International Journal of Engineering & Technology, 7 (3.34) (2018) 576-579

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research paper

Properties of Lightweight Matrix Using Industrial by-Products according to Mixing Ratio of NaOH and KOH

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Abstract

Background/Objectives: When producing 1 ton of cement, it produces 0.9 tons of carbon dioxide, so it is very important to reduce the use of cement or to find an alternative material.
Methods/Statistical analysis: In order to replace cement which is frequently used to make lightweight cured products, blends of blast furnace slag, polysilicon and paper ash were used as binders. In order to stimulate the hardening of blast furnace slag, comparative analysis of characteristics of alkali stimulants was carried out by using KOH and NaOH as alkali stimulants.
Findings: In order to improve the foaming performance for the production of lightweight Matrix, we used polysilicon and paper ash as well as blast furnace slag as one of industrial by - product a binder. KOH and NaOH were used as alkali stimulants. The experimental results are as follows.When alkali stimulants are used, the density decreases and the absorption rate increases. It is considered that the use of an alkali stimulant causes air bubbles to occur, resulting in a lower density and an increased absorption rate. The use of NaOH rather than KOH seems to result in better bubble generation. Strength was significantly decreased when alkali stimulants were used, but it was confirmed that the strength of NaOH was increased than that of KOH.
Improvements/Applications: As a result of this study, we will fabricate a lightweight matrix that can be used as a prototype by using NaOH according to KS F 2701 standards.

Keywords: *Lightweight matrix, Alkali stimulant, Industrial by-products, Non-cement, Blast furnace salg*

1. Introduction

In modern society, cement is the most important material in the construction industry. In the construction industry, cement is the most widely used material to form infrastructure and structures inside and outside of buildings. It is a building material that is essential for modern people's life. However, cement emits a large amount of CO_2 in the manufacturing process, and since it emits 0.9 ton of CO_2 in the production of 1 ton of cement, environmental pollution is intensifying. The construction of modern society is essential, so it is very important to reduce the use of cement or to find alternative materials.[1] Due to the generation of CO_2, environmental pollution problems related to global warming are emerging around the world, and a lot of effort is being made to produce environmentally friendly energy due to depletion of natural resources and depletion of petroleum resources. In order to replace fossil fuel sources, many efforts are being made to develop environmentally friendly energy such as wind power generation, tidal power generation, waterpower generation, geothermal power generation, solar thermal generation, and solar energy generation.[2]However, it is still dependent on fossil fuels. From 2040 onward, it is expected that solar power generation will increase more than fossil fuel usage. The main raw material of Solar Voltaic Module used in solar energy generation is polysilicon, and production volume is also increasing.[3,4] While interest in solar power generation and polysilicon is growing, polysilicon sludge, which is a waste of about 2 tons, is being produced to produce 1 ton of polysilicon during the production of polysilicon. [2,3] Paper sludge, which is produced as a by-product in paper mills, is discarded after incinerating paper sludge. [5,6] This means that sludge is generating another environmental pollution in order to produce environmentally friendly energy.[7]In this study, to reduce the amount of cement used in a part of the building, the non-cement based lightweight wall is manufactured to help the environmentally friendly construction. ALC panels based on cement based on autoclaved curing are typical for lightweight walls. These ALC panels are economically inefficient because they require an expensive curing process called autoclave.[5,7] However, in this study, it is possible to fabricate lightweight martix by using alkali activator and industrial by-products.

2. Materials and Methods

2.1. Experiment Plan

In this study, we aimed to manufacture lightweight matrix by using polysilicon sludge generated during solar cell panel manufacturing, paving ash produced in paper making process, and blast furnace slag discharged from steel making industry as main materials. Blast furnace slag is not cured even when it comes in contact with water with latent hydraulic properties. Alkali activators are required for hardening of blast furnace slag, and NaOH and KOH are used as alkali stimulants as the main parameters of the experiment.Which are stimulant activators for polysulfone sludge and paper ash and at the same time stimulating hardening of blast furnace slag.[5,8] The mixing ratio of alkali

activators was selected as 5, 10, 15, 20 (wt.%). The replacement rate of polysilicon sludge was fixed at 10% and the replacement ratio of paper ash was fixed to 25%. W/B was set at 55%, and curing was performed at constant temperature and humidity. The experimental items were measured for density. The experiment plan is shown in Table 1.

