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Properties of core specimens according to core diameter and coarse aggregate volume

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Abstract: Among methods for safety diagnosis of concrete, estimation of the compressive strength using core specimens, despite excellent accuracy, is less preferred than non-destructive testing methods due to a number of problems. Therefore, the object of the present study is to produce basic data for estimation of small-diameter core specimens by analyzing the ratio of compressive strength versus core specimen diameter, and analyzing the correlations between coarse aggregate volume and ultrasonic pulse velocity. Results showed that the compressive strength tends to decrease as the diameter of the core specimen decreases, and that the ultrasonic pulse velocity tends to increase with the coarse aggregate volume.
Keywords: *Aggregate, Core sampling method, Safety diagnosis, Small diameter core, Ultrasonic pulse speed.*

1. Introduction

The core sampling method, one of the safety diagnosis methods for concrete, estimates the compressive strength by collecting a core specimen from concrete members and exhibits high accuracy compared to non-destructive testing. However, as the method entails collecting a core specimen of 100-150mm from the concrete member, there are concerns of reduced yield strength of vertical members, and repair of the site from which the specimen is collected increases the costs of diagnosis.

In prior research, studies have been conducted on estimating the compressive strength using small-diameter core specimens of 35mm or less. Small diameter cores can be used to address the problems of prior methods by reducing the burden on the concrete member and reducing the repair area. However, if the diameter of the core specimen is three times or less the maximum size of the coarse aggregate, the accuracy of the compressive strength estimation decreases. The volume of the coarse aggregate varies depending on where the small-diameter core is sampled, and there is variation in the compressive strength between specimens. In order to estimate the compressive strength using small-diameter core specimens, it is necessary to analyze the coarse aggregate volume for each small-diameter core specimen.

Measuring the speed of ultrasonic pulses through small-diameter cores allows for estimation of the coarse aggregate volume. The ultrasonic pulse velocity is a non-destructive testing method for estimation of concrete cracks and compressive strength; the speed of the pulse varies depending on the medium being measured. However, most prior research employing ultrasonic pulse velocity related to estimating the compressive strength of concrete members, and studies on the correlation between the coarse aggregate volume and the ultrasonic pulse velocity were few [1].

Therefore, in this study, the properties according to the diameter and the coarse aggregate volume of small-diameter core specimens will be examined. Therefore, the object of the present study is to produce basic data for estimation of small-diameter core specimens by analyzing the ratio of the compressive strength versus the core specimen diameter, and analyzing the correlations between the coarse aggregate volume and the ultrasonic pulse velocity.

2. Experimental plan and method

2.1. Experimental plan

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2.1.1. Properties of the core specimen according to the core diameter

The concrete mix proportion, experimental factors, and levels used in the test are shown in Table 1. Core specimens with four different diameters (100, 68, 44, and 31.5mm) were used, and all core specimens had an L/D of 2. The test items measured were the compressive strength and ultrasonic pulse velocity, and all the tests were conducted in accordance with KS standards.

Table 1.
Concrete mix proportion and experimental plan.

W/C (%)	S/a (%)	Unit weight(kg/m³)						Experimental plan		
		W1)	C2)	S3)	G4)	AE5)	AD6)	L/D7)	Core diameter (mm)	Experimental items
51	44	171	335	770	1021	07	1.7	2	100, 68, 44, 31.5	Compressive strength, ultrasonic pulse velocity

Note: 1)W: Water, 2) C: Cement, 3)S: Sand, 4)G: Gravel, 5)AE: Air-entraining, 6) AD: Admixture, 7) L/D: Length /Diameter

2.1.2. Properties of the Core specimen according to the coarse aggregate volume

The concrete mix proportion, experimental factors, and levels used in this test are as shown in Table 2. In order to examine the properties of the core specimens according to the volume of the coarse aggregate, the formulations were designed with two different coarse aggregate volumes: 30 and 44%. Core specimens with four different diameters (100, 68, 44, and 31.5mm) were used, and all core specimens had an L/D of 2. The test items measured were the compressive strength and ultrasonic pulse velocity, and all the tests were conducted in accordance with KS standards.

Table 2.
Concrete mix proportion and experimental plan.

