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# SCC compressive strength test

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ABSTRACT

This paper mainly introduces the test process of rebound method and ultrasonic method for high strength self-consolidating concrete with strength grade of C50, C60, C70, C80, C90 and C100, and carries out cube compressive strength test on the test cubes under the same conditions. The entire test process, equipment and materials are introduced.

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**SCC compressive strength test**

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**Abstract**

This paper mainly introduces the test process of rebound method and ultrasonic method for high strength self-consolidating concrete with strength grade of C50, C60, C70, C80, C90 and C100, and carries out cube compressive strength test on the test cubes under the same conditions. The entire test process, equipment and materials are introduced.

## Introduction

In this experiment, six groups of SCC test blocks with compressive strength grade of C50, C60, C70, C80, C90 and C100 were prepared, and then the ultrasonic method, rebound method and cube compressive strength test were carried out in succession. This scheme mainly introduces the method of making test block and the process of test, and the test is carried out in strict accordance with the standard [1-5].

## Materials and Methods

### Test materials

#### (1)Cement

In this test, the concrete with higher strength grade is required, so the ordinary silicate concrete of South Brand (strength grade = 52.5MPa) with stable quality and strong activity is selected, which is provided by Hunan Guli Engineering New Materials Co., Ltd.

#### (2)River sand

The river sand is washed for multiple times to remove the clay and stone within, and then dried in the electro-thermal constant temperature air dry oven for 24h (at 105 ± 5 °C). After drying and cooling, the river sand is placed in the top layer of the standard square hole sand screener (as shown in Figure 1), and the shaking time of the sand screener is set as 3 minutes. After shaking, the river sand of each size is collected separately.

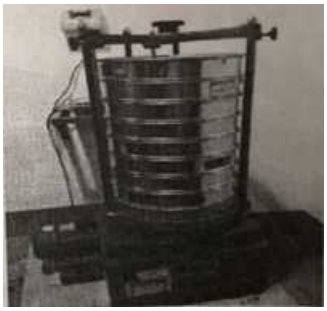

**Fig 1. Standard square hole sand screener**

Referring to the provisions of relevant specifications [1] and pertinent literature, the river sand with diameter greater than 5mm and less than 160μm is removed, and the medium sand with fineness modulus of 3.09 is determined. The detailed grading is shown in Table 1.

**Table 1. Gradation of the River Sand.**

| A | B | C | D | E | F | G |
|---|---|---|---|---|---|---|
| Sieve size | 5.0 mm | 2.5 mm | 1.25 mm | 630 μm | 315 μm | 160 μm |
| Cumulative percentage retained (%) | 4 | 26 | 34 | 44 | 56 | 67 |

#### (3)Limestone gravel

Limestone gravel was used in this test. Cleaning and drying was also carried out, and the particle size of gravel aggregate was controlled between 5mm - 20mm [1].

#### (4) Slag powder

According to the activity index, slag powder can be divided into three grades of S105, S95 and S75. S95 slag powder is adopted in this test. Slag powder is used to replace a certain amount of concrete to improve its working performance, prevent the cracking caused by the high temperature inside the concrete, and solve the reuse problem of industrial waste, which is conducive to environmental protection (specific performance indexes are shown in Table 2).

**Table 2. Property Indices of the Slag Powder.**

| A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|
| Material | Strength | Density (g/cm3) | Specific surface area (m2/kg) | Loss on ignition (%) | Chloride ion (%) | Fluidity ratio (%) | Water content (%) |
| Slag powder | S95 | 2.89 | 425 | 0.60 | 0.036 | 102 | 0.28 |

#### (5) Fly ash



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Fly ash can be divided into three grades according to its performance, that is, Grade I, Grade II and Grade III. In this test, Grade I fly ash is adopted to improve the workability of concrete. Due to the little heat of fly ash generated in hydration, the crack problem caused by temperature is improved and the working performance of concrete is enhanced (specific performance indexes are shown in Table 3).

**Table 3. Property Indices of the Fly Ash.**

| A | B | C | D | E | F |
|---|---|---|---|---|---|
| Material | Grade | Fineness (%) | Water demand ratio (%) | Loss on ignition (%) | Water content (%) |
| Fly ash | I | 12 | 92 | 3.8 | 0.1 |

**(6) Silica fume**

Silica fume is the waste generated in the production of ferrosilicon alloy in industrial production. In this test, micro-silica is adopted, which can improve the strength of concrete in the early and final phases. Because of its small particles, it can evenly fill the micro-pores in concrete, thus increasing its density and improving its disintegration and guttation performance (specific performance indexes are shown in Table 4).

