Changes in Crushing and Granularity Characteristics of Bottom ash as Compaction Energy

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KEYWORDS: bottom ash, granularity, crushing characteristic, compaction energy, IC

ABSTRACT

Bottom ash is about 20% of total coal ash production in Korea, but most of them have been reclaimed in ash landfill. But there are problems in a regard to insufficient ash landfills and economic loss like waste disposal cost, so it is necessary to study recycling of bottom ash and recycling standards in field. Especially, the porous characteristic of bottom ash makes itself more easily crushed during compaction, so it makes some changes of the granularity and the compaction characteristic. This study aims at investigating the crushing and granularity characteristics of bottom ash obtained from Yeongheung coal-fired power plant as compaction energy increases. On compaction curve obtained from compaction method A, sieve analysis of begin and after compaction was conducted into samples compacted in dry condition and wet condition and then index of crushing(IC) was calculated from the change of particle size distribution. The results indicated that as compaction energy increased, percentage of each particle size and fine-grain increased and its changes appeared in different between dry condition and wet condition. If we use bottom ash as construction materials, we can suggest the standard about compaction method or compaction water content in field based on crushing and granularity characteristic

1. Introduction

In today's society, the various types of waste is generated according to urbanization and industrialization. Coal Ash, which is one kind of wastes, is a by-product from thermal power plants and occurs about 10 million tons per year in Korea. Bottom ash forms approximately 15~20% of total coal ash, but a large fraction of the bottom ash is typically disposed of as a waste in utility disposal sites and it causes economical problems in securing disposal sites. Thus many studies are being conducted to recycle bottom ash, especially in the fields of construction. Currently, Bottom ash is being used

as a material of construction for embankment, subgrade, back-fill materials because of its similarities to sand. However, one of differences between common sand and bottom ash is that it has internal pores, in other words, it is porous material (Wei-Hsing Huang, 1990; A. Trivedi, 2002; Kim, 2010;). It makes bottom ash more easily crushed during compaction and change the granularity characteristics and the compaction curve of bottom ash in the results of compaction test. In order to make batter use of bottom ash, such crushing characteristics and changes in granularity characteristics as compaction should be investigated and standards on field compaction in accordance with the characteristics should be suggested.
This study aims at investigating the crushing and granularity characteristics of bottom ash obtained from Yeongheung coal-fired power plant as compaction energy increases and conducting fundamental study for standard of the field compaction.

2. Experimental

2.1. Materials

The ash samples used in this study were extracted from Yeongheung(YH) coal fired power plant in Korea, the specific gravity and particle size distribution of the samples were given Table 1 and Fig. 1.

Table 1
The specific gravity and particle size distribution of Bottom ash (YH).

Division	Gs	Passing Sieve No. 200(%)	D_{10} (mm)	D_{50} (mm)	C_u	C_g	USCS
Value	2.21	7.52	0.10	1.37	20.10	0.80	SW