	W/C (%)	S/C (%)	Unit weight(kg/m³)						Experimental plan		
			W1)	C2)	S3)	G4)	AE 5)	AD 6)	Coarse aggregate volume (%)	Core diameter (mm)	Experimental items
G_44	51	230	150	294	675	1213	0.6	1.5	44	100, 68, 44, 31.5	Compressive strength, ultrasonic pulse velocity
G_30			192	377	865	828	0.8	1.9	30		

Note: 1) W: Water, 2) C: Cement, 3)S: Sand, 4)G: Gravel, 5)AE: Air-entraining, 6) AD: Admixture

2.2. Experimental method

For the experiment, a concrete member of 40×40×22(cm) was cured indoors for 28 days (20±2℃, 60±5%), then the cores were sampled. The core specimen of a diameter of 100mm was ground to an L/D of 2, and specimens of other diameters were cut to an L/D of 2. As for the number of specimens used for each test, three 100 mm diameter specimens, three 68 mm specimens, 15 44mm specimens, and 15 31.5mm specimens were prepared.

3. Experimental result and analysis

3.1. Properties of core specimens according to core diameter

Figure 1 and 2 show the measured compressive strengths and ultrasonic pulse velocities according to core specimen diameters. As the core specimen diameter decreases, the compressive strength tends to decrease while the ultrasonic pulse velocity exhibits no trends. The variation in the compressive strength is determined to be caused by cracks due to vibration in the core sampling process. Furthermore, the standard deviation for the compressive strength and ultrasonic pulse velocity test results tended to increase to 100:0.4, 68:1.8, 44:2.9, and 31.5:2.2, respectively, as the core diameter decreased. This is determined to be due to large variations in internal aggregate distribution among core specimens as diameter decreases, resulting in large variations in experimental results.

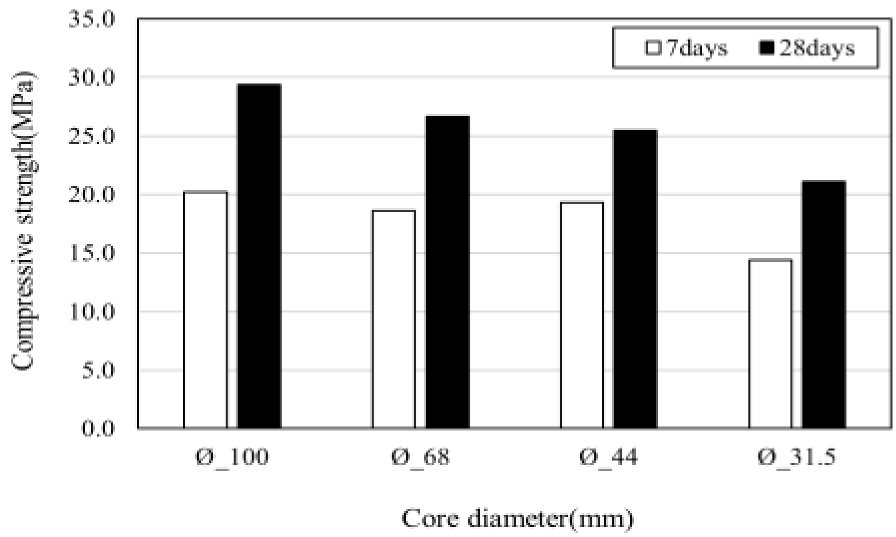

Figure 1.
Compressive strength.

