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≫ 연구논문 ≪

열병합 발전소에서 발생한 우드칩 분진에 대한 특성 분석

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Characterization of Wood Chip Ash Generated from a Power Plant

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요 약

우드칩 분진 발생량은 우드칩 기반 난방과 에너지 수요가 증가함에 따라 계속적으로 증가할 것으로 기대된다. 따라서 우드칩 분진의 활용에 대한 관심도 증가하고 있다. 이 연구를 통해 우드칩 분진의 재활용을 위한 일안으로 열병합 발전으로부터 발생한 우드칩 분진에 대한 물리적, 화학적 특성을 분석했다. 화학 분석 결과 우드칩 분진의 주된 구성성분은 실리카, 알루미나, 알칼리로 나타났다. 우드칩 분진에 대한 strength activity index 분석과 석탄재와의 비교를 통해 이차 시멘트계 재료로써 재활용 가능성을 확인했다. 90일 동안 경화한 우드칩 분진에 대한 strength activity index 최대값은 78%였으며 이는 시멘트계 재료에 대한 혼합물로써 재활용할 수 있음을 제시하는 결과이다.

주제어 : 우드칩, 비산재, 바닥재, strength activity Index

Abstract

The amount of the wood chip ash is expected to increase continuously as demand of wood chip-based heat and electricity increase. Thus, there is increased interest in wood chip ash utilization. In this study, as a program of utilization in wood chip ash, the physical and chemical properties of wood chip ashes generated from a combined heat and power plant were investigated. The chemical analysis showed that the main contents of wood chip ash are composed of silica, alumina and alkali. A possibility of reuse as secondary cementitious materials was investigated by the analysis of strength activity index, and compared with coal ash. The highest value for Strength activity index of wood chip fly ash was 78% at 90 days curing time. This result revealed that wood chip fly ash has the potential to be utilized as the admixture for cementitious material.

Key words : wood chip, fly ash, bottom ash, strength activity Index

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1. Introduction

The demand for bio-based heat and electricity has been rapidly increased because of targets for generating energy from renewables and decreasing the emission of fossil CO_2[1]. Because of increase of biomass conversion, there has been increase of biomass ash production. The quantity of the wood chip ash which was generated in 2013 year in Korea is as approximately 200 thousand ton and most of it is being disposed or utilized as a cements raw material. However, from an economic viewpoint, a lot of transformation costs are required, since most cement plants are far from wood chip ash production place. Also, wood chip ash contains high alkali content which affects cements quality degradation[2].

Several studies to use in agriculture and construction have been conducted as way of utilizing the wood chip ash. According to James et al.[1], wood chip fly ash can be used as a cement replacement in concrete, for soil stabilization, as a road base, structural filler in asphalt base products, lightweight bricks and synthetic aggregate. While much research has been conducted on fly ash utilization, a lot still remains to know about the effective utilization of bottom ash. This study investigated physical and chemical properties of wood chip ash in order to find out the way of efficient reuse. A possibility of reuse as secondary cementitious materials was investigated by the analysis of strength activity index and compared with coal ash.

2. Experimental Procedure

The wood chip fly ash and bottom ash produced at Daegu wood chip combined heat and power (CHP) plant has been used as a sample for this experiment and it has been compared to coal ash used as cement additive and concrete aggregate. Chemical analysis was measured by the chemical element analyzer. The shapes and sizes of the wood chip fly ash were observed using Scanning Electron Microscopy (JSM-6700F, JEOL). Particle size distribution of wood chip fly ash was measured with Malvern particle size analyzer (Mastersizer S Ver. 2.15). Also, sieve analyses of the wood chip bottom ash were carried out using a standard method which is KS F 2526 : 2007 (Concrete aggregate) to know if it can be used as fine aggregate which is applicable in any concrete applications. A strength activity index test was performed in accordance with the Korea industrial standard KS L 5405 specification to investigate the possibility of reuse as an admixture for secondary cementitious material. Two-inch cubes were created using a water-to-cement ratio of 0.484. Replacement levels of 30 percent were measured using as received wood chip fly ash, coal fly ash and coal bottom ash. The compressive strength of the cubes was determined using a Test Mark Compression Testing Machine.