Table 1: Experiment plan

Experimental factor	**Experimental level**	
Binder conditions	BFS*), PA**), PS***)	3
Replacement ratio of PA)**	25 (wt.%)	1
Replacement ratio of PS*)**	10 (wt.%)	1
Addition ratio of alkali activator (KOH, NaOH)	KOH : 0, 5, 10, 15, 20 (wt.%) NaOH : 0, 5, 10, 15, 20 (wt.%)	10
W/B	0.55	1
Test items	Density, Water absorption, Flexural strength	3

*BFS : Blast furnace slag
*PA : Paper ash
*PS : Polysilicon sludge

2.2. Materials Used

2.2.1. Bfs (Blast Furnace Slag)

BFS is a by-product from the production of pig iron, in which the rock components of iron ores melt in the furnace producing iron and float over the tuff. It is made into small sand particles by quenching with water. The blast furnace slag powder refers to a blast furnace slag produced by pulverizing it into a pulverizer.When used as an admixture of concrete, initial strength development is small, but long-age strenth is larger than cement due to the latent hydraulic properties of blast furnace slag. It is highly resistant to chemical erosion such as seawater and sewage, and pozzolanic reaction by blast furnace slag hydration has a great effect on pore filling and alkali aggregate reaction suppression.[8,10] blast furnace slag is a by-product generated during the production of pig iron, and it has advantages such as improvement of long-term strength and reduction of hydration heat when it is used as an admixture of concrete.However, hydration does not occur without external stimuli such as calcium hydroxide ($Ca(OH_2)$), sulfate ($CaSO_4 \cdot 2H_2O$), alkali (Na_2O, K_2O) The density is 2.91 g/㎤, the powder grade is 4,464 ㎠/g The chemical properties are shown in [Table 2]. [7]

Table 2: Chemical composition of BFS

Chemical component (%)						
SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	TiO_2
26.03	10.96	0.18	54.07	4.21	3.28	0.22

2.2.2. Polysilicon Sludge

Polysilicon sludge is an industrial by-product of polysilicon production, which is used as the main material of the heat collecting plate used in the solar energy generation.With the development of solar energy generation, polysilicon is rapidly increasing in quantity, and the waste is so much that it causes another environmental pollution. The density is 1.95g/㎤ and the powder grade is 7,122㎠/g. The main components consist of SiO_2 and CaO. The chemical properties are shown in [Table 3]. [7]

Table 3: Chemical composition of polysilicon sludge

Chemical component (%)				
SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO
41.1	3.64	1.78	30.1	0.83

2.2.3. Paper Ash

The papermaking ash causes the wastewater generated in the papermaking process to sludge, and the sludge is incinerated to produce paper ash. Paper ash is generated by incineration of waste synthetic resin, waste wood, and other waste generated throughout the paper production process, not by incinerating only paper sludge. These industrial by-products are used for cement raw materials, asphalt pavement materials, and artificial lightweight aggregate production.Paper sludge produces CaO by decarbonation from about 640 ° C or higher, usually at 750 ° C when paper sludge is incinerated. At this time, the crystal shape of the paper ash is changed according to the firing temperature. As the firing temperature increases, the amount of CaO produced increases. When papermaking ash is mixed with cement or blast furnace slag, excellent strength development is possible.[5,11] The chemical properties are shown in [Table 4].

Table 4: Chemical composition of paper ash

Chemical component (%)							
SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	TiO	Cl^-
12.4	6.9	8.3	58.7	3.4	1.8	1.4	4.0

2.2.4. NaOH

NaOH is the formula of sodium hydroxide. Sodium hydroxide has a specific gravity of 2.13 at 20 ° C and a melting point of 318 ° C, and the aqueous solution has a solubility of about 53% at 20 ° C. Since a lot of heat is generated when sodium hydroxide solution is diluted, the temperature of water at dilution is suitably 30 to 40 ° C. [5,12] a property of matter of NaOH is shown in [Table 5].

Table5: Physical property of NaOH

Physical property				
separate	specific gravity	melting point(℃)	boiling point(℃)	pH
White solid	2.13	318	1,390	14.0

2.2.4. KOH

KOH is the chemical formula of potassium hydroxide. Potassium hydroxide is obtained by electrolysis of potassium chloride aqueous solution. It is a white solid and has a specific gravity of 2.055. The melting point is 360.4 ℃, the boiling point is 1,320 ℃, and the specific heat capacity is 65.87J / mol. [5,12]a property of matter of KOH is shown in [Table 6].

Table6: Physical propertyof KOH

Physical property				
separate	specific gravity	melting point(℃)	boiling point(℃)	specific heat capacity(J/mol)
White solid	2.06	360.4	1,320	65.87