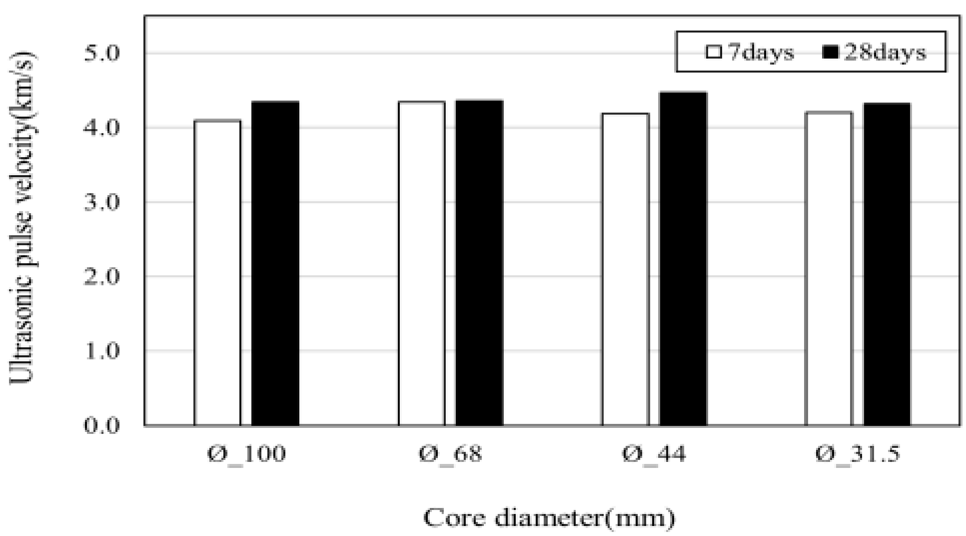

Figure 2.
Ultrasonic pulse velocity.

3.2. Properties of core specimens according to the coarse aggregate volume

Figure 3 and 4 show the measured compressive strengths and ultrasonic pulse velocities according to

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the coarse aggregate volume. The higher the coarse aggregate volume was, the compressive strength tended to be lower or remained similar. Conversely, the ultrasonic pulse velocity tended to increase. It is determined that cracks due to vibration when collecting core specimens have a greater impact as the coarse aggregate volume increases, and that the ultrasonic pulse velocity increases as the volume of the dense coarse aggregate increases.

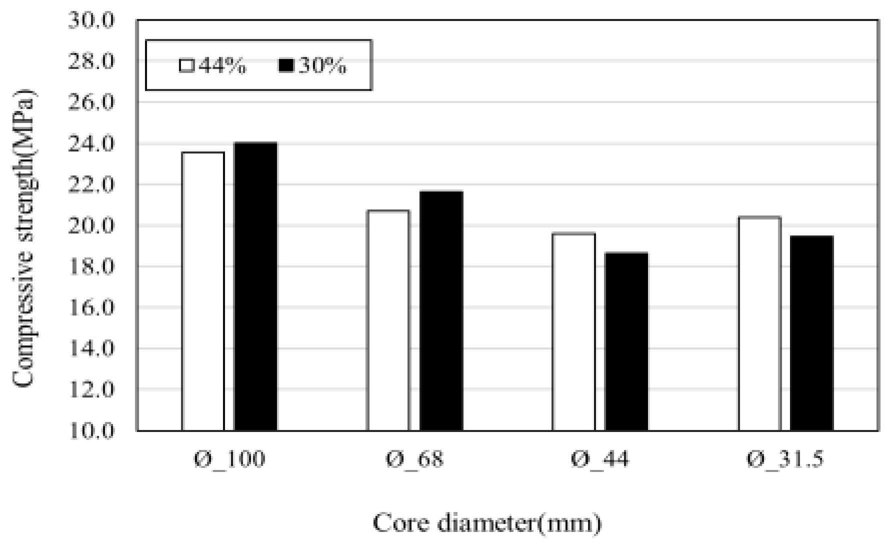

Figure 3.
Compressive strength.

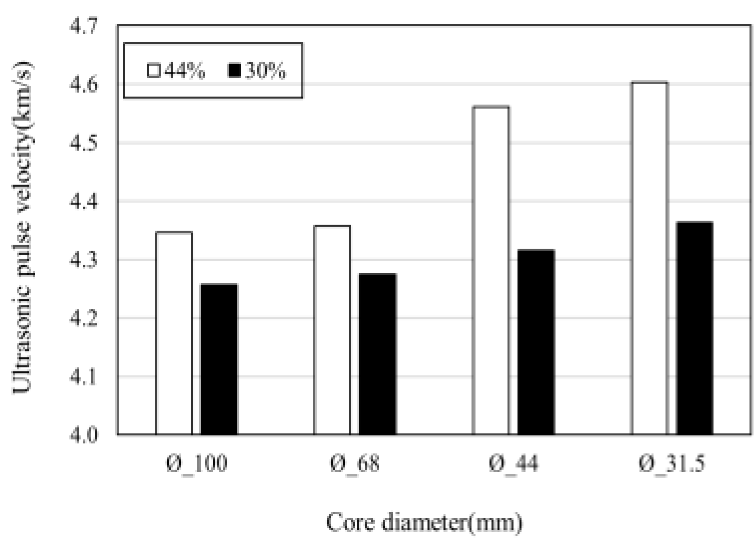

Figure 4.
Ultrasonic pulse velocity.

