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Compressive Strength of Brick Made from Waste Materials

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ABSTRACT The objective of this research was to make brick from waste materials, such as MSWI fly ash, water sludge and coffee sludge. It was made by mixing raw materials, drying at room temperature for 24 hrs, and at 60°C ~ 100°C for 1hrs. The dried bricks sintered to 1100 ~ 1150°C by 5°C/min and then kept at that temperature for 2hrs. Compressive strength, water absorption were measured to discuss the characteristics of brick prepared. Toxicity characteristic leaching procedure(TCLP) test is also used to evaluate the environmental safety.

The optimum condition was obtained at the mixing ratio as followed; 20:19.5:0.5:60 of MSWI fly ash, water sludge, coffee sludge and clay. Considering the value of compressive strength and water adsorption for prepared brick, it can be used as an alternative brick.

1. Introduction

In korea, 441,004 ton of MSWI ash is discharged which is composed of bottom ash (about 369,378 ton) and fly ash (about 71,626 ton) in 2006[1]. MSWI fly ash generally contains high content of heavy metals, so it is regarded as hazardous waste. Therefore, it has to be buried at hazardous waste landfill site[2]. So it has to be treated safely. If it is de-toxificated it can be used as resources by immobilizing toxic component[3,4,5].

Recently photochemical smog becomes serious urbon air pollution problem. The concentration of NOx and VOCs has to be lowered to improve this problem. But it is very difficult, because VOCs is discharged from fugitive emission.

We investigate to prepare external brick to reduce VOCs in ambient air by using waste material such as MSWI fly ash, water sludge and coffee sludge in this study. Mixing ratio of raw materials and sintering temperature are used as parameters.

2. Material and method

2.1 Raw material

MSWI fly ash, water sludge, coffee sludge and clay were used as raw material to make brick. Clay was sampled from a local brick manufacturing plant. The filter press dewatered water sludge was sampled from local water treatment plant. The chemical composition of them is shown in Table

1 and Fig 1. The content of SiO_2, Al_2O_3 in fly ash is lower than that in clay and water sludge. But the content of CaO is higher than that in clay and water sludge

Table 1 Chemical compositions among clay, fly ash and water sludge

[Unit : %]

Compositions	Clay	FA[1]	WA[2]
SiO_2	61.0	1.67	35.7
Al_2O_3	25.9	0.50	38.8
Fe_2O_3	5.43	0.42	8.97
CaO	0.69	53.53	4.55
TiO_2	0.91	0.21	0.45
MnO	0.06	0.04	1.97
K_2O	3.56	4.14	2.49
Na_2O	0.41	9.17	0.67
P_2O_5	0.13	0.20	0.52
Ig. loss	-	-	-

FA[1] : Fly ash, WA[2] : Water sludge

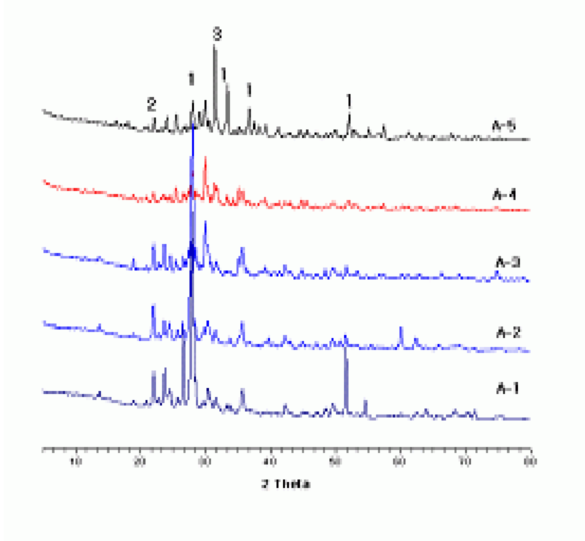

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Fig. 1 XRD patterns of prepared brick with mixing ratio of MSWI Fly ash

2.2 Mixing ratio

According to the results of preliminary experiment, mixing ratio of coffee sludge and clay was fixed as 0.5% and 60%, respectively. Mixing ratio of MSWI fly ash was varied from 10 to 30wt%. Mixing ratio for brick is given in table 2.

