

# Research on Influence of Zeolite Powder on Internal Humidity and Autogenous Shrinkage of Self-Compacting concrete

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**Keywords:** Self-Compacting Concrete, Internal Humidity, Autogenous Shrinkage

**Abstract:** The influence of zeolite powder on humidity, autogenous shrinkage and mechanical properties inside the self-compacting concrete as the self-curing material are researched. The addition amount of zeolite powder is 0%, 2%, 4% and 8% respectively, the results show that self-compacting concrete with zeolite powder as self-curing materials can improve the slump loss. When addition is 2%, it have influence on compressive strength at early age and less influence at later age. Compared with benchmark self-compacting concrete, when internal relative humidity decreases from 100% to 90%, it takes 4d for benchmark self-compacting concrete while self-compacting concrete with 2%, 4% and 8% zeolite powder respectively takes 6d, 14d and 24d. Self-compacting concrete with zeolite powder addition is 2%, 4% and 8%, autogenous shrinkage of 2d respectively decrease 21.4%, 34.9% and 57.3% and 7d autogenous shrinkage respectively decrease 12.6%, 26.8% and 39.4% compared with benchmark self-compacting concrete.

## 1 Introduction

With the development of society, the high-rise, super high-rise buildings are gradually increased. The high-strength concrete and self-compacting concrete has become the trend of development of concrete industry (LIU Yunhua, 2007 & ZHAO Jun, 2003). Self-compacting concrete has significant advantages in reducing construction costs and improve construction environment, etc. (LI Yue, 2005 & OZAWA K, 1989). In order to meet the demand of workability and strength of self-compacting concrete, low water consumption, high amount of cementitious material and the active mineral admixture become the key technology for preparation of self-compacting concrete. Due to the use of high amount of cement and low water consumption, the autogenous shrinkage becomes higher, thus easy to cause shrinkage cracking and affect the structural safety of building (YANG Yuhong, 2010).

Internal relative humidity of concrete fall is caused by high-strength self-compacting concrete produced from the root causes of autogenous shrinkage. How to improve and enhance the internal humidity of concrete has become an important method to solve high-strength self-compacting concrete autogenous shrinkage.

Previous study showed that self-curing materials can reduce the autogenous shrinkage of high-strength self-compacting concrete. At present, self-curing materials mainly have SAP and lightweight aggregate, but they all have their own disadvantages to limit their use. The porous powder--zeolite powder is as new self-curing materials gradually coming into our sight. The influence of zeolite powder on humidity, autogenous shrinkage and mechanical properties inside the concrete as the self-curing material is studied, which provides a technical basis for preparation of self-curing high-performance concrete.

## 2 Experiment

### 2.1 Raw materials

Cement: P·O42.5 cement produced by Sichuan Lafarge are used in the test. Their basic performance is shown in table 1.

**Table 1: Basic performance of cement**

Index	Result
Specific area	334 m <sup>2</sup> /kg
Flexural Strength(3d)	5.6MPa
Flexural Strength(28d)	8.9MPa
Compressive strength(3d)	27.1MPa
Compressive strength(28d)	50.9MPa
Density	3.12g/cm <sup>3</sup>
Stability	Conforming

Fly ash: Grade I fly ash are used in the test. Their basic properties are as follows: fineness of 6.5%, SO<sub>3</sub> addition of 0.69%, loss on ignition of 1.9%, water requirement 95%.

Slag: S95 slag are used in the test. Their basic properties are as follows: loss on ignition of 0.71%, fluidity ratio of 100%, density of 2.88 g/cm<sup>3</sup>, specific surface area of 457m<sup>2</sup>/kg.

Silica fume: Silica fume is, when collected, an ultrafine powder having the following basic properties: SiO<sub>2</sub> addition at least 90%, specific surface area of 16115m<sup>2</sup>/kg.

Zeolite Powder: Zeolite Powder as a kind of new-type self-curing materials. Their basic properties are as follows: density of 2.41g/cm<sup>3</sup>, specific surface area of 701m<sup>2</sup>/kg, water requirement 124%, and fluidity ratio of 69%.

(6)Machine-Made Sand: Fineness modulus of 2.7, apparent density 2740kg/m<sup>3</sup>, mud addition of 0.3%.

Gravel: 5~20mm gravel are used in the test, mud addition of 0.5%, apparent density 2710kg/m<sup>3</sup>, crushing value of 7.9%.

Superplasticizer: Polycarboxylate superplasticizer are used in the test. Solid addition of 20.1%, water reducing ratio of 29%.

## 2.2 Mix Design

The influence law of zeolite powder on self-compacting concrete workability, mechanical properties, internal humidity and shrinkage is studied for the purpose of analyzing mechanism of its influence on self-compacting concrete. The addition amount of zeolite powder is 0%, 2%, 4% and 8% respectively. Test mix proportion is shown in table 2.