**Table 4. Property Indices of the Silica Fume.**

| A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|
| Material | Loss on ignition (%) | Chloride ion (%) | Silica (%) | Specific surface area (m2/kg) | Water content (%) | Water demand ratio (%) | Activity index |
| Silica fume | 2.5 | 0.014 | 94.05 | 2.51×104 | 1.1 | 113 | 112 |

**(7) Water reducing agent**

In order to improve the strength level of self-compacting concrete, the water-to-binder ratio must be reduced in the proportioning design. However, in order to ensure the fluidity of self-consolidating concrete, Superplasticizer should be added to the concrete. In this test, PCA polycarboxylate superplasticizer was adopted to release free water in concrete slurry, so as to achieve the effect of water reduction. During construction, the water reducing admixture should be dissolved in water first, and then mixed with the gelatinous aggregate evenly [1].

**(8) Admixture**

Admixtures are added in the process of concrete mixing in order to improve the workability of concrete, ensure the micro expansion of concrete in the hardening process, avoid cracks due to shrinkage, and improve the working performance of self-consolidating concrete. ZW self-consolidating non-shrinkage concrete admixture (produced by Hunan Guli Engineering New Material Co., Ltd.) was adopted in this test, which was directly mixed with concrete and other gelatinous materials evenly to be used for construction.

**(9) Wooden formwork and mould**

Before concrete pouring, a professional carpenter is required to make 60 sets of wood formwork, one set of five pieces. Each piece should be in the size as 150 mm × 150 mm × 150 mm, and the dam-board between two adjacent pieces can be pulled out for the production of test cubes. Several black plastic moulds for three-piece 150 mm test cube were purchased at the same time, (the formwork and moulds are shown in Fig 2 and Fig 3) [6].

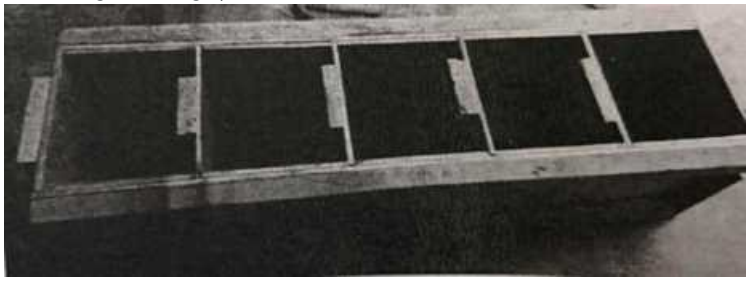

**Fig 2. Wooden formwork**



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**Fig 3. Mould of test cube**

**(10) Other related materials**

Clean tap water, formwork separation agent, ultrasonic test couplant.

**Test production**

After making wood formwork and purchasing moulds, the proportion of high-strength self-consolidating concrete with strength grade of C50-C100 is obtained through repeated mixing and referring to relevant specifications and literatures, (see Table 5) [1-3].

**Table 5. Mix Proportions of SCC.**

| A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Test ID | Total (kg) | Cement (kg) | Silica fume (kg) | Fly ash (kg) | Slag powder(kg) | Admixture (kg) | Water (kg) | Sand (kg) | Gravel (kg) | Water reducing agent (kg) | | | | | |
| A | 331.21 | 226.86 | 0.00 | 13.61 | 56.71 | 34.03 | 104.06 | 446.70 | 550.00 | 0.95 | | | | | |
| B | 353.10 | 254.38 | 15.10 | 15.26 | 30.20 | 38.16 | 97.24 | 440.81 | 550.00 | 1.01 | | | | | |
| C | 375.32 | 251.32 | 33.74 | 18.82 | 33.74 | 37.70 | 93.01 | 402.58 | 550.00 | 2.15 | | | | | |
| D | 376.94 | 253.07 | 33.51 | 18.89 | 33.51 | 37.96 | 86.21 | 411.38 | 550.00 | 2.51 | | | | | |
| E | 359.91 | 226.87 | 44.11 | 21.10 | 33.80 | 34.03 | 79.12 | 417.07 | 550.00 | 2.75 | | | | | |
| F | 347.82 | 224.00 | 44.66 | 11.27 | 34.30 | 33.60 | 74.73 | 420.00 | 550.00 | 2.99 | | | | | |
| | | | | | | | | | | | | | | | |

Start and test the mixer (as shown in Fig 4). If the mixer runs properly, use clean tap water to wet the inner wall of the mixer, so as to prevent the water-to-binder ratio of raw materials from changing due to the water absorption of the inner wall of the mixer. First, the coarse aggregate of sand and stone should be mixed in a forced concrete mixer for 5 minutes until they are evenly mixed, then the gelatinous materials such as fly ash, slag powder, concrete and self-consolidating concrete admixture are added to mix for 10 minutes until they are evenly mixed, finally the water-reducing admixture is dissolved in the tap water and added to the mixer to mix for 15 minutes.

**Fig 4. Concrete mixer**

The formwork separation agent is applied evenly on the inner wall of the wood formwork and the mould, and the evenly mixed concrete is poured into the wood formwork and the mould respectively. A small vibrating rod is used to vibrate the concrete in the wooden formwork layer by layer until compacted. At the same time, the test cubes poured in the mould are placed on the vibrating table to vibrate until compacted, and wait for the natural closure. The vibration and production are shown in Fig 5 and Fig 6



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respectively.