2.3 Preparation of brick

Raw materials were mixed as designed proportion with little water. In the mixing process of sample, raw materials are placed in a concrete mixer and mixed for 5min. Then they are compressed b an automatic press with the bed size of 11 × 23 cm^2, thickness of 1.5 cm and the pressure of 120 kg/cm^2. The molded bricks were air-dried at room temperature for 24 hrs, and then oven-dried at 60°C for 4hrs and at 100°C for 6hrs. The dried bricks were sintered to 1100 ~ 1150°C as the rate of 5°C/min. And then they kept at that temperature for 2 hrs

2.4 Measurement

Compressive strength and water absorption of bricks were measured by Korea testing standard. Toxicity characteristic leaching procedure (TCLP) was performed to investigate the leach ability of metals from bricks[6].

3. Results and discussion

3.1 Sintering temperature

Sintering temperature affects seriously compressive strength of brick like mixing ratio of raw material. Compressive strength with sintering temperature is compared I Table 3. Compressive strength at 1150°C was higher than that at 1100°C. But it was lowered over 1115°C in previous research see Table 4) [7]. It is due to the difference of raw material, or amounts of sludge used.

3.2 Mixing ratio

The value of compressive strength was affected by mixing ratio of raw material. According to Table 4, compressive strength was highest at 20wt% of fly ash without sintering temperature under our experimental condition. The value of water absorption measured was given I Table 5. The value was increased by raising amounts of fly ash.

Table 2 Mixing ratio of brick to prepare brick

[Unit : wt%]

FA	WS	CS[1]	Clay
10	29.5	0.5	60
20	19.5	0.5	60
30	9.5	0.5	60

FA: Fly ash, WA : Water sludge, CS[1] : Coffee sludge

Table 3 Effect of temperature on the compressive of MSWI Fly ash

[Unit : MPa]

FA : WS: CS : clay	1100°C	1150°C
10 : 29.5 : 0.5 : 60	8.6	10.5
20 : 19.5 :0.5 : 60	9.2	19.1
30 : 9.5 : 0.5 : 60	7.8	14.6

Table 4 Effect of the compressive streaght on raw material

[Unit : MPa]

FA: MS[1] : SS[2] : Clay	Compressive strength			
	1080°C	1100°C	1115°C	1130°C
10 : 20 : 5 : 65	15.3	16.6	40.7	13.8
20 : 20 : 5 : 55	7.5	10.4	18.5	5.7
30 : 20 : 5 : 45	4.9	7.7	14.5	13.3

MS[1] : Melting Slag, SS[2] : Sweage Sludge

3.3 Leaching test

Leaching amount of heavy metal with TCLP for MSWI fly ash and brick prepared was described in Table 6. According to the results, heavy metal in ash was immobilized in brick..

Table 5 Water absorption of brick prepared

FA: MS[1] : SS[2] : Clay	Water absorption(%)
10 : 20 : 5 : 65	9.43
20 : 20 : 5 : 55	11.02
30 : 20 : 5 : 45	12.16

Table 6 Heavy metal concentration in ashs, brick by leaching test

[Unit : mg/L]

Metals	FA	Bricks	Regulated TCLP limit
Pb	29.47	0.16	3.0
Cu	0.12	0.05	3.0
Cd	N.D[1]	N.D	N.D
Zn	20.51	0.23	0.3

ND[1] :Not Detected

4. Conclusions

The result which is obtained in this study is as follows.

1. The optimum mixing ratio of MSWI fly ash and water sludge is to be 20% and 19.5%, respectively. Compressive strength was 19.1MPa at this mixing ratio
2. Highest compressive strength and water absorption were 19.1 MPa and 14.7 %, respectively.
3. According to the TCLP result, heavy metal in fly ash was immobilized through the preparation of brick.

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