The Research and Analysis of the Influence of Nano-materials on the Performance of Cement Concrete

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Abstract. With the rapid development of nano materials, it becomes a new material science. Aiming at the application of nano materials in concrete, this paper briefly introduces the nano material and analysis the mechanism of the effects of nano materials on the properties of concrete. Meanwhile, the research achievements of various researchers about the influence of different dosage of nano materials on the concrete performance and the optimal incorporation amount are expounded systematically.

Introduction

As a result of the continuous understanding of nano materials, it has been widely used in biological, aerospace, computer, materials science and other fields. The research both at home and abroad shows that the incorporation of appropriate amount of nano materials in concrete can improve the strength and durability of concrete and other properties to meet the requirements of modern construction and construction technology.

Application of Nano-materials in Concrete

Nano-TiO2 has the properties of nano powders, such as surface and interface effects. it also has strong ability of oxidation decomposition, stable catalytic ability and super hydrophilicity . Use these properties made the construction materials improving human living environment, such as antibacterial ceramics, architectural coatings and other ecological building materials[1].

Nano-SiO2is a kind of white, non-toxic and micro-powder solid. The particle size is about 0.01~1nm, and its stability is high, the surface area is large, the surface adsorption force is strong. It is widely used in coatings, rubber and other fields. It also haspozzolanic effect, filling effect and crystallization nucleation and so on.

Nano-CaCO3 is a kind of nano material with certain activity and low cost [2]. Nano-CaCO3 activity is low and the price is about 1/10 of nano-SiO2 compared with nano-SiO2. It is widely used in rubber, plastics, paper, chemical building materials and other industries.

Effects of Different Dosage of Nano-materials on the Performance of Concrete

Effect of Nano-SiO_2 on the Performance of Concrete .

Xuebiao Hou et al. In the ordinary concrete by replacing cement with nano-SiO2 0.5%, 1%, 2% and 3% to test the effects of nano-SiO2 on the performance of concrete. Research shows thatthe slump of concrete markedly reduced after mixed with nano-SiO2 [3].

Xiaoping Tang et al. Take the concrete of 7d age as an example, through the dosage of 0%, 2%, and the same amount of nano-SiO2 replace cement to concrete mix design, as shown in table 1. Research shows that with the increase of nano-SiO2 content, the slump of concrete decreases [6].

Table 1The test results of different dosage of nano-SiO_2 onthe influence of concrete slump

Dosageofnano-SiO_2	0.0%	2.0%	5.0%
The slump of concrete /mm	185	155	110

Qing Ye et al. Comparison of properties of high strength concrete with nano-SiO2 and silica fume added. Research shows that: compared with silica power concrete, adding 3% nano-SiO2 concrete, its flexural strength at 3d, 7d, 28d age increased about 31%~57%, the tensile strength increased by about12%~21% in the early, the compressive strength at 1d, 3d, 7d, 28d the age of about20%~30%[4].The incorporation of 3% nano-SiO2 is more favorable to improve the strength of concrete.

Haiyan Zhang et al. Influence of nano-Si02 on mechanical property of the high performance concrete. The study found that enhancing the strength of concrete is most obvious when water cement ratio of 0.30 and the dosage of nano-SiO2 is3%.Compared with the specimens without mixing nano-SiO2, the compressive strength increased by 11.3% on average.When the dosage of nano-SiO2 reached 5% to improve the effect of concrete compressive strength is not very big. Only from the point of view of improving the compressive strength of concrete, mixed with 3% nano-SiO2 can serve as a suitable dosage [5].

Xiaoping Tang et al. Study on the different dosage of nano-SiO2 and different age of concrete axial compression test block. as shown in table 2. When the added amount does not exceed 2% of nano-SiO2, mixed with the quantity increase of concrete strength is increased by 1% per relative amplitude is greater than the amount of nano-SiO2 added is 5%. Considering the concrete strength and workability, the appropriate mix content of nano-SiO2 is 1.5-2.5% [6].

Table 2 Statistic data of axial compressive bearing capacity test for the concrete contained different contents of nano-SiO_2 (unit: kN)

Dosage of nano-SiO_2	Loading value	The age of concrete								
		Specimen number								
		7d			28d			56d		
		1	2	3	1	2	3	1	2	3
0.0%	Sample value	166.5	166.8	159.3	372.5	373.1	373.4	416.0	415.2	415.0
1.5%	Sample value	221.2	220.6	220.0	408.9	409.6	409.4	431.0	429.6	430.0
2.0%	Sample value	217.8	217.0	216.8	347.0	347.3	346.5	401.2	401.6	401.4
2.5%	Sample value	198.0	197.9	197.2	343.5	343.0	342.7	391.3	391.5	390.5
3.0%	Sample value	200.0	200.7	199.5	376.0	376.5	375.7	403.0	403.8	403.7

Effect of Nano-$CaCO_3$ on the Performance of Concrete

Shan Yang et al. Study on the effect of nano-CaCO3 on the workability of steel fiber reinforced concrete. As shown in table 3.The results show that: incorporation of nano-CaCO3 increased from 0.5% to 2%, the slump of concrete reached 184mm. Along with the increase of nano-CaCO3 doping amount, the slump of concrete began to decline and its cohesion increases[7].

Table 3 The test results of steel fiber reinforced concrete

Dosage of nano-$CaCO_3$	0.0%	1.0%	1.5%	2.0%	2.5%
The slump of concrete /mm	142	150	165	184	168
Cohesive	Better	Good	Good	Good	Too sticky
Water-holding capacity	A little bleeding	Good	Good	Good	Good

The effect of nano-$CaCO_3$ on the properties of concrete was studied by SengLi. As shown in table 4. The results show that: when the nano-$CaCO_3$ content is 1.5%, the slump of concrete reaches 170mm, increased 48mmrelative to the reference group. With the increase of nano-$CaCO_3$ content, the slump of concrete decreases [11].