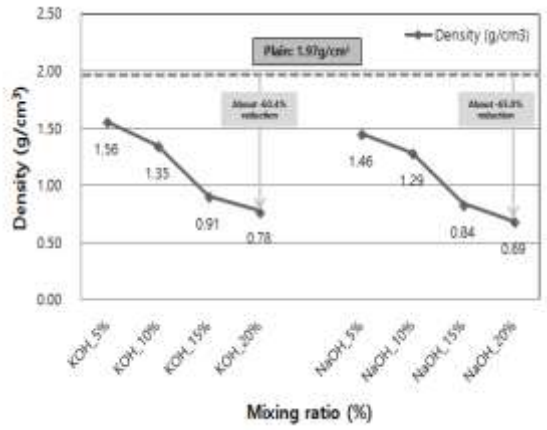
3. Results and Analysis

For the production of non-cement lightweight matrix, blast furnace slag, polysilicon and paper ash were used as binders to replace cement. Polysilicon and paper ash were mixed with blast furnace slag base, and KOH and NaOH were used as alkali stimulants for hardening of blast furnace slag. Experiments were conducted to analyze the properties of KOH and NaOH. Density, water absorption, and flexural strength were measured by KOH and NaOH tests. The molds used according to 'KS F ISO 679' were 40x40x160 size and measured after fabricating the

specimens. The flexural strength was measured at 3, 7, and 28 days of age. The experimental results are as follows.

3.1. Density and Water Absorption

[Figure 1] shows the density of cemented lightweight cement mixed with polysilicon sludge and paper ash, according to the ratio of alkali activator. As the mixing ratio of alkali activator increases, the density decreases. Compared with KOH, The density of NaOH was measured to be about 10% lower. In comparison with Plain, KOH was measured 60.4% lower and NaOH was measured 65.0% lower. These results suggest that the increase of the mixing ratio of alkali activators increases the foaming reactivity and the density is low. It is considered that the foaming performance is comparatively effective when NaOH is used as compared with KOH. [Figure 2] shows the absorption rate of the cement lightweight cured product incorporating the polysilicon sludge and ash, according to the ratio of alkali activators. It is shown that the absorption rate increases with the incorporation rate of the alkali activators. water absorption rate is measured higher when NaOH is used than KOH.Compared with Plain, KOH was measured up to about 238%, and NaOH was measured up to about 256%. These results show that the increase of the mixing ratio of alkali stimulant increases the foaming reactivity and the water absorption rate is measured to be high. In comparison with KOH, the foaming performance is considered to be relatively effective when NaOH is used.



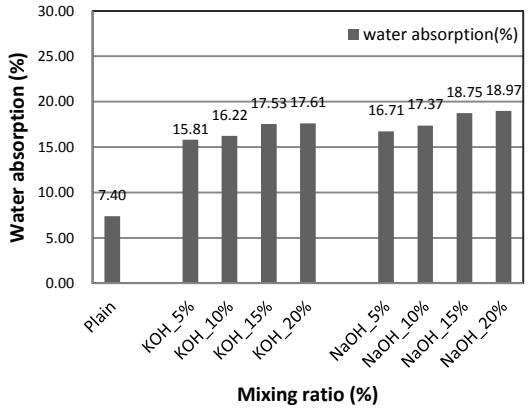


Figure 1: DensityFigure 2. Water absorption rate

3.2. Flexural Strength

[Figure 3] is a graph showing the flexural strength of the cement lightweight matrix incorporating polysilicon sludge and paper ash with the ratio of alkali activators. The flexural strength tends to decrease with increasing alkali activators content.Compared with Plain, the strength decreases drastically with a maximum reduction of about 13.5% for KOH and about 15.3% for NaOH. The strength of NaOH was slightly higher when KOH and NaOH were compared.These results suggest that the increase of the mixing ratio of alkali stimulants increases the foaming reactivity and decreases the strength.The use of NaOH rather than KOH is effective for the development of strength, but it is considered impossible to use it as an important structure due to its low strength. To increase the strength, the ratio of polysilicon to paper ash must be reduced.

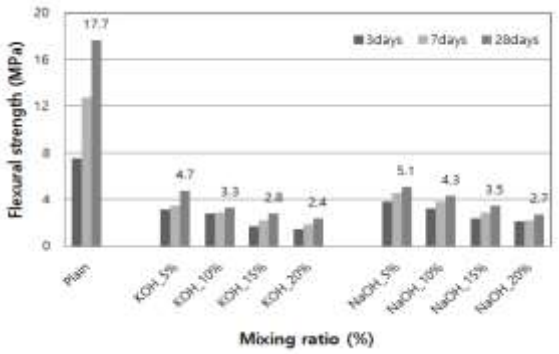


Figure 3: Flexural strength

4. Conclusion

The properties of NaOH and KOH mixing ratios were investigated in order to find out the optimum ratio of alkaline stimulants for the production of lightweight matrix containing polysilicon sludge and paper ash.As a result, the density tends to decrease when alkali stimulants are used, and the density decreases when NaOH is used compared to KOH. Absorption rate tends to increase when an alkali stimulant is used. Absorption rate increases when NaOH is used compared to KOH. Therefore, it was confirmed that the foaming performance was improved when the alkali stimulant was used, and it was judged that the foaming performance was comparatively effective when NaOH was used rather than KOH. Strength is significantly reduced when using alkaline stimulants rather than plain, It was confirmed that NaOH exhibited a higher intensity than KOH. These results show that NaOH is effective as an alkali stimulant for this study.

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