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Properties of MgO matrix according to replacement ratio of TiO_2

YongGu Kim[1], JeongJun Lim[2], WonGyu Lee[3], SangSoo Lee[*4]
[1,2,3]Research Scholar, Department of Architectural Engineering, Hanbat National University, Daejeon, 34158, S. Korea
[*4]Professor, Department of Architectural Engineering, Hanbat National University, Daejeon, 34158, S. Korea
kyg0824@hanmail.net[1], jjl582@naver.com[2], insom99@naver.com[3], sslee111@hanbat.ac.kr[*4]

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Abstract
Fine dust has emerged as a global problem. This study is an experiment to develop functional building materials that can reduce fine dust. This experiment is a basic experiment to investigate the fine dust adsorption performance of hardened body due to the incorporation of magnesium oxide TiO_2 and its usefulness as a building material. Magnesium oxide was used as the binder and TiO_2 was used as the adsorbent. Magnesium chloride was used as a stimulator of magnesium oxide. Test items are fine dust concentration, compressive strength, flexural strength, thermal conductivity and flowability. Results of the experiment, As the replacement ratio of TiO_2 increased, the flexural strength tended to decrease gradually as the TiO_2 addition rate increased. The compressive strength tends to decrease as the addition rate of TiO_2 increases. The reason for this is considered that the amount of unit cement decreased with increasing replacement ratio of TiO_2. The flowability was the highest when TiO_2 was not replaced when compared with before and after hitting and decreased with increasing replacement ratio of TiO_2. The thermal conductivity of the thermal conductivity increases as the TiO_2 conductivity tends to decrease over time. Finally, the measurement TiO_2 of the fine dust concentration was measured for 24 hours at 1 hour intervals. The higher replacement ratio of TiO_2, the faster the reduction of fine dust. When not added, the fine dust reduction effect is insignificant, while when TiO_2 is added, it can be seen that it drops to zero. In conclusion, It can be used as a heat insulator because of its low thermal conductivity, but further research is needed because its strength is reduced.

Keywords: *Magnesium oxide, TiO_2, Fine dust concentration, Thermal conductivity, Flowability.*

1. Introduction

Recently, air pollution has emerged as a global problem. As shown in [Figure 1], fine dust is a serious problem in Korea. Fine dust is the main cause of the air pollution. Fine dust is produced by burning fossil fuels such as coal and petroleum or by gases emitted from cars and factories.[1] In addition, [Figure 2] shows that yellow dust originating in China is becoming more serious as it flows into Korea in a western style. In [Figure 3], the fine dust can be harmful to the human body causing respiratory diseases, stay in the air and absorbed by the human body through the human respiratory system can adversely affect health.[2] According to the research results of the National Institute of Environmental Research, the risk of fine dust is higher than that of other pollutants.[1] This is because fine dust is easier to enter the human body because the particle size is smaller than other harmful substances.[1] When fine dust enters the human body, the cells responsible for immunity remove dust and cause side effects and cause inflammation.[1] This study is a basic experiment

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for the development of functional building materials capable of absorbing and reducing fine dust, which is an air pollutant.

Figure 1. Fine dust situation in korea
(source : https://news.sbs.co.kr/news/endPage.do?news_id=N1005161339)

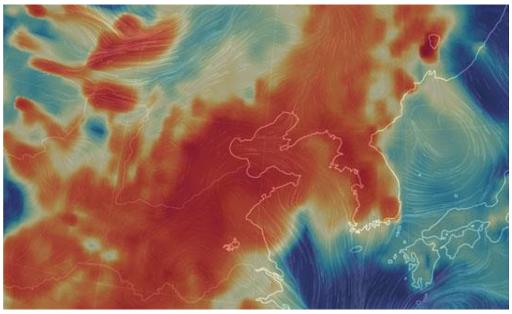

Figure 2. Impact of yellow sands in china
(source : http://news.kbs.co.kr/news/view.do? ncd=4114522)