Figure 5, 6, 7 and 8 represent the ultrasonic pulse velocity and apparent density according to the core diameter. For all core diameters, the higher the coarse aggregate volume, the higher the ultrasonic pulse velocity tended to be. This is believed to be due to a decrease in porosity as the volume of the dense coarse aggregate increases and the amount of mortar decreases.

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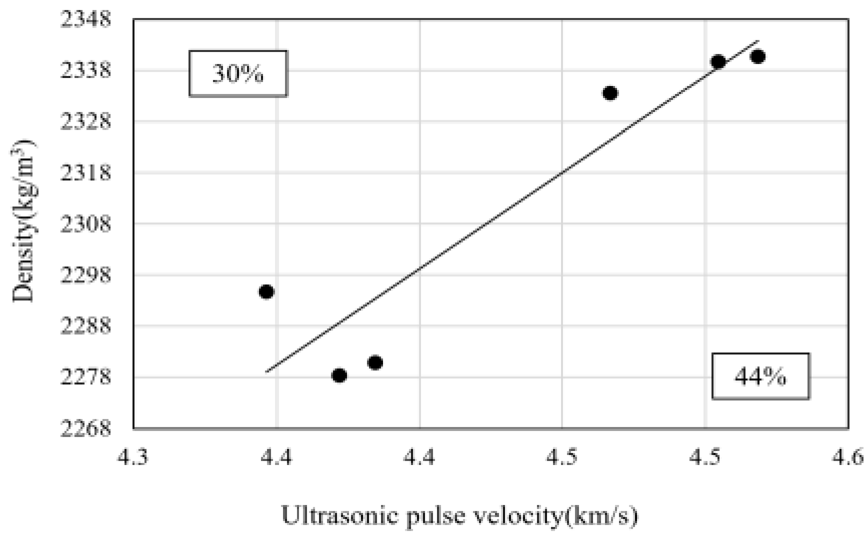

Figure 5.
Density and ultrasonic pulse velocity(100mm).

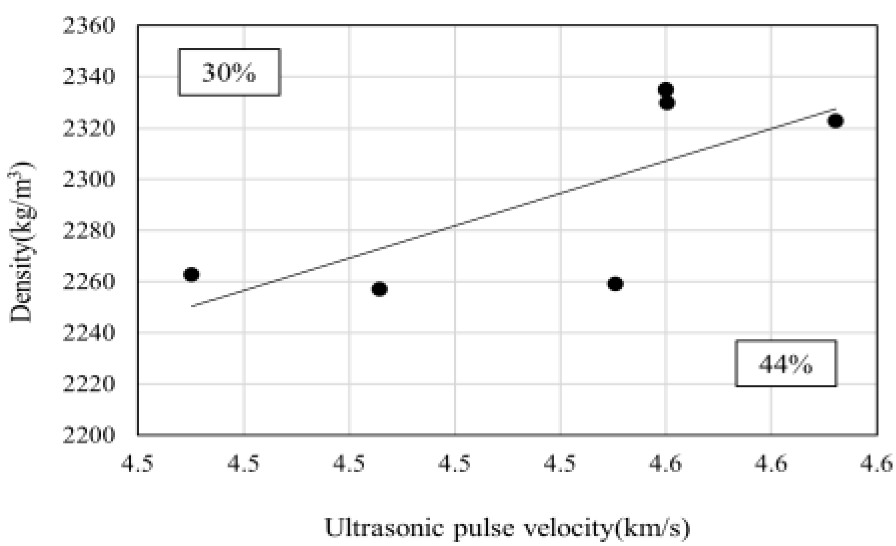

Figure 6.
Density and ultrasonic pulse velocity(68mm).

