Production and Characteristics for Concrete Waste Forms to Stabilize Concrete Waste Produced during Decommissioning Procedure.

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1. Introduction

Since the decommissioning of nuclear plants and facilities, large quantities of slightly contaminated concrete waste have been generated. In Korea, the decontamination and decommissioning of the KRR-1, 2 at the KAERI have been under way. Concrete waste was generated 83 drums of 200L and 41 containers of 4 M^3. These concrete wastes consist of rubble, coarse, and fine aggregates. And also, 24 drums of concrete sludge were generated from the saw cutting of radioactive concrete. The conditioning of concrete waste is needed for final disposal.

The concrete waste is conditioned as follows: mortar using coarse and fine aggregates is filled void space after concrete rubble pre-placement into 200 L drum.

The mortar needs to be solidified using cement or other materials to protect from sufficient strength and harmful opening. Especially, cement was frequently used solidification/stabilization above all the other ones because of competitive prices, convenient method and excellent quality. Thus, this paper has developed an optimizing mixing ratio of concrete waste, water, and cement and has evaluated characteristics of a cement waste form containing radioactive concrete to meet the requirements specified in disposal site specific waste acceptance criteria.

2. Experimental

Fig. 1 shows the particle size distribution of concrete waste.

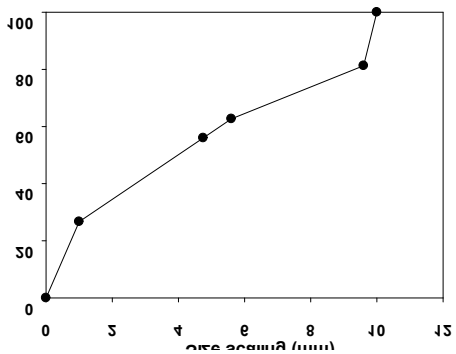


Fig. 1. Particle size distribution of concrete waste.

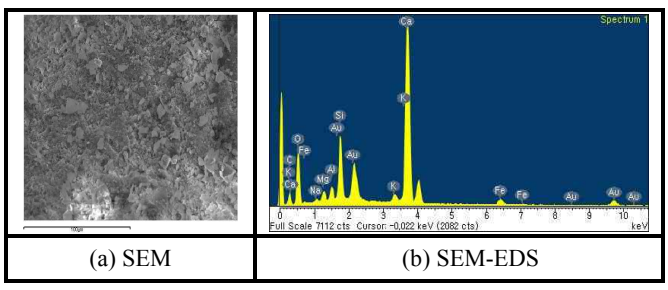
The concrete waste less than 4.75 mm is about 65% and these are used for conditioning because of a cement waste form's mold size, the size of which is 5 cm diameter and 10 cm length. The mortar is made by varying a mixing ratio of concrete, water, and cement 50 ~ 80%, 10 ~ 30 %, and 5 ~ 35 %, respectively. The mortar involving the concrete sludge is also made and sludge content in the concrete waste is from 10 to 40%. The cement waste form is made after curing the mortar during 28 days. Workability of the mortar is tested to evaluate its fluidity as KS L 5111 and compressive strength of the cement waste form is tested as KS F 2405. Scale-up test is carried out using a mold of 15 cm diameter and 30 cm high. This test use concrete waste of size distribution as follows: 15 % above 50 mm, 37.4 % less than 4.75 mm, 24.9 % from 1 mm to 4.75 mm, 22.7 % less than 1mm.

The physical properties of material were detected by SEM (JSM-6300, JEOL, Japan), SEM-EDS, X-ray diffraction (D5000, SIEMENS, Germany).

3. Results and Discussion

3.1 Materials

Figure 2 is a SEM image and EDS result of the concrete waste. The components involved in the concrete waste consists O, Si, Ca, Mg, Fe, Na, Al, K, and C. Chemical compound can be calculated from the EDS result. Concrete consist of 15.83wt% of SiO_2, 53.37wt% of $CaCO_3$, 21.11wt% of CaO, 2.37wt% of Al_2O_3, 2.94wt% of Fe_2O_3, 2.59wt% of MgO, 0.64wt% of Na_2O, 1.15wt% of K_2O. SiO_2, Al_2O_3, CaO, and $CaCO_3$ generated as a hydration reaction of the cement were confirmed. The X-ray diffraction (XRD) pattern of concrete waste was illustrated in Fig. 3. It is confirmed that major compounds are SiO_2 and $CaCO_3$ like the EDS result.



