

Effect of nano CaCO₃ on durability of concrete

Jiangong Yang*

Tianjin College, University of Science and Technology Beijing, Tianjin 301800, China

Abstract. Through comparatively analyzing the impermeability and compressive strength test data of nano CaCO₃ concrete with different content, this paper puts forward the method of optimizing the durability of nano CaCO₃ concrete, and studies the influence of the content of fly ash on the durability of nano CaCO₃ concrete on this basis, so as to provide a reference for improving the durability of concrete, so as to improve the recycling and reusing efficiency of building materials, and accelerate the practical application of nano CaCO₃ concrete in engineering.

1 Introduction

Nano materials are at least 1-100 nm in three-dimensional space. Because of its small size, it has the characteristics of small size effect, quantum size effect, surface interface effect and macro quantum tunneling effect which are not possessed by macro objects. It is known by scientists as "the most promising material in the 21st century" [1]. There are many researches on nano materials as admixtures to replace cement equivalently. Li Guhua et al [2]. studied the properties of nano CaCO₃, nano SiO₂ and concrete compounded with silica fume. Ye Qing [3] of Zhejiang University of Technology has shown that nano SiO₂ has higher pozzolanic activity than silica fume. Shaikh et al [4]. concluded that with the increase of nano CaCO₃ content, the fluidity of mortar, mortar mixed with fly ash and fly ash concrete decreased. Ji Tao et al [5]. of Fuzhou University added nano SiO₂ to fly ash coagulation, and made a preliminary experimental study on its physical and mechanical properties. The results show that adding nano SiO₂ can improve the compressive strength and flexural strength of fly ash concrete for 7 d and 28 d.

In addition, after adding fly ash, although the total porosity of concrete decreases little, it has a great influence on the pore size distribution, the critical pore size of concrete decreases, the relative number of harmful holes with the pore size greater than 100 nm decreases obviously, the pore size is effectively refined, and the connectivity of the pore structure network of slurry becomes poor. When fly ash can reduce the diffusion of chloride ion in nano concrete, capillary adsorption is also decreasing.

2 The Influence of Nano Materials on the Durability of Concrete

The research of nano CaCO₃ in cement concrete is still in the exploratory stage, and there are few related reports

at home and abroad. Therefore, the influence of CaCO₃ content on the concrete mechanical properties will be studied. The concrete mechanical properties at 28 days will be compared by group test, and the improvement of concrete mechanical properties by adding nano CaCO₃ will be analyzed in depth, so as to provide scientific basis for the application of nano CaCO₃ in the field of concrete. Some nano materials are added to the concrete, which can affect the self-performance of the concrete, so as to meet the needs of some special buildings. Therefore, the application of nano materials in concrete has become a research hotspot in the current concrete industry.

In our experiment, the influence of nano CaCO₃ on the performance of concrete will be studied. In order to observe the influence of nano CaCO₃ on concrete, we use the control variable method. Keep the certain water cement ratio, strength, sand ratio and cement strength of concrete, only change the content of nano CaCO₃, so as to observe its influence on concrete. In order to be used as a comparative test, after that, we changed the type of concrete from plain concrete to fly ash concrete, and the rest remained unchanged, changed the content of nano CaCO₃, and observed the effect of nano CaCO₃ on fly ash concrete.

3 Test Principle and Method

3.1 Principle of Impermeability Test

In order to study the influence of nano materials on the performance of concrete, we use the idea of control variable method and control single variable to carry out impermeability for different content of test blocks. The test is carried out according to the test method for impermeability of cement concrete (T0568-2005) in reference .

Calculation formula of impermeability grade:

$$S = 10H - 1 \quad (1)$$

S: Impermeability grade of concrete;

* Corresponding author: tjxyyang@163.com

H: Water pressure at the beginning of water seepage on the top surface of concrete test piece.

Note: 1. The impermeability grade of concrete is divided into $S_4, S_6, S_8, S_{10}, S_{12}$. If the concrete is pressurized to 1.2MPa and still does not seep after 8h, the test shall be stopped, and the impermeability grade of the test piece is represented by S_{12} .

2. When calculating the impermeability grade according to the above formula, if the maximum water pressure h is measured as an even number, then the calculated S value is an odd number. At this time, $S-1$ is the impermeability grade, for example: $H = 0.8\text{MPa}$, $S = 7$, then the impermeability grade is S_6 .