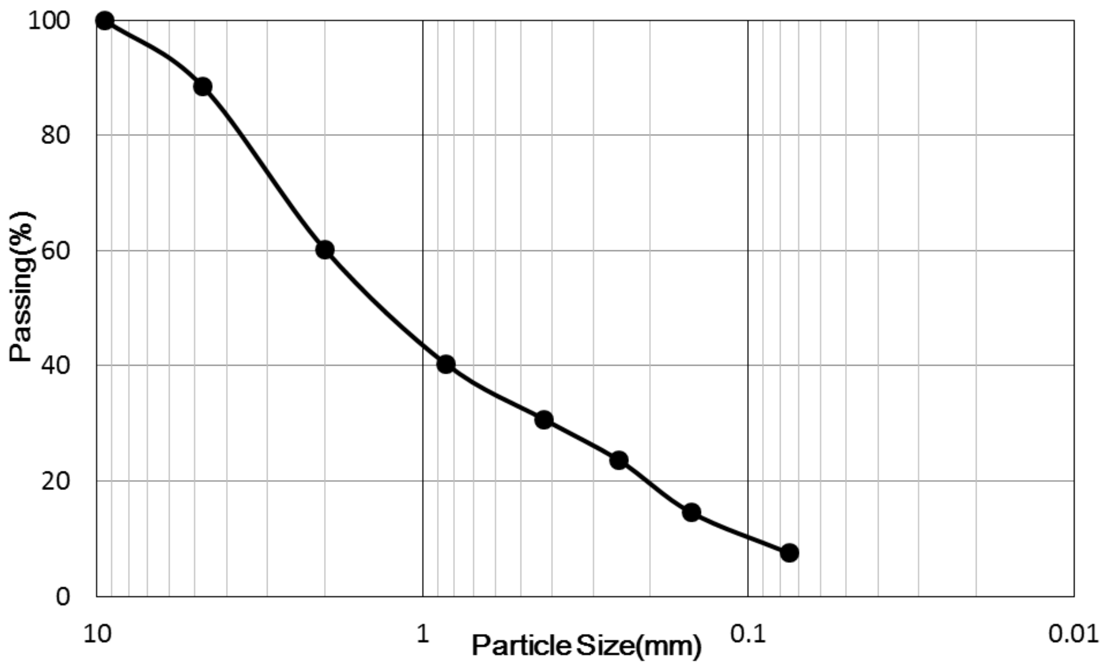


Fig. 1 Particle size distribution of bottom ash(YH)

2.2. Compaction test

Standard compaction tests were performed following KS F2312-91(Method A). To prevent the crushing of the bottom ash particles influencing the compaction curve, the samples were thrown out after compacting and fresh samples were used each test.

2.3. Sieve analysis before and after compaction for confirming particle crushing

Compaction tests were performed by 100%, 200%, and 300% energy of method A compaction energy in the dry condition and the optimum water content(wet condition) on compaction curve obtained from standard compaction tests. And sieve analysis by washing samples after compaction was conducted in each condition.

Photo 1 Views of compaction test and sieve analysis test

2.4. Index of crushing

The Index of crushing(IC) was calculated through the particle size distribution curve before and after compaction (Shergold, 1954), and the method of calculation is shown as

$$\text{Index of crushing(IC)} = 100 \times (\sum C - \sum E) / \sum C \quad (1)$$

Where, C = Initial weighted (%); E = Final weighted (%)

3. Results and discussion

3.1. Compaction curve

Fig. 2 shows the compaction curve for YH bottom ash. Type of the compaction curve was type B appeared in common coarse sand and bottom ash, optimum water content was 22% in the wet condition. Compactions were performed in the dry condition and the wet condition of 22% water content on the results.

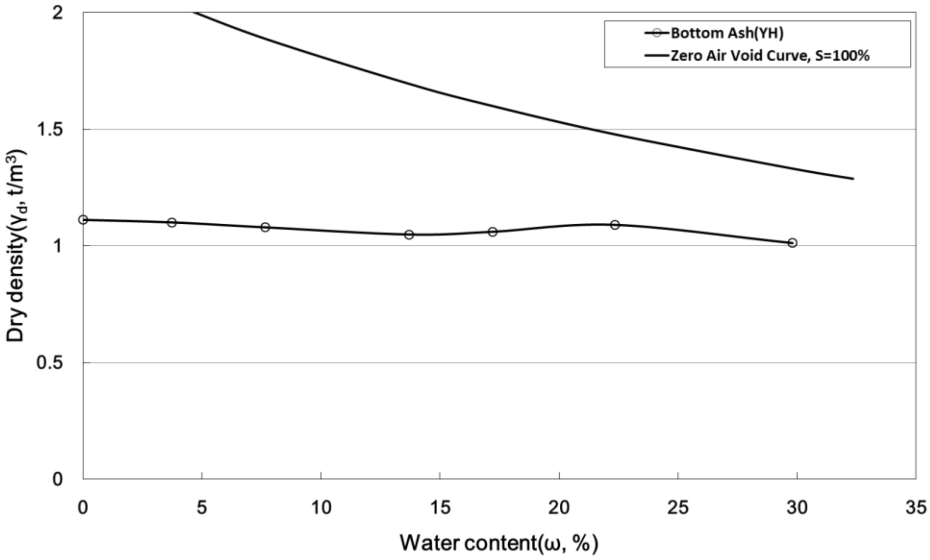


Fig. 2 Compaction curve for YH bottom ash

3.2. Change of particle size distribution as compaction energy

Fig. 3 shows the particle size distribution each compaction energy in dry condition and wet condition and granularity characteristics of each case is summarized in Table.2. The particle size distribution curves were shifted up as each particle size becomes fine-grained due to crushing by compaction and it was confirmed in that the effective particle size and the average particle size become smaller. Also both uniformity coefficient(Cu) and coefficient of curvature in each case decreased after compaction and consequently it indicated grading of each case became poor, but all samples had well graded after crushing in a regard classification of each sample by the USCS were not changed and remained SW.