**Fig 5. Concrete test cube vibration**

**Fig 6. Diagram of test cube**

The test piece is kept for 24h at room temperature to keep the concrete surface moist. After the initial setting of concrete, the test piece is demoulded and the test cubes and the test pieces are placed in the curing pond at constant temperature (60 ℃) for 3 days. After that, the test pieces were taken out from the curing pond, watered at room temperature and covered with plastic film for 28 days. The test pieces used as control group for exploring the influence factors of rebound method and ultrasonic rebound method shall be additionally cured to 60 days and 90 days.

**Rebound method, ultrasonic rebound comprehensive method, cube compressive strength test**

After 28 days of curing, the specimens were subjected to the ultrasonic, rebound, and cube compressive strength tests. The specific procedures are as follows:

**UPV measurement by the ultrasonic method**

The ultrasonic method used a nonmetallic ultrasonic detector to measure the sound velocity. The cast surface of the specimen was used as a test surface, and the exact measurement point on the opposite surface of the specimen was located and coated with the coupling agent. Then, three sound velocities were measured at the ultrasonic measurement point, and their mean value was taken as the final sound velocity of the cube specimen [7,8]. The schematic diagram of the ultrasonic method test is shown in Fig 7.

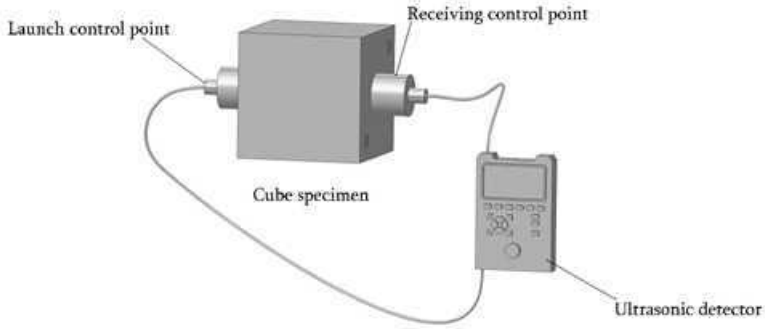


**Fig 7. Schematic Diagram of the Ultrasonic Test.**

**Rebound measurement by the rebound method**

A high-strength rebound meter with an impact energy of 4.5 J was used for the test. After the sound velocity measurement was completed, the test cube coated with the coupling agent was wiped clean and then placed on a press and subjected to a compression of 30 to 50 kN (with lower compression for lower grade concrete cubes). The pair of opposite surfaces not used in the sound velocity test were each subjected to a total of eight rebound strokes. During the rebound test, the rebound hammer was



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perpendicular to the measurement area, the compression was applied slowly, and the reading was reset quickly. The three maximum and three minimum values were eliminated, and the mean value of the remaining ten values was used as the representative rebound value R (accurate to 0.1) of the specimen. The rebound test is schematically shown in Fig 8. Fig 9 illustrates the distribution of the ultrasonic-rebound measurement points, with the ultrasonic measurement points labelled as “1” and the rebound measurement points labelled as “2”.

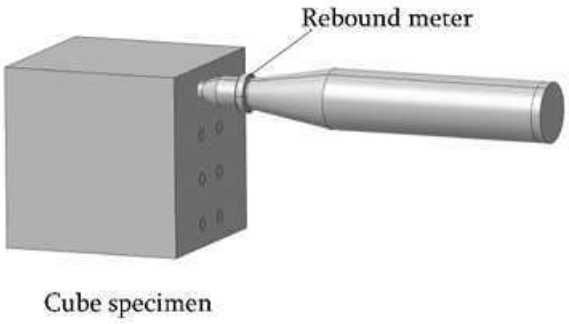


**Fig 8. Schematic Diagram of the Rebound Test.**

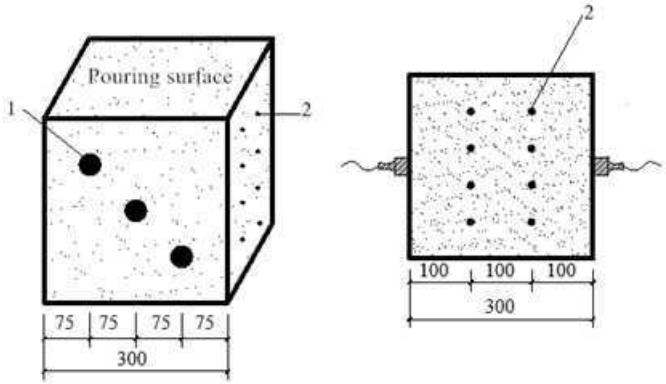


**Fig 9. Distribution of Ultrasonic and Rebound Measurement Points.**

### Cube compressive strength test

After the ultrasonic and rebound tests, each test cube was directly compressed to failure (Fig 10) at a compression rate of 8-10 kN/s to obtain the compressive strength

of the test cube (accurate to 0.1 MPa [9]).

**Fig 10. Cube Compressive Strength Test.**

[1] Ministry of housing and urban rural development of the people's Republic of China. Technical specification for application of self



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