Calculation formula of impermeability coefficient:

$$K = aD^2 / (2 \times T \times H) \quad (2)$$

K: Relative impermeability coefficient cm / s

D: Average seepage height cm

H: The pressure of water is expressed by the height of water cm

T: constant pressure time s

a: Water absorption of concrete. Water absorption formula: $a = (m_0 / m) \times 100\%$

m_0 is the mass without water absorption; m is the mass after water absorption

(Note: Impermeability grade is different from impermeability coefficient. Impermeability coefficient is used in hydraulic concrete, and the relative permeability coefficient is calculated by referring to the seepage height. Foreign countries tend to use impermeability height and relative permeability coefficient to evaluate the impermeability of concrete)

Because of the condition, the impermeability tester in the laboratory is a pressure boosting impermeability tester, so the calculation formula of impermeability grade should be selected in the selection of calculation formula.

3.2 Data of Impermeability Test

Table 1. Experimental data of impermeability of nano concrete(upper limit 0.8MPa lower limit 0.6MPa)

Amount of nano-material added (%)	0.00	0.50	1.00	1.50	2.00	2.50	3.00
compressive strength (MPa)	16.43	18.89	19.44	22.09	22.16	22.26	22.09
Impermeability strength (MPa)	0.29	0.31	0.34	0.52	0.48	0.45	0.43

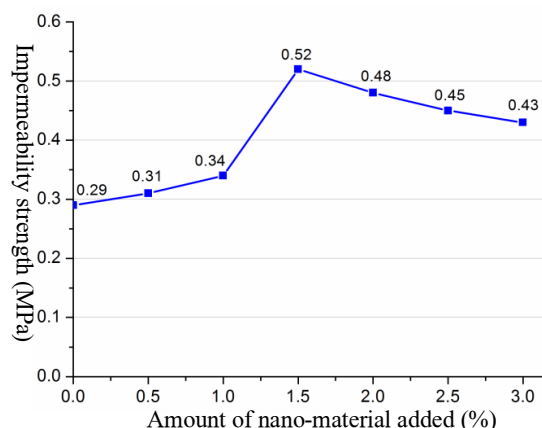


Fig 1. Impermeability strength of nano concrete

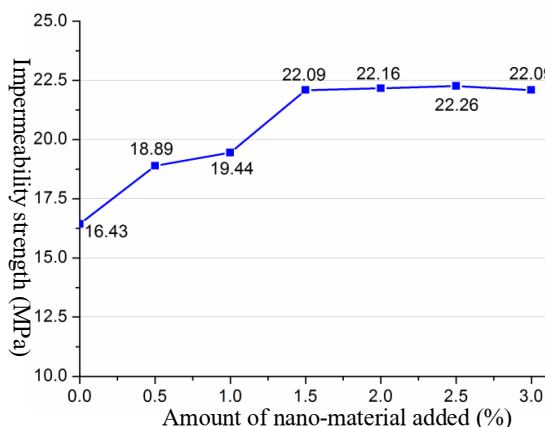


Fig 2. Compressive strength of nano concrete

Table 2. Experimental data of impermeability of nano fly ash concrete(upper limit 0.8MPa lower limit 0.6MPa)

Amount of nano-material added (%)	0.00	0.50	1.00	1.50	2.00	2.50	3.00
compressive strength (MPa)	11.48	11.62	11.82	11.93	12.40	12.51	12.00
Impermeability strength (MPa)	0.21	0.27	0.34	0.39	0.31	0.27	0.29

Note: in this experiment, the influence of nano materials on the performance of concrete added with quantitative fly ash is studied. Replace 1 / 3 cement with quantitative fly ash and add different content of nano materials. The total content of cement fly ash is the same as that of original cement to form a single variable.

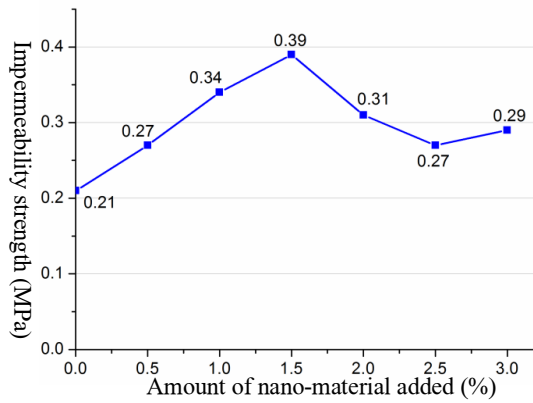


Fig 3. Impermeability strength of concrete with 1 / 3 replacement rate of fly ash