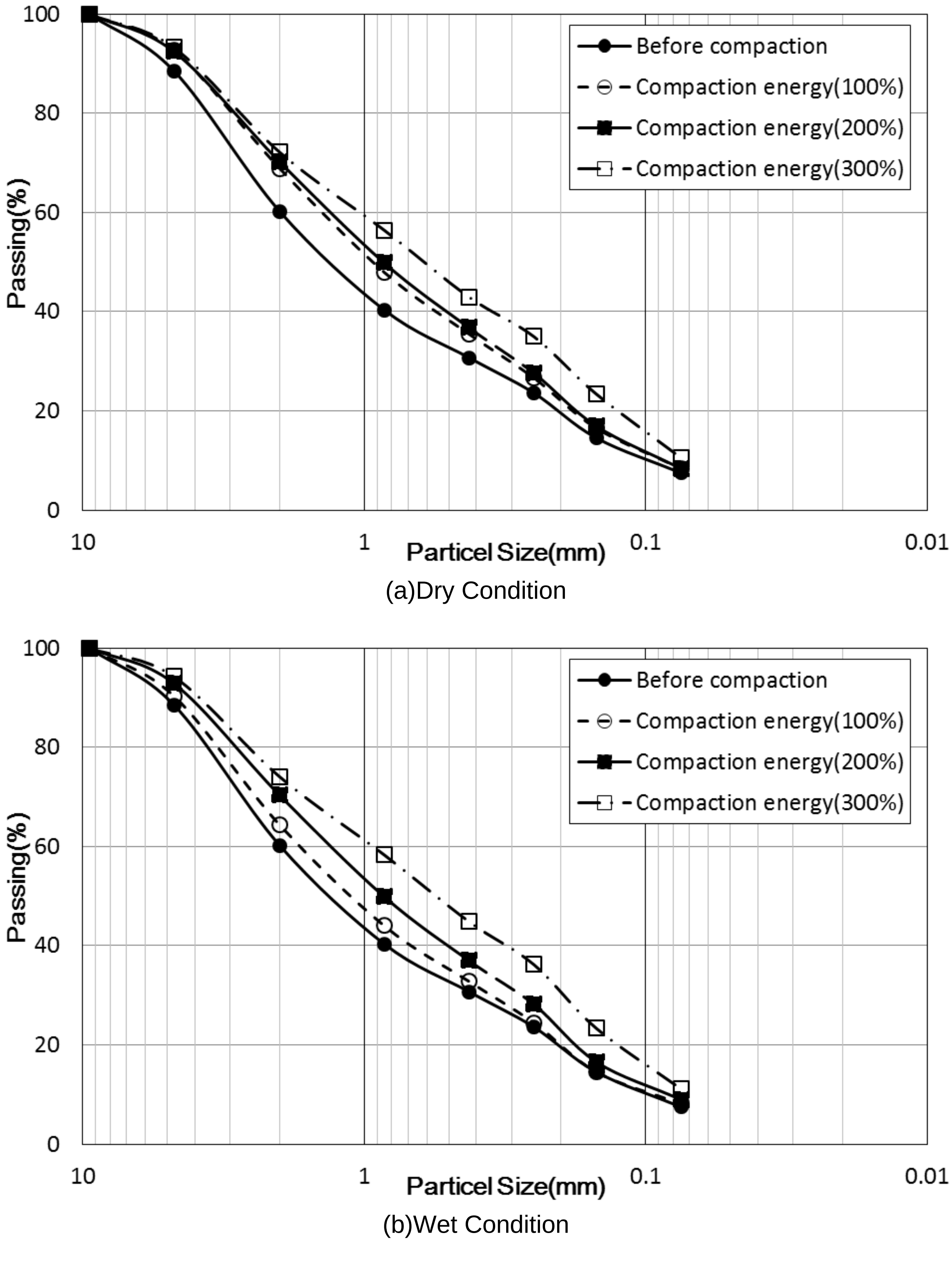


Fig. 3 Particle size distribution on 100%, 200%, 300% compaction energy

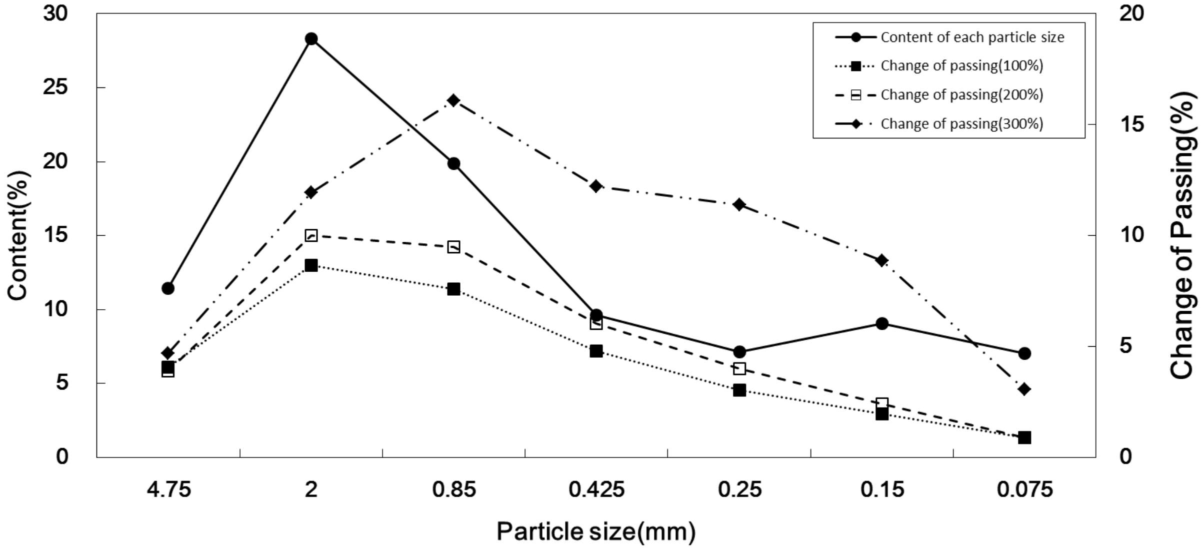
Table 2 Granularity characteristics in each case

Condition	Compaction Energy(%)	D_{10}	D_{30}	D_{50}	D_{60}	Cu	Cg	No.4 Passing(%)	No.200 Passing(%)	USCS
Before Compaction		0.10	0.40	1.37	2.01	20.10	0.80	88.57	7.52	SW