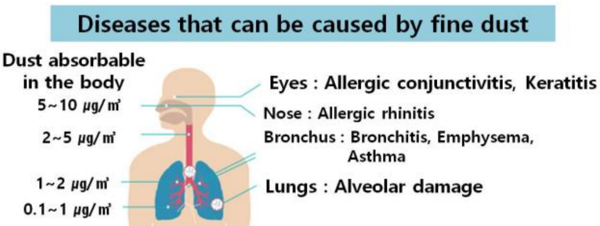

Figure 3. Effect on human body by fine dust
(source : http://www.neins.go.kr/ltr/lifeenvironment/pm10_02.asp)

2. Experimental plan

This experiment is a basic experiment to investigate the fine dust adsorption performance of hardened body due to the incorporation of magnesium oxide –based TiO_2 and its usefulness as a building material. Magnesium oxide was used as the binder and TiO_2 was used as the adsorbent. Magnesium chloride was used as a stimulator of magnesium oxide. W/B was 30%, titration of TiO_2 was 0, 4, 8, 12, 16, 20 (%).Curing conditions were constant temperature and humidity curing. Test items are fine dust concentration, compressive strength, flexural strength, thermal conductivity and flowability. Experimental factors and levels are shown in [Table 1]

Table 1. Experimental factors and levels

Experimental factor	Experimental level	
Binder	$MgO^{1)}$, $MgCl_2^{2)}$, $TP^{3)}$	3
W/B	30 (wt.%)	1
$MgCl_2$ addition ratio	30 (wt.%)	1
Replacement ratio of TiO_2	0, 4, 8, 12, 16, 20 (wt.%)	6
Curing condition	Constant temperature-Humidity curing (Temp.20±2℃,Hum.60±5%)	1
Test items	Fine dust concentration, Flexural strength, Compressive strength, Thermal conductivity, Flowability	5

1) MgO : Magnesium oxide 2) $MgCl_2$: Magnesium chloride
3) TP : TiO_2 Photocatalyst

2.1 Materials

• Magnesium oxide

It is a white powder and has a melting point of 2,800℃ and a specific gravity of 3.65. It is a sodium chloride-type on-crystal made by Mg^{2+} and O^{2-}. In addition, it easily reacts with acids to form salts, but it is also relatively easy to pyrolyze and return to MgO. This is due to the fact that Mg^{2+} is smaller than Ca^{2+} or Ba^{2+}, it is strongly attracted to O^{2-} and electrostatically, creating a hard crystal lattice. Fire resistance due to very high melting point. It is used as a raw material for bricks, crucibles, etc. It is also used for catalysts, adsorbents, magnesia cement, medicines(antacids and diarrhea). The product in this study was a chinese product with a density of $3.42g/cm^3$ and purity of 88.25%.[3]

• Magnesium chloride

It is a compound of chlorine and magnesium, followed by sodium chloride, which is dissolved

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in seawater, and contains about 20% in salt water, a by-product of making salt from seawater with a bitter taste. The chemical formula is $MgCl_2$, and in addition to anhydrides, there are 2, 4, 6, 8, 10, 12 hydrates, etc., but are usually present as hexahydrate $MgCl_2 \cdot 6H_2O$. Anhydride is colorless crystalline powder, melting point is 712℃, boiling point is 1,412℃, density is 2.33g/cm^3 at 25℃, hygroscopicity is strong and soluble in water and alcohol carbohydrates are colorless crystals with a specific gravity of 1.56, soluble in water, and soluble in water and alcohol. Anhydride is used as a raw material for the manufacture of metal magnesium, and, is also used to make magnesia cement by mixing magnesium oxide. Carbohydrates are used for the manufacture or tofu, preservatives of wood, purification of wool, and production of sulfated paper.