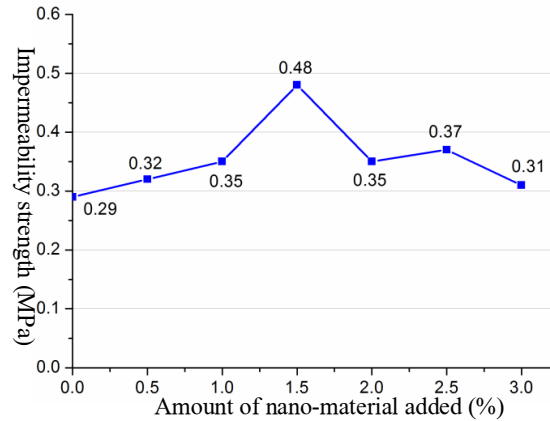


Fig 5. Impermeability strength of concrete with 1 / 4 replacement rate of fly ash

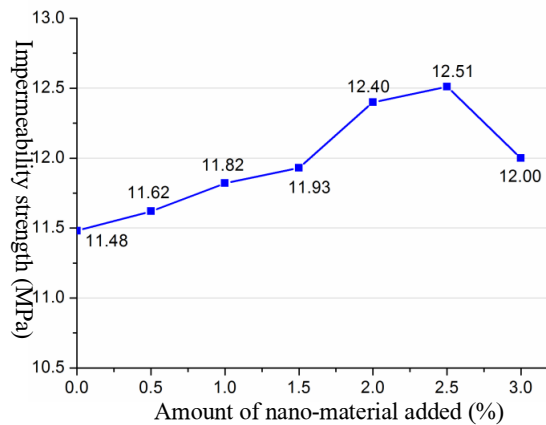


Fig 4. Compressive strength of concrete with 1 / 3 replacement ratio of fly ash

Table 3. Experimental data of impermeability of nano fly ash concrete(upper limit 0.8MPa lower limit 0.6MPa)

Amount of nano-material added(%)	0.00	0.50	1.00	1.50	2.00	2.50	3.00
compressive strength(MPa)	11.98	12.13	12.30	12.43	12.90	13.17	12.50
Impermeability strength(MPa)	0.29	0.32	0.35	0.48	0.35	0.37	0.31

Note: in this experiment, the influence of nano materials on the performance of concrete added with quantitative fly ash is studied. Replace 1 / 4 cement with quantitative fly ash and add different content of nano materials. The total content of cement fly ash is the same as that of original cement to form a single variable.

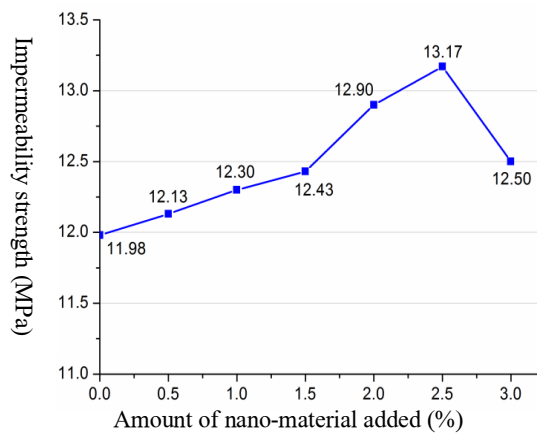


Fig 6. Compressive strength of concrete with 1 / 4 replacement ratio of fly ash

Table 4. Experimental data of impermeability of nano fly ash concrete(upper limit 0.8MPa lower limit 0.6MPa)

Amount of nano-Material added(%)	0.00	0.50	1.00	1.50	2.00	2.50	3.00
compressive strength(MPa)	15.69	16.74	17.03	17.56	18.25	18.50	18.29
Impermeability strength(MPa)	0.42	0.47	0.46	0.57	0.51	0.51	0.46

Note: in this experiment, the influence of nano materials on the performance of concrete added with quantitative fly ash is studied. Replace 1 / 5 cement with quantitative fly ash and add different content of nano materials. The total content of cement fly ash is the same as that of original cement to form a single variable.

