Evaluation of the Size Effect on the Compressive Strength Test in Cement Waste Form

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1. Introduction

It is difficult to carry out the evaluation of the integrity and safety of radioactive waste forms produced in the nuclear facilities with a size of 200L real waste form. Therefore waste form's characterization, consisting of the compressive strength test, the leaching/ immersion test, the thermal cycling test, and the radiation resistance test, is performed by using small size specimens extracted from waste form. The compressive strength, one of the most important items to evaluate structural safety of waste form, highly depends on the test conditions such as the shape and size of specimen and the loading rate of compression machine [1, 2].

According to the destructive mechanism with compression it is known that the destruction breaks out because of the concentration of the high stress in the vicinity of a spot existing non-homogeneity such a defect and crack inside the specimen.

In this work, the compressive strengths were measured with the variation of the specimen size and the loading rate. And then, the compressive strengths were evaluated for the variation of the above parameters to be affected to the compressive strength. It was also compared with the compressive strength before and after thermal cycling test.

2. Methods and Results

The compression machine to measure compressive strength of cement is a oil hydraulic system, has a maximum load capacity of 30ton and compression plate diameter of 160mm.

2.1 The preparation of the specimen

The specimens of cement waste form incorporating boric acid were made by using Portland cement and boric acid of fine powder type and 99.8% purity. At the solidification, those were made by using of the mixture ratio of boric acid/cement/calcium hydroxide (39.0/55.1 /5.9wt%) being applied to the nuclear power [3]. And then, after a lapse of 28 days, compressive strength test of those specimens was performed.

2.2 The specimen size

The loading rate of compression machine was set up 367.09kgf/cm^2, after that, compressive strength test was executed. The results are shown in Figure 1, 2. The diameter of specimens used to the test is sorted of 50, 75, 100mm and the ratio of height(H)/diameter(D) of the specimens are respectively 1, 1.25, 1.5, 1.75, 2 for the 3 diameters.

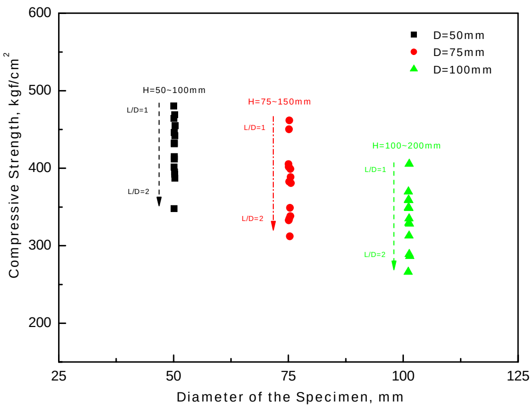

Figure 1. The variation of compressive strength with the diameter (loading rate: 367.09kgf/cm^2)

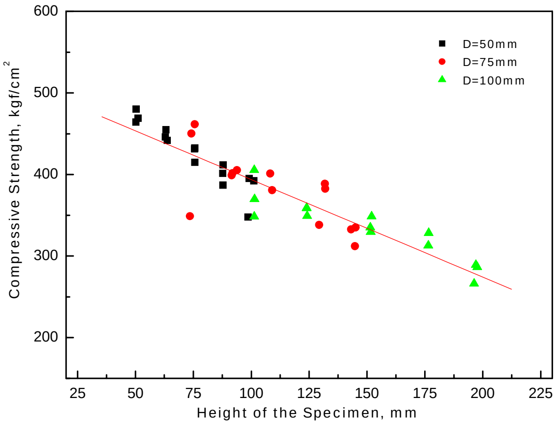

Figure 2. The variation of compressive strength with the height (loading rate: 367.09kgf/cm^2)

The compressive strength with the size is generally expressed with the diameter such as figure 1. In case of the expression with the height such as figure 2, it can obtain a linear expression. As looking above figure 2, the compressive strength decreases at the constant rate with the increase of the specimen height.

2.3 The loading rate

In this experiment, we measured the compressive strength by the size of specimens in varying of the loading rate, and hence, evaluated what the variation of the loading rate have an effect on the specimen size. The loading rates selected in this experiment are 85.65, 146.82, 305.91, and 367.09kgf/min.

