タイトル	FREEZE-THAW TEST RESULTS OF POROUS CONCRETE WITH CRUSHED SCALLOP SHELL MATERIAL ADDED
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引用	北海学園大学学園論集，120：1-6
発行日	2004-06-25

FREEZE-THAW TEST RESULTS OF POROUS CONCRETE WITH CRUSHED SCALLOP SHELL MATERIAL ADDED

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ABSTRACT. This paper addresses the possibility of recycling an abundantly available byproduct of the fisheries industry, scallop shells, by adding it to porous concrete. If these shells, now discarded as refuse, can be used as an additive in porous concrete, this concrete may later be recycled to help protect water resources. Test results show that the compressive strength of the porous concrete decreases as the amount of added crushed shell material is increased. In addition, porous concrete with crushed shell material added exhibits poor freezing and thawing resistance. Despite these initial results, it is important to further study the effective utilization of discarded scallop shells so that the environmental impact of their disposal may be lessened.

Keywords: Compressive strength, Freezing and thawing resistance, Porous concrete,Crushed scallop shells.

INTRODUCTION

The annual investment in construction in Japan amounts to about 70 billion yen, corresponding to about 14% of the gross domestic product. This activity produces about one hundred million tons of waste from construction sites, about 25% of the total amount of industrial waste in Japan [1, 2] .

It has been shown that crushed scallop shell material can filter muddy water, effectively

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cleaning it [3] . If this beneficial effect can be obtained from porous concrete containing this crushed shell material, the environment will be improved with the ability to recycle both the shells as well as the resulting concrete when it becomes waste.

In this paper, crushed scallop shell material was mixed into porous concrete, and the freezing and thawing resistance was tested.

EXPERIMENTAL DETAILS

Design of Experiments

The crushed shell material was added as 0%, 50%, and 100% of the volume of the aggregate. The experiment consisted of three series of tests. The first series determined the freeze-thaw resistance of porous concrete specimens using ASTM-C666 Methods A and B. The second series measured the void percentage of the specimens. The last series tested the compression strength of the specimens.

Mix Proportions

The mix proportions are shown in Table 1. The water-cement ratio and the target air void for all test specimens were 22% and 30%, respectively. As mentioned above, the crushed shell material was used to replace the aggregate at volumetric mixing ratios of 0%, 50%, and 100%. The materials used in the concrete are as follows: ordinary cement (density 3.16), aggregate (crushed stone, sieve size 5-15 mm, density 2.84), crushed shell material (sieve size 5-25 mm, density 2.50), and high-range water reducing admixture (1.68%). The porous concrete was cured in water at 20°C for four weeks.

Table 1. Mix proportions.

Crushed Shell (%)	W/C (%)	Water (Kg)	Cement (Kg)	Aggregate (Kg)	Crushed Shell (Kg)	Admixture
0		53	240	1622	0	High-range
50	22	53	240	811	714	Water Reducing
100		53	240	0	1428	Admixture

Fabrication Procedure for Test Specimens

The concrete was manually placed into forms using table and hand vibrators. The concrete specimens were removed from the forms the next day and then cured in water for four weeks at 20°C.

Freeze-Thaw Test

Two different freeze-thaw test methods were used.

1. ASTM-C666 method A: This test method both freezes and thaws specimens in water.
2. ASTM-C666 method B: This test method freezes specimens in air and thaws them in water.

The test specimens for the freeze-thaw test were 10x10x40cm. In both methods, the freeze-thaw cycle took about 4 hours. The freeze-thaw tests were conducted after four weeks of curing.

Compressive Strength Test

The compressive strength tests were conducted after 28 days of curing. The dimensions of the specimens were 10ϕx20cm.

Air Void Percentage Measurement of Porous Concrete

The air void percentage was measured using Japan Concrete Institute Methods: volumetric and weight [6]. The dimensions of the specimens were 10ϕx20cm.

1. Volumetric method

$$A = (1-(W_2-W_1)/V)\times 100$$

Where A = Air void percentage of porous concrete (%)

W_2 = Weight in air

W_1 = Weight in water

V = Volume.

2. Weight method

$$A = (T-W)/T\times 100$$

Where A = Air void percentage of porous concrete (%)

T = Weight, per unit volume, of concrete from which air was removed

W = Weight, per unit volume, of the concrete specimen

EXPERIMENTAL RESULTS

Compressive Strength and Air Void Percentage

The results of compressive strength and air void percentage tests are shown in Table 2. The compressive strength measured after four weeks of curing ranged from 10.6 to 0.3N/mm^2. The compressive strength at 0% crushed shell, i. e., no shell material added, is sufficient for porous concrete. It should be noted that the compressive strength decreased as the percentage of crushed shell material was increased.

The target void percentage was 30%. The actual air void percentage determined by the volumetric method ranged from 28.1 to 55.7%; the weight method showed this parameter ranging from 28.3 to 51.1%. Thus, both test methods produced similar results. The air void percentage at 0% crushed shell content is close to the target value. However, the air void percentage increased significantly as the percentage of crushed shell material was increased.

Table 2. Compressive strength and air void percentage.

