UDC 624.01.691

Shilin Yang, PhD, Meiyu Shao, PhD, Stepanchuk O.V.
(National Aviation University, Ukraine)

Research Progress on the influence of nano-SiO2 on concrete properties

This paper reviews the current research progress of scholars on the application of nano-silica in concrete and its influence on the mechanical properties and durability of concrete. Proposals for further in-depth research are proposed, and the development prospects of nano-silica in concrete are prospected.

The particle size of nanomaterials is generally 1-100 nm, and the particles are extremely small but the surface area is large. This characteristic makes it have some special properties such as high surface activity and strong oxidation. Concrete is one of the most widely used materials in the construction industry today. Ordinary concrete has high rigidity and low flexibility. At the same time, due to some natural defects existing in itself, concrete often cracks during use, and even causes structural damage. At present, one of the common methods to improve the performance of concrete is the compounding of materials. Incorporating nanomaterials into concrete can improve the physical and mechanical properties of concrete to a certain extent. Scholars at home and abroad have added different nanomaterials (such as nano-SiO2, CaCO3, TiO2, etc.) to concrete, and have conducted a lot of research on their mechanical and durability properties, and have achieved rich results. However, there are still some immature research areas, which need to continue to carry out in-depth and systematic experimental research and theoretical analysis. In this paper, the research contents about the influence of nano-SiO2 on concrete properties in recent years are reviewed, and suggestions and suggestions are put forward for the problems in the current researches on nano-SiO2 concrete and the need for further research.

1.Effect of nano silica on mechanical properties of concrete

Nano silica (hereinafter referred to as NS) has small particle size, large specific surface area, high stability and purity. It has stronger pozzolanic activity than silica fume. It can improve the hydration reaction rate of cement and improve the hydration effect of cement. In addition, its better nucleation and filling effect have become the focus of many scientific and technological workers.

When NS is mixed into concrete, good filling effect makes the density of concrete increase, and NS has very high activity. It combines with hydration products to form a new hydrated calcium silicate gel phase. At the same time, NS can consume part of Ca (OH) $_2$, promote cement hydration, and improve the mechanical properties of concrete. Zheng Junying et al. studied the compressive and splitting tensile strength of NS concrete with different dosage. It was found that when the dosage of NS was 0 ~ 1.5%, the compressive strength of concrete increased significantly, and gradually increased with the increase of NS dosage, but had little effect on the splitting tensile strength of concrete. Chen Jian et al. studied the influence of NS on the compressive performance of steel fiber reinforced concrete. The results show that when the content of NS is in a certain range, it can improve the compressive strength of steel fiber reinforced concrete, especially the early compressive strength. Liang Bo et al. carried

out compression and split tensile tests on ordinary concrete and ultra-fine fly ash concrete mixed with ns. The results showed that the appropriate content of NS was 0.8% for ordinary concrete, and 1.0% for ultra-fine fly ash concrete. Amin m et al. [1] studied the effects of different dosage of NS on the compressive strength, splitting tensile strength, flexural strength and elastic modulus of concrete. The results show that the optimal dosage of NS is 3%. Yan Lan et al. compared the compressive strength of ordinary concrete and steel fiber reinforced concrete mixed with NS before and after high temperature, and found that ns can improve the high temperature compressive strength of ordinary concrete and steel fiber reinforced concrete. Mohammed b s et al. [2] studied the effect of NS on the performance of permeable concrete with fly ash partially replacing cement. The study found that the compressive strength of NS modified permeable concrete was improved, but had no adverse effect on its porosity and permeability. Jalal m et al. [3] studied the effect of NS content on the mechanical properties of high-performance self-compacting concrete. From the perspective of microstructure, the pore structure of concrete mixed with NS, especially at a longer age, is more refined and denser, and the concrete strength is improved. When NS is mixed into concrete, good filling effect makes the density of concrete increase, and NS has very high activity. It combines with hydration products to form a new hydrated calcium silicate gel phase. At the same time, NS can consume part of Ca (OH) $_2$, promote cement hydration, and improve the mechanical properties of concrete. However, the mechanism of NS on the improvement of concrete performance has not been fully studied, such as the reasonable content of NS, and the research results of different scholars are not consistent.

2. Influence of NS on durability of concrete

Chithra S et al. [4] studied the effect of NS on the resistance to chloride ion penetration of high performance concrete. Through the chloride ion penetration test, it can be seen that the addition of NS can improve the impermeability of concrete. Zhang Peng et al. studied the effect of NS on the carbonation resistance of concrete, and the results showed that an appropriate amount of NS (7%) could improve the carbonation resistance of concrete, but if it was excessive, it would be detrimental to the carbonation resistance of concrete. Atmaca N et al. studied the effect of NS on the air permeability and durability of high-strength lightweight concrete, and the results showed that the incorporation of nanomaterials reduced the water absorption and air permeability of concrete. Mei Junshuai et al studied the effect of NS modified mortar on the chloride ion permeability of concrete by means of X-ray diffraction and SEM scanning. Resistance to chloride ion penetration. Yu Wenyong, Sun Ling et al studied the effect of NS on the salt-freezing resistance of bridge concrete through anti-freezing tests. The study showed that NS and concrete hydration products were bound together in large quantities, which improved the microstructure of concrete and made the concrete structure more stable. It is more compact and greatly enhances the anti-salt freezing and denudation performance of concrete. Yu WY[5] studied the frost resistance of ordinary concrete and fly ash NS concrete and found that the addition of NS can significantly improve the frost resistance of concrete.

Conclusion

This paper mainly introduces the current research on the application of NS in concrete. By studying the existing results, it is found that when the amount of NS is appropriate, nanoparticles can fill the pores inside the concrete and improve the performance of the concrete. The compactness of concrete improves the physical properties of concrete, thereby improving the strength and durability of concrete.

References

1. Amin M, Abu E, Khaled. Effect of using different types of nano materials on mechanical properties of high strength concrete [J].Construction and Building Materials,2015,80:116-124.

2. Mohammed B S, Liew M S, Alaloul W S, et al. Properties of nano -silica modified pervious concrete [J].Case Studies in Construction Materials,2018,8:409-422.

3. Jalal M, Mansouri E, Sharifipour M, et al. Mechanical, rheological, durability and microstructural properties of high performance self -compacting concrete containing SiO2 micro and nanoparticles [J].Materials and Design,2012,34:389-400.

4. Chithra S, Senthil Kumar S R R, Chinnaraju, K. The effect of colloidal nano -silica on workability, mechanical and durability properties of high performance concrete with copper slag as partial fine aggregate [J].Construction and Building Materials,2016,113:794-804.

5. Yu W Y, Sun L, Wu C L, et al. Study for frost resistance of cement concrete pavement with nano-SiO2 as admixture [J]. Advanced Materials Research,2014, 952:47-50.