Kuangliang Qian et al .Effects of nano-CaC03intermediate on physical and mechanical properties of cement-based materials. The dosage was 0%, 0.5%, 1% and 2%, respectively. The results showed that the compressive strength of cement increased by54%,24%and 39% respectively at 12h,72h and 28d after the addition of 1% nano-CaCO3compared with the benchmark [8].

Table 4 The test results of different dosage of nano-$CaCO_3$on the influence of concrete slump

Dosage of nano-$CaCO_3$	0.0%	0.5%	1.0%	1.5%	2.0%	3.0%	4.0%
The slump of concrete /mm	122	148	156	170	165	154	140
Cohesive	General	Better	Better	Good	Good	More stick	Too stick
Water-holding capacity	A little bleeding	Better	Better	Good	Good	Good	Good

Sha Yang et al. Research has shown that3d,7d, 28d flexural and compressive strength of concrete along with the increase of nano-$CaCO_3$content increased. The age of the compressive strength and flexural strength reaches the highest value when the nano-$CaCO_3$ content is 2%, and then increase the dosage of nano-$CaCO_3$, the compressive strength and flexural strength of concrete began reduce. The optimum dosage of nano-$CaCO_3$ in steel fiber reinforced concrete is 2.0%[7].

Yong chao zhang studies on the effect of different content of nano-CaCO3 on the mechanical properties of concrete. The results show that the best effect is in the range of 1% ~ 1.5%, which can effectively improve the compressive and flexural strength of concrete. When the nano-CaCO3 content is 1.5%, the compressive strength of 3d is 3.9% higher than the reference concrete; the flexural strength increased 13.5%; the compressive strength of 7d increased by7.5%, the flexural strength increased by14%;28d compressive strength increased by5.6%, the flexural strength increased by 6.6% [9].

Effect of Nano-TiO_2on the Performance of Concrete

Yayun Tan studied the effect of nano-TiO2 mixed crystal on the performance of concrete under different dosage. The results showed that: with the increase of nano-TiO2 mixed crystal content, the slump of concrete decreases, because the specific surface area of the mixed nano-TiO2 mixed crystal is larger than that of the cement particles, more water is needed to wet the cement and nanoparticle surface [10].

YayunTanpointed out that the mixed crystal content in nano-TiO2 concrete compressive strength increased from 0.5% to 2%, 7d age were increased by 9.2%, 16.8%, 15.4%, 10.6%;the compressive strength of concrete of 28d age were increased by 7.7%, 14.8%, 12.5%, 8.5%; the compressive strength of concrete of 56d age were increased by 4%,12.2%, 8.5%, 4.5%.The compressive strength increases with the increase of nano-TiO2 mixed crystal content. The best dosage should be controlled in the range of 1%~1.5% [10].

Effect Mechanism of Nano-materials on the Performance of Concrete

Based on the related literatures, it boils down to the effect mechanism of nano materials on the performance of concrete:

Filling effect of nano materials. Due to the existence of mineral particles between cement and other micro pores in the concrete cementations materials, and the particle size of nano materials is far less than the micro pore size, therefore, nano materials can act as a "micro aggregate" filling the micro pore to reduce the porosity and internal defects of the concrete cementations materials, optimizing the whole structure of matrix cementing materials, so as to improve the compactness of concrete, strength and durability.

The concrete added with nano-SiO2 has a higher early strength, but is weaker than the latter. The reasons are as follows: firstly, the nano-SiO2 has the pozzolanic effect. In the early hydration reaction, when the alkaline exciting agent Ca(OH)2 was generated after mixing water in cement concrete and nano-SiO2 with highly active to produce chemical reaction, the hydrated calcium silicate gel with high strength was formed. At the same time, the grain Ca(OH)2 tends to refine, which improves the structure between the cement paste and the aggregate, and the early strength of concrete is improved. Second, when nano-SiO2and alkaline activator Ca(OH)2 reaction produces a lot of heat of hydration, accelerate the hydration reaction of cement aggregate, so as to promote the improvement of the early strength of concrete. In the late hydration reaction, because the

nano-SiO2surface area extremely large, a lot of water adsorption on the surface after mixing with water, relative to the no of concrete mixed with nano-SiO2 need more water, the role of hydration reaction need water, however, the hydration reaction will stop when the water is not enough to support the hydration reaction of aggregate, so its late concrete strength growth is not obvious.

The reason for the improvement of the strength of the concrete by the incorporation of nano-CaCO3 is that the nano-CaCO3 is an intermediate, which is helpful to accelerate the speed of the solidification and refinement effect. In the process of hydration reaction, the Ca(OH)2 grains were refined by nano-CaCO3,which changes the Ca(OH)2 in aggregate grain size on the interface of the matrix sequence and distribution density of the interface of crystal structure transition from flat to space. Moreover, the hydration products contain a large amount of high strength C - S - H gel, due to the nano material surface and interface effect, make the nano-CaCO3crystal nucleation effect, so that the surrounding of nano-CaCO3 was full of C - S - H gel and the formation of mesh structure of nano-CaCO3 for nuclear matrix to make the order between concrete aggregate structure more reasonable to improve the strength of concrete.

Conclusions

In order to meet the using demand of the special environment as well as the consideration of energy conservation and environmental protection, the development of concrete tends to high performance, multi-function, intelligent and environmental protection direction, which drives us to the direction of research. The nano material is an important step towards our leading direction in this research. In the concrete material mixed with the application of nano materials research is still in its infancy, it is necessary to strengthen the nano material in the concrete application research.

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