**Table 2: Testing mix proportion of self-compacting concrete with zeolite powder (Unit: kg/m<sup>3</sup>)**

No Mix	SCC-1	SCC-2	SCC-3	SCC-4
Cement	330	330	330	330
Fly ash	160	148	136	112
Slag	80	80	80	80
Silica fume	30	30	30	30
Zeolite powder	0	12	24	48
Sand	760	760	760	760
Gravel	920	920	920	920
Water	144	144	144	144
Superplasticizer	9.0	9.0	9.5	10.2

## 3 Results and analysis

### 3.1 Influence of zeolite powder on workability of self-compacting concrete

The influence of zeolite powder on self-compacting concrete slump, inverted slump cone and U-box is studied for analyzing of its influence on self-compacting concrete workability. The addition amount of zeolite powder is 0%, 2%, 4% and 8% respectively. Test mix proportion is shown in table 2 and the test result is shown in table 3.

Table 3 shows the influence of zeolite powder on self-compacting concrete workability. By conducting analysis on Table 3, we know that with increase of zeolite powder addition amount,

self-compacting concrete slump flow reduce gradually from 700mm to 580mm and U-box increases gradually from 10mm to 170mm. This shows that zeolite powder is not conducive to workability of self-compacting concrete.

Workability loss result shows that self-compacting concrete with zeolite powder as self-curing materials can improve the slump loss. 2h workability of self-compacting concrete with 2% zeolite powder addition is better than benchmark self-compacting concrete, when the zeolite powder addition of more than 4%, although self-compacting concrete slump and inverted slump cone has been improved, but still flow properties far less than the benchmark self-compacting concrete. Therefore, in order to ensure a good workability of self-compacting concrete, zeolite powder addition is not to over 4%. That is because major components of zeolite powder is porous vitreous, some water absorbed earlier will release as hydration prolongs, then workability of self-compacting concrete can improves. Besides, zeolite power has good water conservation effect, therefore, can improve the slump loss.

Table 3: Influence of zeolite powder on workability of self-compacting concrete

No Index	SCC-1	SCC-2	SCC-3	SCC-4
Slump(0h)	270mm	260mm	255mm	240mm
Slump(2h)	265mm	275mm	270mm	245mm
Slump flow(0h)	700mm	670mm	635mm	580mm
Slump flow(2h)	680mm	685mm	660mm	600mm
Inverted slump cone(0h)	3.6s	5.3s	9.3s	13.2s
Inverted slump cone(2h)	4.2s	5.1s	8.5s	12.2s
U-box(0h)	10mm	10mm	80mm	170mm

### 3.2 Influence of zeolite powder on compressive strength of self-compacting concrete

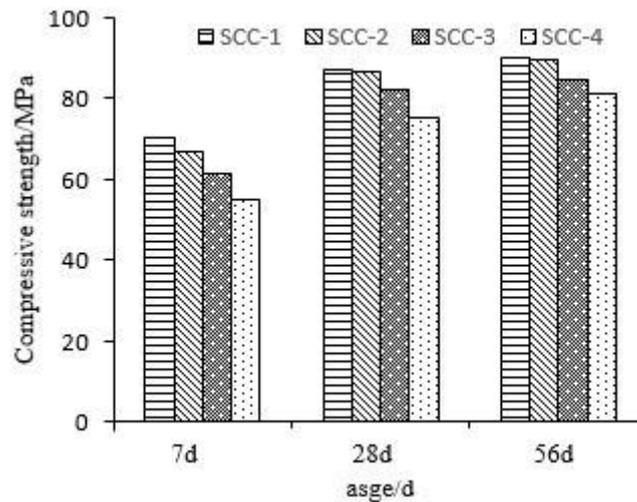


Figure 1: Influence of zeolite powder on mechanical property of self-compacting concrete

Figure 1 shows influence of zeolite powder on mechanical property of self-compacting concrete. According to this figure, self-compacting concrete with zeolite powder has a great influence on compression strength. When addition is 2%, 4% and 8%, compressive strength of self-compacting concrete decreased significantly and the more zeolite powder is, the lower compressive strength will be. Especially for early strength will decline rapidly as zeolite amount increases. When it curing 7d age, compared with benchmark self-compacting concrete, compressive strength will decline 3.9MPa, but when curing 56d age, it only decreased 0.5MPa. When the zeolite content of 4% and 8%, the 7d compressive strength decreased 9.2MPa and 15.5MPa, 56d compressive

strength decreased 5.6MPa and 9.2MPa. Test results show that zeolite powder will have greater influence on compressive strength of self-compacting concrete, but when addition is 2%, it have influence on compressive strength at early age and less influence at later age. Therefore, in order to ensure compressive strength of self-compacting concrete with zeolite powder should be less than 4%.

### 3.3 Influence of zeolite powder on internal humidity of self-compacting concrete

This test designs for zeolite powder addition up 0%, 2%, 4% and 8% to research on influence of zeolite powder on internal humidity of self-compacting concrete. Figure 2 shows influence of zeolite powder on internal relative humidity of self-compacting concrete. According to figure 2, internal relative humidity of self-compacting concrete with a big decline in early curing age, when zeolite powder addition in self-compacting concrete, the internal relative humidity of self-compacting concrete increase gradually and the addition increases the higher internal relative humidity. Compared with benchmark self-compacting concrete, self-compacting concrete with 8% zeolite powder addition shows slower decrease in internal relative humidity of self-compacting concrete.