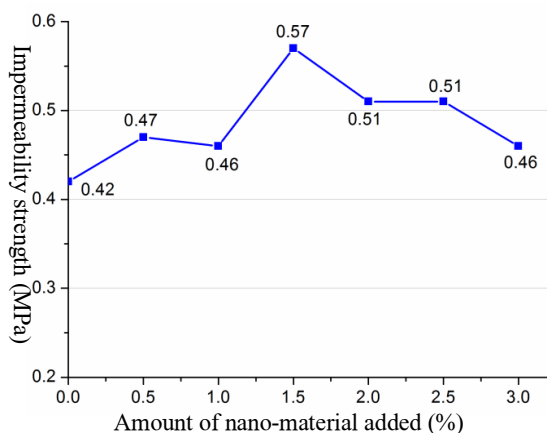


Fig 7. Impermeability strength of concrete with 1 / 5 replacement rate of fly ash

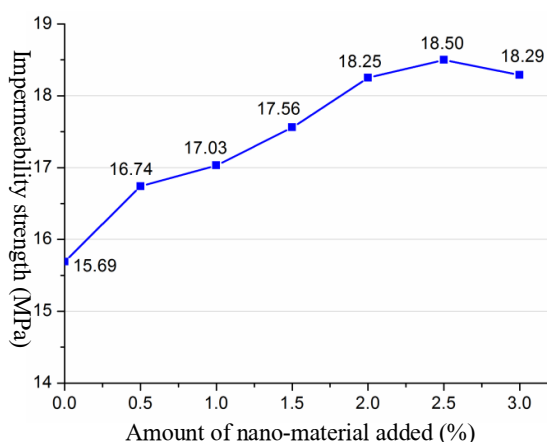


Fig 8. Compressive strength of concrete with 1 / 5 replacement ratio of fly ash

According to the line chart of impermeability test, when the content of nano materials is 1.50%, the impermeability strength of nano concrete is the maximum. Therefore, controlling the content of nano materials to about 1.50% can not only improve the impermeability strength of nano concrete, but also save the cost effectively. In addition, when the replacement ratio of fly ash is 1 / 5, the impermeability strength of nano fly ash concrete is the maximum.

According to the line chart of compressive test, when the content of nano CaCO₃ is 2.5% while the other content is kept unchanged, the compressive strength of concrete is the maximum. With the increase of nano CaCO₃ content, the compressive strength decreases constantly. Therefore, controlling the content of nano CaCO₃ to about 2.50% can improve the compressive strength of nano concrete. In addition, when the incorporation ratio of fly ash is 1 / 5, the compressive strength of nano concrete is the maximum.

4 Conclusion

(1) Because of the high activity and microparticle of nano materials, the reaction area and route of cement slurry increase, and the surface effect increases. Therefore, compared with concrete samples, the

hydration reaction in concrete specimen with nano powder is fast and fully developed. However, the nano production should not be too large, because nano based materials need to consume a lot of hydration water, which hinders the hydration process of cement particles. When the content of nano materials is 1.50%, the impermeability strength of nano concrete is the maximum.

(2) The impermeability of nano concrete can be improved by replacing cement with low content fly ash. Because the small size of fly ash can fill the pores, the impermeability of nano concrete can be improved properly when the content of fly ash is about 30%.

(3) When the content of nano CaCO₃ is controlled at about 2.50%, the compressive strength of nano concrete can be improved properly.

(4) Adding appropriate amount of fly ash in concrete can reduce water consumption and increase concrete strength, but there is a peak value of the influence of fly ash on concrete performance. When the proportion of fly ash is 1 / 5, it can give full play to the role of fly ash. Too much fly ash will reduce the strength.

5 Expectation

As for the influence of nano materials on the performance of concrete, most of the researches at home and abroad are on its strength, durability, frost resistance and axial fracture. However, considering the variety and composition instability of nano materials, all the research results have some limitations. In order to make nano concrete widely used in our country, it is necessary to carry out multi-faceted and single-sided research on this subject, study nano materials to take the road of green and sustainable development, and widely apply them to life.

References

1. LiuWei. Study on mechanical properties of nano cement concrete[J]. Transportation Standardization, 2012(02):91-93.
2. Guhua Li, GaoBoEffect of Level SiO₂ and Level CaCO₃ on Concrete Performance[J]. Journal of the China Railway Society,2006(01):131-136.
3. YeQing, ZeNan Zhang etal..Comparison of Properties of High Strength Concrete with Nano-SiO₂ and Silica Fume Added[J].Journal of Building Materials,2003(04):381-385.
4. SHAIKH F U A, SUPIT S W M. Mechanical and durability properties of high volume fly ash (HVFA) concrete containing calcium carbonate (CaCO₃) nanoparticles[J]. Construction and Building Materials,2014,70: 309-321.
5. Jitao, Yuzhou Huang, Zuoqiao Zheng. Primary investigation of physics and mechanics properties of nano-concrete[J]. Concrete,2003(03):13-14+48.