Dry	100	0.09	0.31	0.94	1.43	15.89	0.75	92.65	8.41	SW
	200	0.09	0.29	0.85	1.33	14.78	0.70	92.45	8.42	SW
	300	0.07	0.20	0.60	1.05	15.00	0.54	93.25	10.57	SW
Wet	100	0.10	0.35	1.16	1.72	17.20	0.71	90.35	8.16	SW
	200	0.08	0.27	0.84	1.35	16.88	0.68	92.89	9.03	SW
	300	0.07	0.20	0.56	0.92	13.14	0.62	94.26	11.15	SW

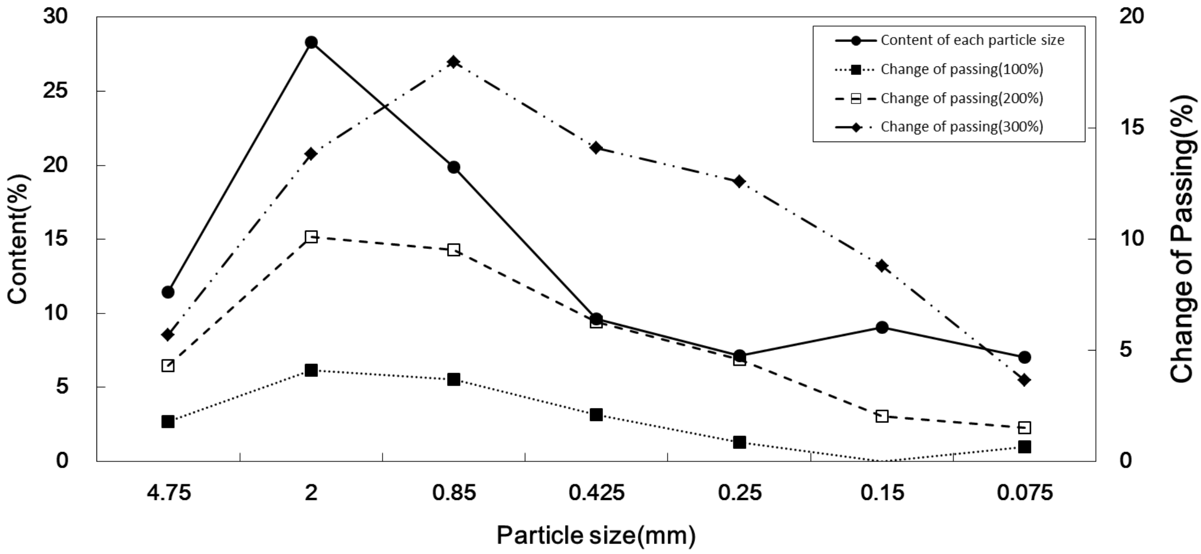
3.3. Change of passing ratio in each particle size as compaction energy