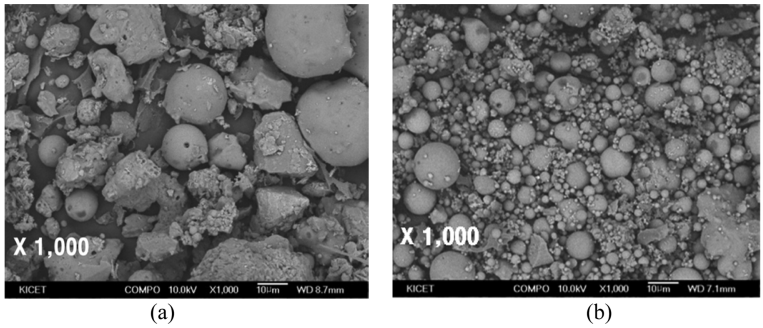
3. Results and Discussion

Table 1 lists chemical analysis data for composition of wood chip ash and coal ash. As seen in the table, wood chip ash is mainly composed of SiO_2, whereas coal ash has a considerable amount of Al_2O_3 and Fe_2O_3 beside of SiO_2. Also, wood chip ash has a lot of alkali contents compare with coal ash. According to Naik et al.[3], the average value of available alkali (alkali metal/ earth metal ion) in wood fly ash was 3.3%, which is significantly above maximum allowable alkali (1.5%) for coal fly ash in accordance with ASTM C 618. The presence of a high amount of alkali may lead to a favorable acceleration of early-age hydration reaction in pozzolanic materials used in making cement-based construction materials. However, available alkali may also impact cement-based construction materials negatively due to the possible alkali-silica reaction (ASR) in presence of reactive aggregates and/or high-alkali Portland cement. It is known that the average loss on ignition (LOI) value of wood ash ranged from 6.7% to 58.1%.[4] This result shows much higher than our results. Generally LOI values are closely related to combustion condition in boiler.

The SEM micrographs are shown in Fig. 1, and they confirm that the most particle size of wood chip fly ash ranges from 10 to 110 μm, which is much coarser than that of coal fly ash. Coal fly ash particles are generally spherical shape. However, some portions of

Table 1. The chemical analysis data of wood chip ash and coal ash (wt%)

	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Na_2O	K_2O	SO_3	P_2O_5	LOI	Cl (ppm)
Wood chip Fly ash	70.6	14.8	4.3	2.7	1.14	1.70	3.56	0.07	0.28	0.14	49
Wood chip bottom ash	71.4	14.0	3.69	2.6	1.23	2.36	3.70	0.02	0.22	0.03	16
Coal Fly ash	54.9	20.6	6.77	5.3	2.10	1.50	1.72	0.76	0.60	5.05	Tr
Coal bottom ash	54.9	22.0	7.82	4.1	1.34	1.05	1.12	0.11	0.36	1.28	735



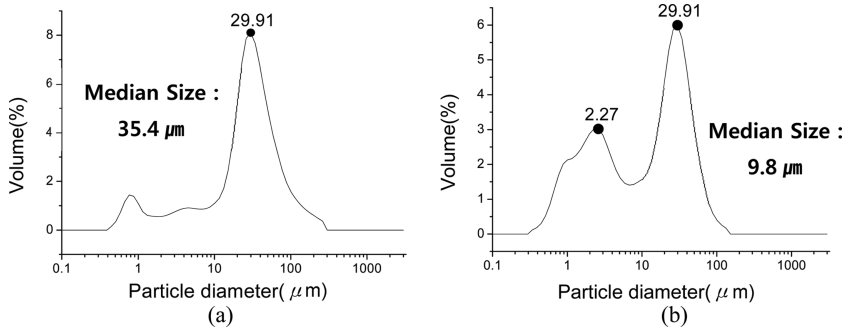
(a) (b)

Fig. 1. SEM image of (a) wood chip fly ash and (b) coal fly ash.

irregular and angulate shapes are more observed than spherical in wood chip fly ash.

The particle size distribution of the wood chip fly ash and coal fly ash are shown in Fig. 2. The mean particle size of wood chip fly ash is 35.4 μm which is larger than that of coal fly ash. Most particles of coal fly ash are smaller than those of wood chip fly ash. Bimodal distribution of particle size is represented in the respect of entire particle size distribution. Specially, portion of particle size under 10 μm are more observed in coal fly ash than that of wood chip fly ash.