The results are shown in Figure 3. As looking below figures, it seems that the compressive strength increases with the increase of the loading rate. It also seems that the compressive strength with the variation of the loading rate is highly influenced as the specimen size decrease.

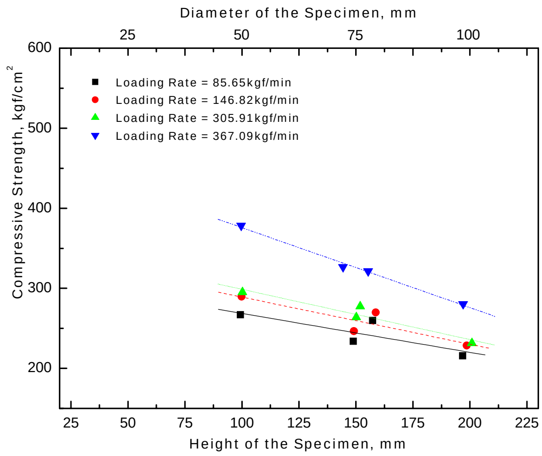

Figure 3. The compressive strength by the size of specimen in varying the loading rate (loading rate: 86.5, 146.82, 305.91, 367.09kgf/cm^2)

2.4 The thermal cycling test

After the thermal cycling test, the crack grows and that causes the specimen to be weak, because of the generation of the stress due to the difference of thermal expansion coefficient between the variety elements in the specimen [4]. In this experiment, after thermal cycling test by the specimen size, we measured the compressive strength by its size and compared with the data before thermal cycling test. The result is shown in figure 4. The loading rate of compression machine was set up 367.09kgf/cm^2 at the time of the compressive strength measurement. The data before thermal cycling test utilized a linear fitting function of figure 2. The condition of thermal cycling test is given in table 1.

Table 1. The condition of the thermal cycling test

Temperature range	-18 ~ +4 ^{o}C
Number of cycles	300 cycles
Rising & falling rate of temperature	0.5 ^{o}C/min
Stay time at the max. & min. temperature	40 min

As looking below figure 4, it seems that the variation of compressive strength is high as the specimen size decreases, on the contrary is considerably low as the specimen size increases.

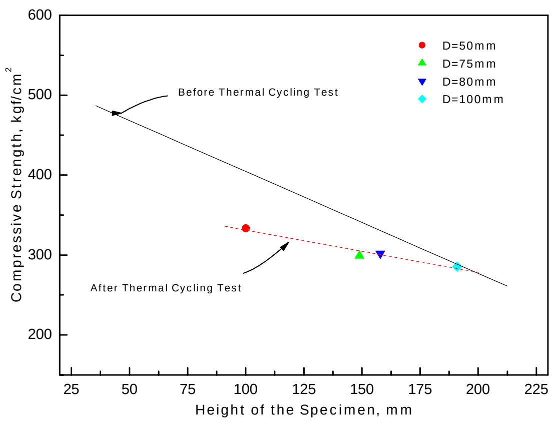

Figure 4. The compressive strength by the size of specimen before and after thermal cycling test

3. Conclusion

The compressive strength was measured with the variation of the specimen size. The results are as follows;

1) We concluded that the compressive strength was a linear form in function of the specimen's height.

2) The compressive strength increased up to 29.5%, 28.5% and 23.1% for 100, 150 and 200mm height respectively, during the variation from 85.65 to 367.06kgf/min.

3) After thermal cycling test, the compressive strength decreased by 11.9%, 9.4% and 1.6% for 100, 150 and 200mm height respectively.

REFERENCES

[1] Ki-Hong Kim et al, "A Study on the Characterization of Radioactive Waste Forms", KAERI-NEMAC/RR-139/94.

[2] ASTM C 39-86(1986), "Compressive Strength of Cylindrical Concrete Specimens", Annual Book of ASTM Standards, pp. 25-29.

[3] C. Y. Kim, "The Development of the Solidification Process", KRC-87N-105(1989)

[4] Ki-Hong Kim et al, "Development of Radwaste Form's Characterization Technology", KAERI-NEMAC/RR-98-93, Vol. 2.