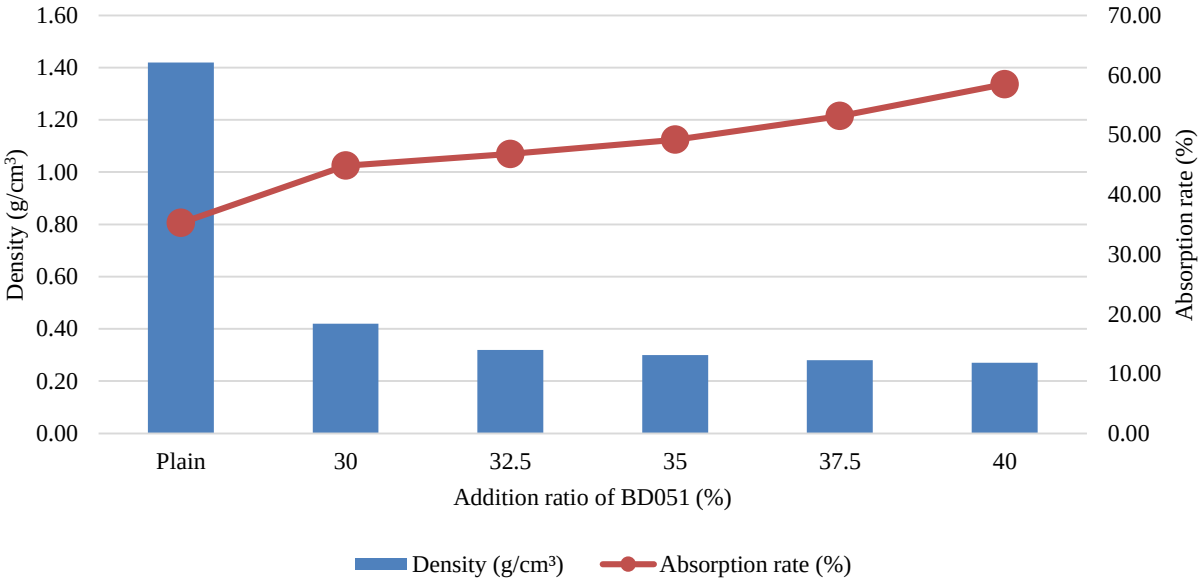

Figure 8. Density and absorption rate

3.4. *Thermal conductivitiy and Thermal resistance*

As shown in [Figure 9], as the addition ratio of BD051 increased, the thermal conductivity showed a tendency to decrease. In addition, in the case of plain, a value of 1.160W/mk was shown, and when the addition ratio of BD051 was 40%, a value of 0.130W/mk was shown, and it can be seen that it is significantly lowered. The thermal resistance showed a tendency to increase as the addition ratio of BD051 increased. It is considered that cork has porosity, and as voids are formed inside the cement matrix, the thermal conductivity is lowered and the thermal insulation effect is improved.