• TiO_2

The catalyst plays a role in causing a reaction rate change or reaction without changing itself in a chemical reaction. Photocatalyst is included in one kind of catalyst and is a substance that catalyzes change of reaction rate or cause reaction by receiving sunlight or UV rays. TiO_2, the most widely used and studied photocatalyst, is also called "titanium dioxide" and consists of a molecule in which a transition metal titanium atom and two oxygen atoms are combined. The adsorption principle of TiO_2 is that when it receives UV rays such as sunlight or fluorescent light, electrons(e-) with electricity and holes (h+) with (+)electricity are formed, and holes (h+) are hydroxides that generate oxidation. The TiO_2 used in this study was a powder with an anatase structure. The photocatalyst had a density of 0.45g/ml, a particle size of 20`30nm, a specific surface area of 60-70m2/g, and a photocatalytic activity of 99%.[2]

2.2 Experimental methods

In order to measure the concentration of fine dust, install the dust measuring instrument and the fan to circulate the air inside the sealed chamber, and then place the test specimen inside. Then, fine dust is generated through a device that generates fine dust to measure the concentration of fine dust in an enclosed space. The measurement time is 1 hour interval and a total of 24 hours is measured. Flexural strength and compressive strength are measured using a universal measuring machine according to KS L ISO 679. The flowability is measured using the mortar flow meter after placing the paste on the cone and compacting it with a compaction rod. Finally, the thermal conductivity is measured according to KS L 9016.

3. Experimental result and analysis

• Strength

[Figure 4, Figure 5] show the flexural and compressive strengths according to replacement ratio of TiO_2. As replacement ratio of TiO_2 increased, the flexural strength of 10.41 MPa was expressed on the 28th day when TiO_2 was not added, and gradually decreased to 9.05, 8.92, 8.55, 8.43, 8.01 (MPa) in order as the TiO_2 content was increased. When TiO_2 was not added, the compressive strength of 45.95 MPa was expressed on a 28-day basis, and as the addition rate of TiO_2 increased, it tended to decrease to 44.33, 44.21, 40.56, 38.62, 37.44 (MPa). The reason for this is considered that the amount of unit cement decreased with increasing replacement ratio of TiO_2. [4-6]

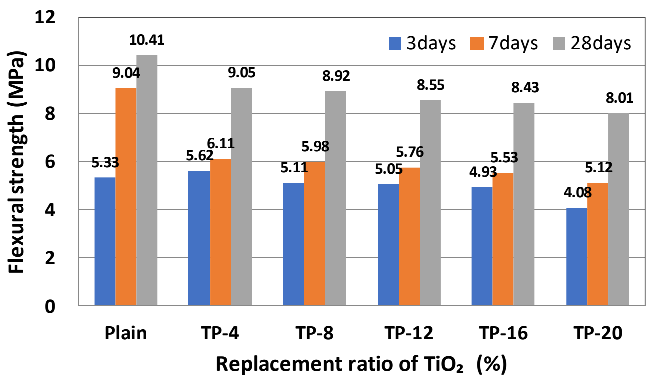

Figure 4. Flexural strength

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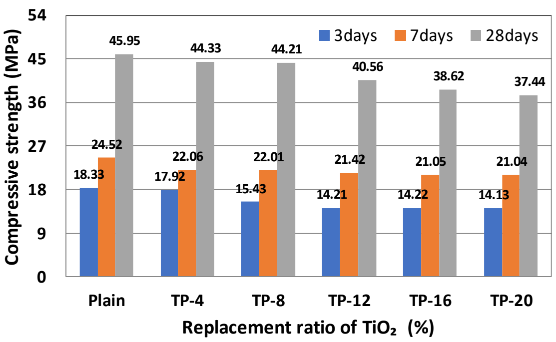

Figure 5. Compressive strength

• Fine dust concentration

[Figure 6] shows the fine dust concentration. The measurement time was measured for a total of 24 hours at 1 hour intervals. The higher replacement ratio of TiO_2, the faster the reduction of fine dust. In the case of fine dust reduction effect is insignificant, when added to TiO_2 it can be seen that falls to zero. In view of these results, it is determined that TiO_2 is adsorbed fine dust.[2,10]