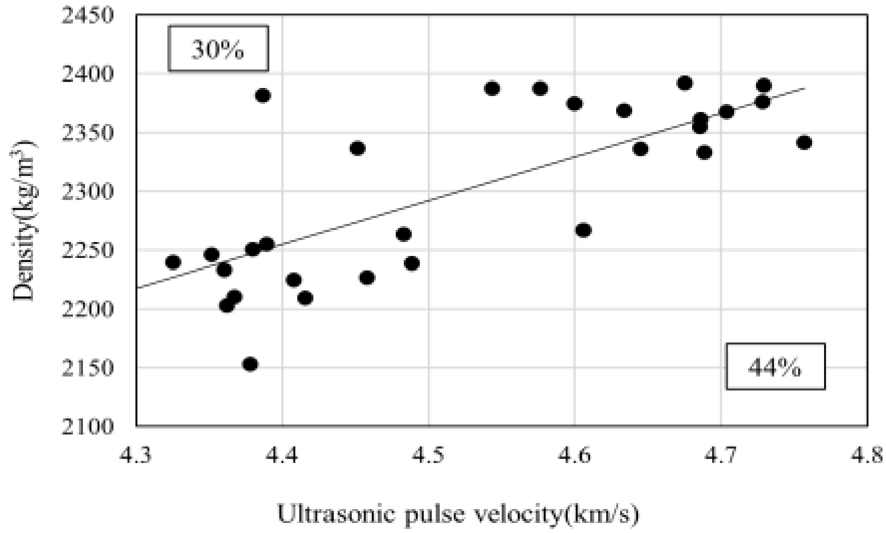

Figure 7.
Density and ultrasonic pulse velocity(44mm).

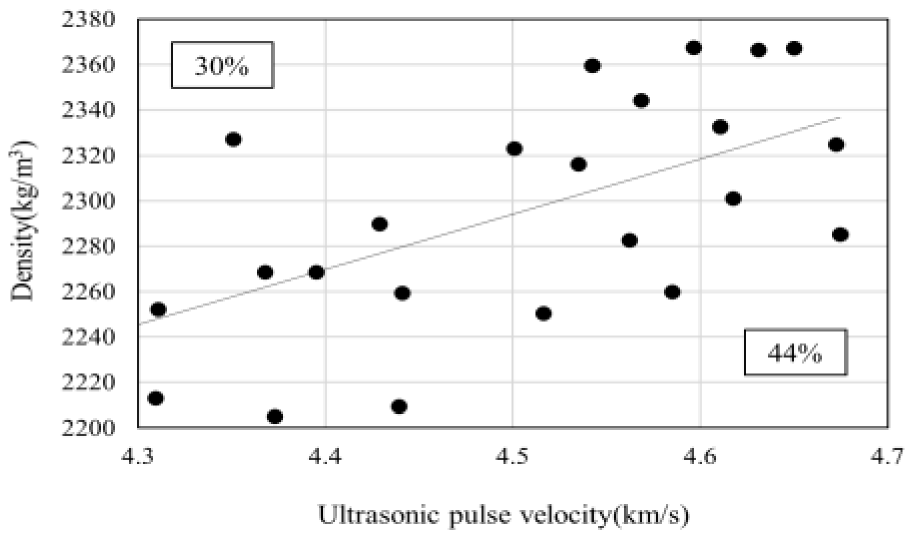

Figure 8.
Density and ultrasonic pulse velocity(31.5mm).

4. Conclusion

In this study, core specimen properties according to the core diameter and the coarse aggregate volume were analyzed. In the results, the compressive strength tended to decrease as the core specimen diameter decreased, while standard deviation increased. In addition, the higher the coarse aggregate volume of the core specimen, the higher the ultrasonic pulse velocity was. Therefore, as the ultrasonic pulse velocity tends to increase with the coarse aggregate volume, it is determined that the estimation of the coarse aggregate volume through the ultrasonic pulse velocity measurement of the small-diameter cores will be possible. Further studies will analyze the correlation between the compressive strength and the ultrasonic pulse velocity of small-diameter cores, deducing a correction formula for correction of the compressive strength for small-diameter cores.

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