Wood chip and coal bottom ash have angular grains with very porous surface texture. The grain size distribution of the wood chip bottom ash and coal bottom ash is shown in Fig. 3. Also, it was compared with grading envelope of fine aggregate (KS F 2502) to investigate of the possibility as replacement of fine aggregate. From the grading coal bottom ash were falling with the target



(a) (b)

Fig. 2. Particle size distribution of (a) wood chip fly ash and (b) coal fly ash.

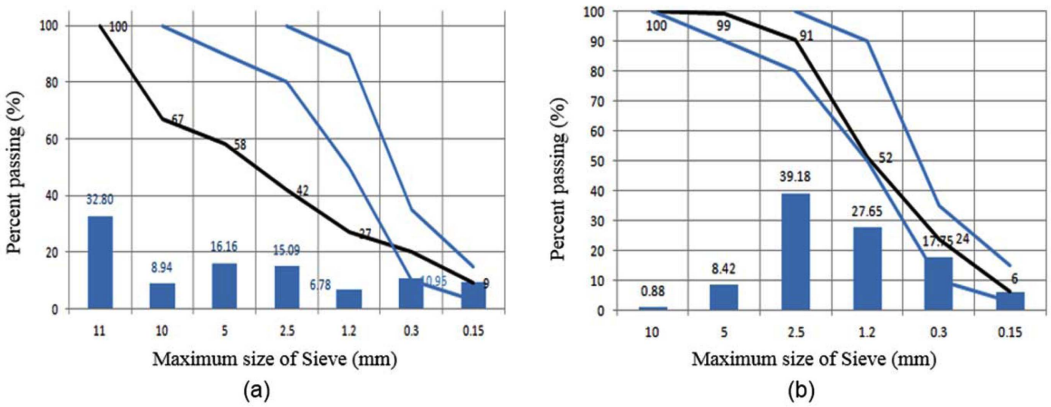


Fig. 3. Grain size distribution of (a) wood chip bottom ash and (b) coal bottom ash.

grading envelope of the fine aggregate. Whereas, size of wood chip bottom ash was much coarser than that of coal fly ash. Wood chip bottom ash has 4.75 mm size is over than 40 percent, on the other hand coal bottom ash less than 1 percent.

When we consider to reuse as an admixture for secondary cementitious material, it is required that the cementitious material products should possess suitable properties[5].

To investigate the possibility of reuse as an admixture for secondary cementitious material, a strength activity index test of wood chip fly ash was performed in accordance with the KS L 5405. Table 2 lists compressive strength of mortar and strength activity index of wood chip fly ash, coal fly ash and coal bottom ash. The KS L 5405 specification requires that a fly ash have a strength activity index of at least 90 percent of the control at 90-day, so the as-received wood chip fly ash would not be satisfied the requirement of 2nd grade fly ash quality. This result attributed to coarse particle size of wood chip fly ash since strength activity index is cl1osely relate to reaction surface area. However, this test found that the increasing range of wood chip fly ash compressive strength is much higher than that of coal ash with increasing curing time 7-day, 28-day and 90-day. This result is closely related to SiO_2 contents of wood chip ash, since SiO_2 react with $Ca(OH)_2$ in the pozzolanic reaction.

4. Summary

Characterization of wood chip ashes generated from a combined heat and power plant were analyzed and compared to coal ash to investigate the possibility of utilization of it as the admixture for cementitious material. Wood chip ash contains higher amount of silica and coarser particle size compared with coal ash. Generally, strength activity index is closely related to particle size and silica content. Particle size of fly ash is related with reaction surface area and silica contents are related

Table 2. Strength activity index results of wood chip ash and coal ash (wt%)

Samples	Compressive Strength (Mpa) - Strength Activity Index (%)			Remarks
	7-day	28-day	90-day	
Wood chip fly ash	35-67	49-71	57-78	Fly ash quality (Strength Activity Index) 1st grade > 100, 2nd grade > 90
Coal fly ash	52-97	59-85	69-95	
Coal bottom ash	32-59	43-62	46-63	

to react with $Ca(OH)_2$ in the pozzolanic reaction. Strength activity index of wood chip fly ash shows lower than that of coal fly ash. This result attributed to particle size effect was dominant than silica contents at wood chip fly ash. However, the increasing range of wood chip fly ash strength active index is much higher than that of coal ash with increasing curing time. This result revealed that wood chip fly ash has the potential to be reused as the admixture for cementitious material even though strength activity index of wood chip fly ash does not satisfy the requirement of fly ash quality.

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