Crushed Shell (%)	Air Void Percentage (%)			Compressive Strength, After 4 Weeks of Curing (N/mm^2)
	Target of Air Void %	Volumetric Method	Weight Method	
0	30	28.1	28.3	10.6
50		43.1	40.0	1.9
100		55.7	51.1	0.3

Results of Freeze-Thaw Tests

The test results using methods A and B are shown in Figures 1 and 2, respectively. Method A test results show that all the porous concrete specimens, regardless of crushed shell content, greatly deteriorated within the first 100 cycles of freezing and thawing, the relative dynamic elastic modulus decreasing to about 40%. In the case of method B, the relative dynamic elastic modulus deteriorated more rapidly at higher percentages of crushed shell material relative to that seen with method A.

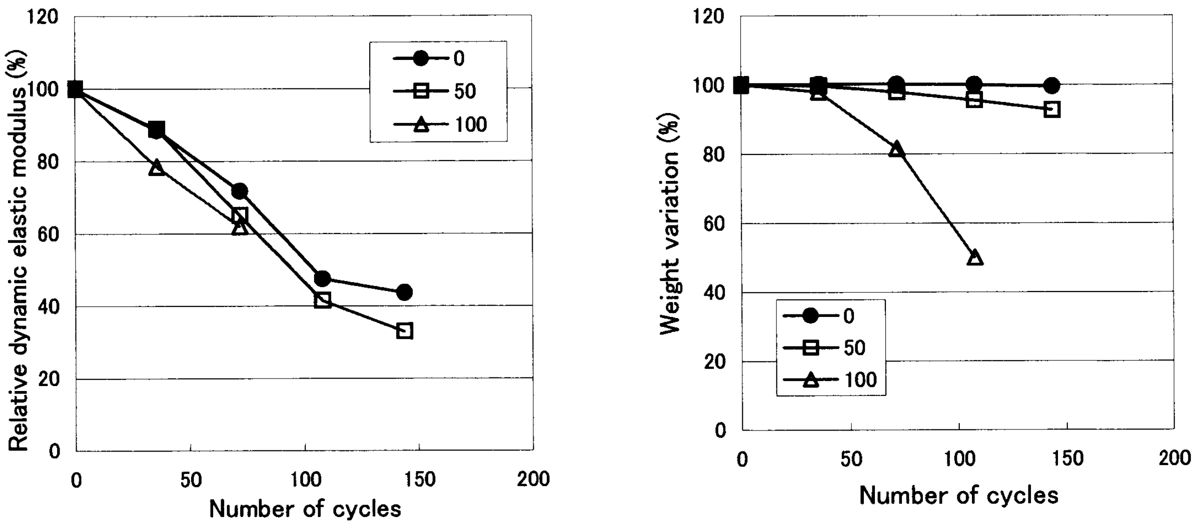

Figure 1. Freeze-thaw test results (method A)

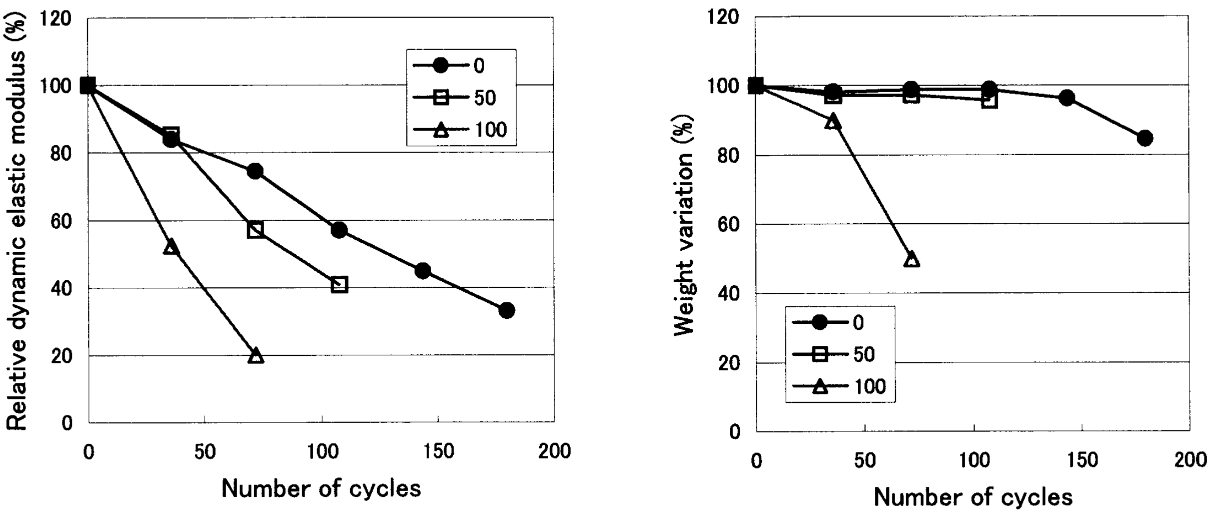

Figure 2. Freeze-thaw test results (method B)

An examination of specimen weight variation using methods A and B showed that the porous concrete with 100% of its aggregate replaced with crushed shell material suffered significantly greater weight loss than the other specimens.

CONCLUSIONS

This study examined the compression strength, the air void percentage and the freezing and thawing durability of porous concrete containing various amounts of crushed scallop shell material as an aggregate component.

The following has become known:

1. The compressive strength of porous concrete decreases as the percentage of aggregate replaced by crushed shell material is increased.
2. The voids in the porous concrete increase as the percentage of aggregate replaced by crushed shell material is increased.
3. In general, the frost resistance of all the porous concrete specimens is poor, regardless of the crushed shell content. At higher percentages of crushed shell replacement of aggregate, the frost resistance is markedly worse. Future studies will center on improving this freezing and thawing resistance.

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