According to figure 2, compared with benchmark self-compacting concrete, when internal relative humidity decrease 100% to 90%, benchmark self-compacting concrete takes 4d while self-compacting concrete with 2%, 4% and 8% zeolite powder respectively takes 6d, 14d and 24d, which means zeolite powder addition can increase internal relative humidity of self-compacting concrete at same curing age. This is because zeolite internal porous structure can absorb and reservoir water for self-compacting concrete. As hydration time increases, water in zeolite powder releases gradually which increase internal relative humidity of self-compacting concrete. It shows that zeolite powder as self-curing materials have good curing effect, which can increases internal relative humidity of self-compacting concrete.

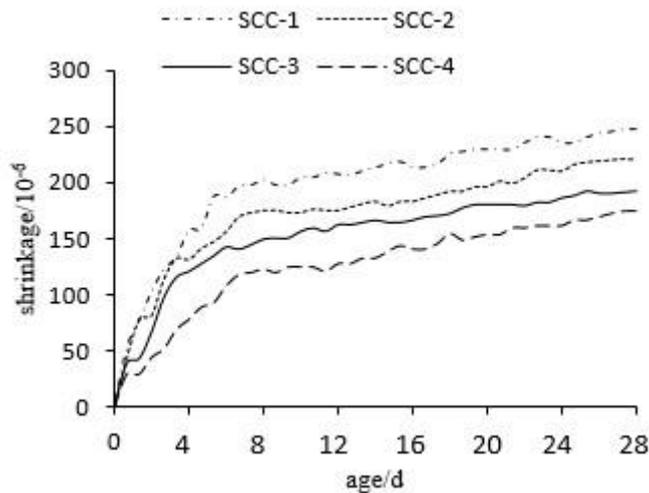


Figure 2: Influence of zeolite powder on relative humidity of self-compacting concrete

### 3.4 Influence of zeolite powder on autogenous shrinkage of self-compacting concrete

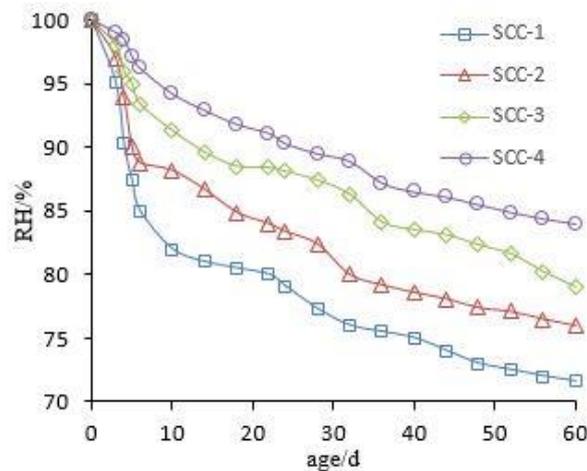


Figure 3: Influence of zeolite powder on autogenous shrinkage of self-compacting concrete

Figure 3 shows influence of zeolite powder on autogenous shrinkage of self-compacting concrete, according to figure 3, all group self-compacting concrete, autogenously shrinkage mainly happens in early curing age. As curing age increases, autogenous shrinkage of self-compacting concrete, specimen gradually tends to be stable. When zeolite powder addition is 2%, 4% and 8%, autogenous shrinkage of 2d zeolite powder self-compacting concrete respectively decrease 21.4%, 34.9% and 57.3% and 7d autogenous shrinkage respectively decrease 12.6%, 26.8% and 39.4% compared with benchmark self-compacting concrete. Therefore, zeolite powder can decrease the autogenous shrinkage of self-compacting concrete. This is because water in zeolite powder internal porous structure releases gradually with curing, compensate water lost cause internal relative humidity decreases of self-compacting concrete, and decreases autogenous shrinkage of self-compacting concrete.

## 4 Conclusion

Self-compacting concrete with zeolite powder as self-curing materials, can improve the slump loss. According to test result, self-compacting concrete with zeolite powder has a big influence on compression strength, but when addition is 2%, it has influence on compressive strength at early age and less influence at later age. Therefore, in order to ensure compressive strength of self-compacting concrete with zeolite powder should be less than 4%.

When zeolite powder is added in self-compacting concrete, the internal relative humidity of self-compacting concrete increases gradually and the addition increases the higher internal relative humidity. Compared with benchmark self-compacting concrete, when internal relative humidity decrease 100% to 90%, benchmark self-compacting concrete takes 4d while self-compacting concrete with 2%, 4% and 8% zeolite powder respectively takes 6d, 14d and 24d, which means zeolite powder addition can increase internal relative humidity of self-compacting concrete at same curing age.

The test results show that zeolite powder can reduce the autogenous shrinkage of self-compacting concrete. When zeolite powder addition is 2%, 4% and 8%, autogenous shrinkage of 2d zeolite powder self-compacting concrete respectively decrease 21.4%, 34.9% and 57.3% and 7d autogenous shrinkage respectively decrease 12.6%, 26.8% and 39.4% compared with benchmark self-compacting concrete.

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