(a) SEM | (b) SEM-EDS

Fig. 2. SEM image and SEM-EDS result of concrete waste

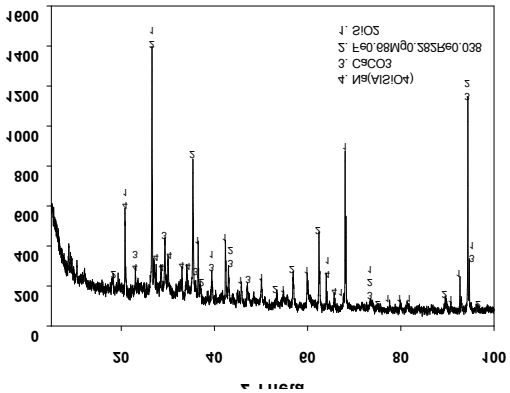


Fig. 3. XRD patterns of concrete waste.

The surface of concrete aggregate is rougher than sand. Surface roughness would be the significant importance among such factors to affect the concretes compressive strength as the ratio of water and cement [1]. Therefore, it is expected that the concrete waste could be used to make cement waste form instead of an aggregate.

3.2 Concrete Mortar

Fig.4 shows the compressive strength of the cement waste forms made as several mixing ratios of concrete, water, and cement. This result was essential to create optimizing mixing ratio and to know physical durability, stability of concrete waste form.

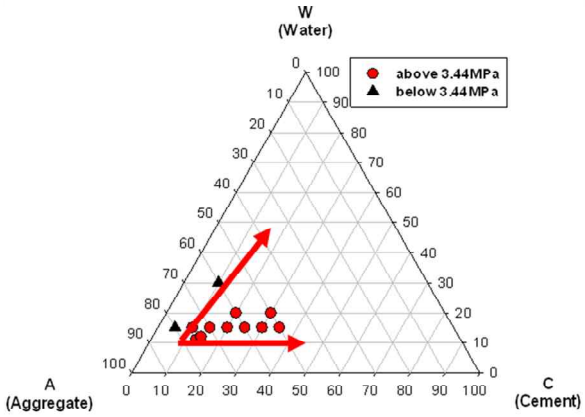


Fig. 4. Result of solidification concrete waste by cement.

Plots on the Figure marked by an arrow show the cement waste form meets satisfied compressive strength (> 3.44 MPa). Mixes with concrete waste varying from 50 to 80 %, water varying from 10 to 20 %, cement varying from 10 to 35 % is proper.

Proper mortar flow rate was made good filling into the drums after pre-placing rubble and a matter of great importance of volume reduction. Flow rate was detected by workability test. For requirement of compressive strength of waste form and requirement of mortar flow rate, 75:15:10 was optimized content of concrete waste, water and cement.

Scale-up test differ from small scale test in optimum mixture ratio. This paper suggested 75:10:15 as optimizing mixing ratio at scale-up test because specific surface area decreased with increasing particle size.

The mortar involving the concrete sludge is also made. Cement mixed waste form tends to slightly increase the compressive strength, because water consumed for cement solidification lessens due to sorption by the fine concrete sludge powder [1]. Scale-up test is conducted. The mixture of concrete (concrete waste + concrete sludge), water and cement is 75(30+70):15:10 and 75(10+90):12.5:12.5 shows optimizing value.

Table 1. Mixing ratio and results of concrete mortar involving the concrete sludge.

Mixing ratio (wt %)					Compressive Strength (MPa)
Aggregate	Sludge concrete	Water	Cement	w/c	
75	40	15	10	150	4.274
	60				
	30				4.994
	70				
	20				4.344
	80				
	10				5.234
	90				
	10	12.5	12.5	100	3.789
	90				

3. Conclusions

The concrete waste generated from decommissioning is conditioned as follows: mortar using coarse and fine aggregates is filled void space after concrete rubble pre-placement into 200 L drum. And 200 L drums send to final disposal site. The mortar is needs to be solidified by cement to meet the requirements specified in disposal site specific waste acceptance criteria.

The concrete waste, water, cement has suggested 75:10:15 as optimizing mixing ratio. Also optimized content of concrete (concrete waste + concrete sludge), water, cement is 75(30+70):15:10 and 75(10+90):12.5:12.5. Furthermore, leaching test, thermal cycling test, irradiation test, immersion test will be conduct to estimate the release of contaminants.

REFERENCES

[1] T. Ishikura, H. Ueki, K. Ohnishi and D. Oguri, Utilization of crushed radioactive concrete for mortar to fill waste container void space. Journal of Nuclear Science and Technology, Vol. 41, p. 741-750, 2004.