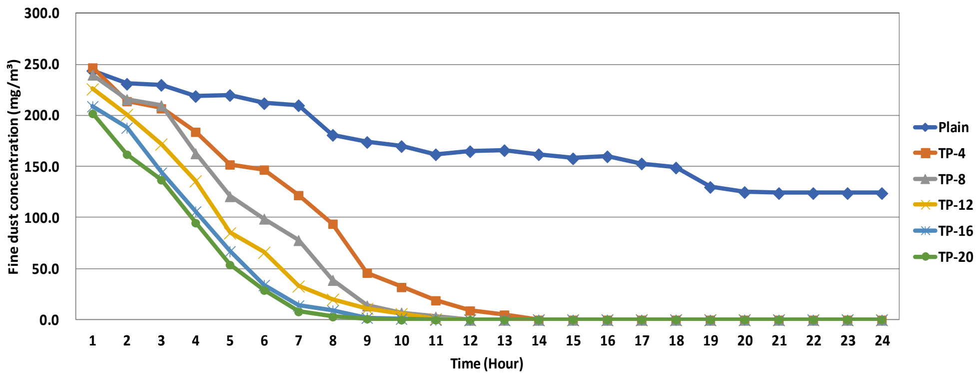

Figure 6. Fine dust concetration

• Flowability and thermal conductivity

[Figure 7] shows the flowability. Flowability was the highest when TiO_2 was not substituted when compared with before and after hitting and decreased with increasing replacement ratio of TiO_2, [Figure 8] shows the thermal conductivity. As the replacement ratio of TiO_2 increased, the thermal insulation performance increases as the thermal conductivity decreases. In addition, the thermal conductivity tends to decreases with time.[1,7-9]

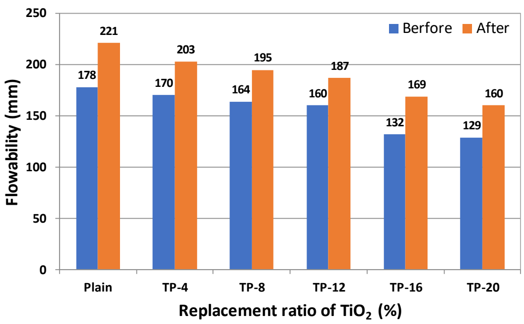

Figure 7. Flowability

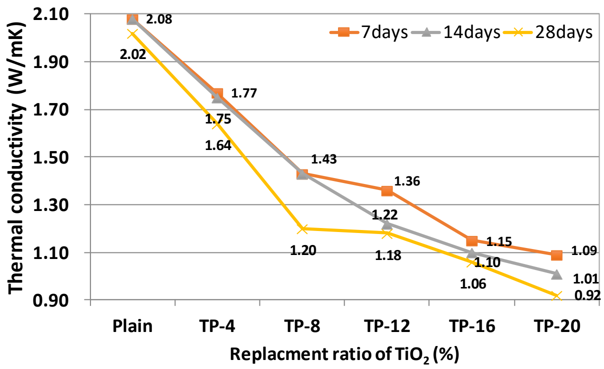

Figure 8. Thermal conductivity

4. Conclusion

As a result of experiments on the properties of the magnesium oxide cured product according to replacement ratio of TiO_2, the decrease rate of the fine dust concentration increased with the increase of the replacement ratio of TiO_2, and the thermal conductivity also showed the low thermal conductivity as the replacement ratio of TiO_2 increased, resulting in high thermal insulation

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performance and sufficient role as an insulating material. I think you can. However, as the replacement ratio of TiO_2 increases, it can be seen that the flexural strength and the compressive strength decrease. It is believed that the strength decreases as the amount of unit cement decreases. Therefore, further research is needed to secure the strength suitable for use as building materials.

5. Acknowledgment

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