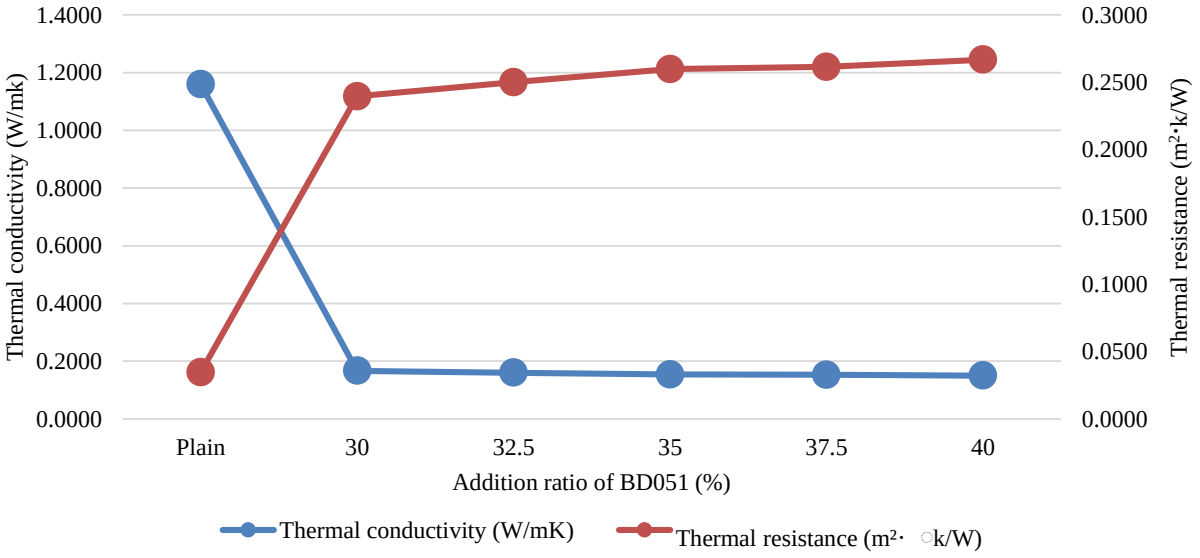

Figure 9. Thermal conductivity and thermal resistance

3.5. *Flexural strength and Compressive strength*

As shown in [Figure 10], as the addition ratio of BD051 increased, the flexural strength showed a tendency to decrease as it was derived to 9.62, 6.21, 6.09, 5.54, 5.51, 5.12 (MPa) at 28 days of age. However, in terms of the number of days of age, the increase in flexural strength from 3 days to 7 days of age was insignificant, but the flexural strength increased markedly at 7 days and 28 days of age. As shown in [Figure 11], as the addition ratio of BD051 increased, the compressive strength showed a tendency to decrease as it was derived to 35.22, 20.93, 20.26, 19.87, 19.64, 19.14 (MPa) at 28 days of age. However, in terms of the number of days of age, not only the increase in compressive strength from 3 days to 7 days of age was evident, but also the compressive strength increased markedly at 7 days and 28 days of age.

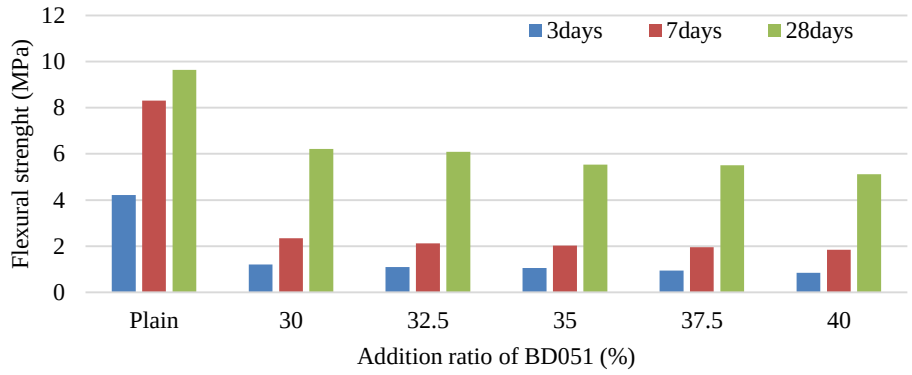

Figure 10. Flexural strength

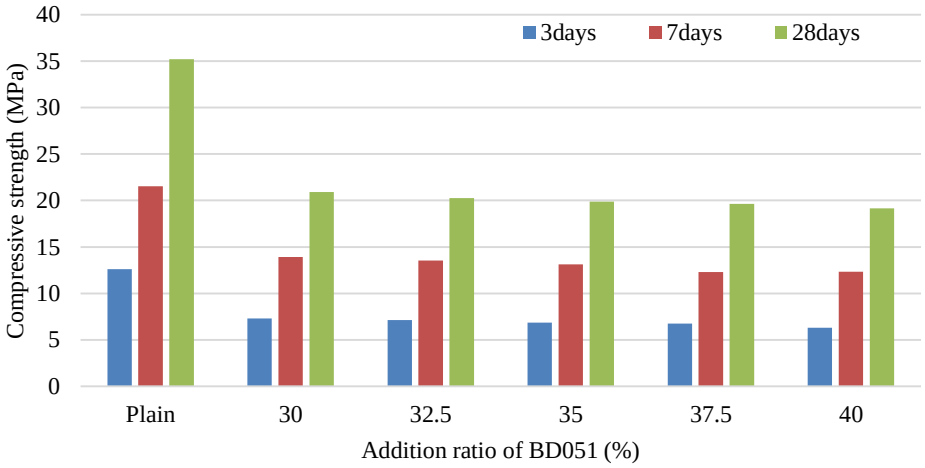

Figure 11. Compressive strength

4. Conclusion

In this study, the properties of cement matrix using cork, which is an inorganic material and has a hexagonal honeycomb structure, are as follows in order to secure the thermal conductivity equivalent to the use of organic materials while suppressing the thickness of the insulating material. As the addition ratio of BD051 increased, table flow, density, thermal conductivity, flexural strength and compressive strength decreased. However, as the addition ratio of BD051 increased, air content, absorption rate and thermal resistance increased. Therefore, it is judged that it can be used as basic research data for manufacturing a new insulating material because it can be seen that the thermal conductivity is lowered by using BD051 and the thermal insulation effect is improved. In addition, we intend to conduct additional research to examine the possibility of actual use by fabricating insulation materials.

5. References

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