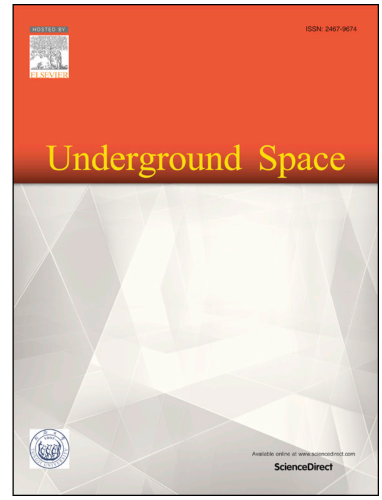

Experimental research on the microstructure and compressive and tensile properties of nano-SiO_2 concrete containing basalt fibers

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Experimental research on the microstructure and compressive and tensile properties of nano-SiO_2 concrete containing basalt fibers

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Abstract

Urban underground space resources are gaining increasing attention for the sustainable development of cities. Traditional concrete cannot meet the needs of underground construction. High-performance concrete was prepared using varying dosages of nano-SiO_2 and basalt fiber, and its compressive and tensile strength was measured. The concrete microstructure was analyzed and used to assess the mechanisms through which the nano-SiO_2 and basalt fibers affect the strength of concrete. The cement hydration productions in concrete produced varied with the dosage of nano-SiO_2. When the nano-SiO_2 dosage was between 0 and 1.8%, the mass of the C-S-H gel and AFt crystals increased gradually with the nano-SiO_2 dosage. When the nano-SiO_2 dosage was 1.2%, optimum amounts of C-S-H gel and AFt crystals existed, and the compactness of concrete was well, which agreed with the results of the compressive strength tests. When the basalt-fiber dosage was between 3 and 4 kg/m^3, the basalt fibers and the cement matrix were closely bonded, and the splitting tensile strength of the concrete markedly improved. When the basalt-fiber dosage exceeded 5 kg/m^3, the basalt fibers clustered together, resulting in weak bonding between the basalt fibers and the cement matrix and, consequently, the basalt fibers were easily pulled apart from the cement. When the nano-SiO_2 and basalt fiber dosages were 1.2% and 3 kg/m^3, respectively, the compactness of the concrete microstructure was well and the strength enhancement was the greatest; additionally, the compressive strength and splitting tensile strength were 9.04% and 17.42%, respectively, greater than those of plain concrete. The macroscopic tests on the mechanical properties of the nano-SiO_2 concrete containing basalt fibers agreed well with the results of microstructure analysis.

Keywords: Concrete; Nano-SiO_2; Basalt fiber; Compressive strength; Splitting tensile strength; Microstructure

1. Introduction

Development of societies and economies presents many problems that hinder the sustainable development of modern cities, such as heavy traffic congestion, shortages of urban construction land, and pollution of urban environments. Extending spaces from ground level to underground is an inevitable tendency of future urban development (Zhu, 2016), and underground construction has been carried out in many cities. However, traditional concrete cannot meet the needs of underground construction, and therefore, engineers and scholars at home and abroad have studied high-performance concrete, which has a high durability and good workability. Nano-SiO_2 has many characteristics, such as small size and high surface activity. Replacing some of the cement in concrete with nano-SiO_2 improves the compactness of concrete on the micro-scale (Li, 2015). Consequently, the compressive strength of concrete has been improved significantly by adding nano-SiO_2 (Wang, 2013). Zhu (2015) evaluated the properties of nano-SiO_2 concrete under dynamic loads. Alireza (2016) evaluated the properties of high-performance nano-SiO_2 concrete and found that nano-SiO_2 played an important role in improving the mechanical properties of concrete.

Basalt fiber has also been used as an additive to overcome the extreme brittleness and breakability of concrete. Basalt fiber is an environmentally friendly inorganic silicate material with a working performance similar to that of carbon fiber, while its price is only $1/10^{th}$ of carbon fiber. Using appropriate amounts of evenly distributed chopped basalt fibers can effectively inhibit crack propagation and significantly improve the tensile strength and crack resistance of concrete (Pan, 2009; Jin, 2010; Jiang, 2014). Aref (2013) estimated the compressive strength of self-compacted concrete containing fibers consisting of nano-SiO_2 using ultrasonic pulse velocity tests. Zhang (2014) investigated the influence of nano-SiO_2 and carbon fibers on the mechanical properties of concrete using X-ray photoelectron spectroscopy (XPS).

Optimizing the nano-SiO_2 dosage could enhance the compressive strength of concrete, and using dispersive chopped basalt fibers could improve its tensile strength and anti-cracking

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