Fig. 4 shows the content of each particle size versus change of passing ratio as compaction energy.

As for the samples compacted by 100% and 200% compaction energy, the results show the content of the particle size would be significantly associated with the amount of particle crushing in that it was generally indicated that the higher the content of each particle size was, the higher increasing of passing ratio was. But, in the samples compacted by 300% compaction energy, the result indicated the amount of particle crushing in which have a particle size range from 0.25mm to 0.85mm had increase significantly compared with their content. Thus, the particles which have a size range from 0.25mm to 0.85mm can be considered to have bigger single particle crushing strength than other particles



(a)Dry Condition



(b)Wet Condition

Fig. 4 Content and change of passing ratio in each particle size

3.4. Change of IC as compaction energy

Table 3 presents index of crushing(IC) and increment of No.200 passing for quantitative comparison of the degree of crushing in dry condition and wet condition. As for compaction bigger by compaction energy of method A(100%), the value of the index of crushing and the increment in percent of fines(No. 200 passing) in dry condition were bigger than the value in wet condition. However, as compaction energy increased, both the value of the index of crushing and the increment of No. 200 in wet condition became slightly higher than the values in dry condition. The results indicate the degree of crushing would be increased in a field compaction which has a bigger compaction energy than method A and if it is required to decrease a degree of bottom ash crushing in order to meet a field criteria

Table 3

Condition	Compaction Energy (%)	Percent fines			Index of crushing (%)
		Before Compaction (%)	After Compaction (%)	Increment of No.200 Passing (%)	
Dry	100	7.52	8.41	0.88	18.61
	200		8.42	0.89	20.40
	300		10.57	3.05	27.62
Wet	100	7.52	8.16	0.64	8.49
	200		9.03	1.51	21.37
	300		11.15	3.63	32.14

4. Conclusions

Based on laboratory tests, the crushing and the changes of granularity characteristics of Yeongheung(YH) bottom ash was occurred by compaction and it was affected by the content of each particle size, compaction energy, and dry/wet condition. Especially, the results showed that YH bottom ash has a different single particle crushing strength by each particle size, and a degree of bottom ash crushing was increased as compaction energy increased, but its degree was slightly higher in wet condition. When bottom ash is used as construction materials, it is necessary to confirm these crushing and changes of granularity characteristics of bottom ash for deciding bottom ash recyclable or not and choosing a decent compaction method in field.

5. Acknowledgment

This paper was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (MEST) (No. 2012R1A1A1010633)

REFERENCES

[1]Shergold, F. A. A study of the crushing and wear of surface-dressing chippings under rolling and light traffic, Research Note No. RN/2298/FAS.B.P, 1954, p. 397.

[2]Huang, W.-H. The Use of Bottom Ash in Highway Embankments, Subgrades, and Subbases, 1990.

[3]Trivedi, A. and V. Sud, Grain characteristics and engineering properties of coal ash, Granular Matter, 2002, pp. 93-101.

[4] Kim, Y. S., Lee, J. Y., Shin, H. C., Shin, J. J. and Kim, Y. G. The Study on the Fundamental Properties of Cement Mortar Using Coal-Based Bottom Ash(CBBA), Korean Recycled Construction Resources Institute, 2010, pp. 121-126.