An Experimental Study on Frost Resistance of Concrete Pavement Containing Nano-silica and Polypropylene Fibers

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Abstract

In this study frost resistance and mechanical properties of concrete containing both nano-silica and polypropylene fibers are studied. Nano-silica is employed to be as substitute of a portion of cement. For comparison the frost resistance and mechanical properties of plain concrete, concrete containing nano-silica (without fibers) and concrete containing polypropylene fibers are also experimentally studied separately in this work. The specimens were subjected to cycles of freezing and thawing in water according to ASTM C666A. Loss of mass and reduction in compressive strength measured after different cycles. Experimental results show that using nano-silica incorporating polypropylene fibers enhances frost resistance and compressive strength of concrete pavement because of that the permeability and porosity of concrete are reduced due to the use of nano-silica and also the tensile strength of concrete is enhanced due to the use of polypropylene fibers.

Keywords: durability, concrete pavements, freeze and thaw, nano-particles, polypropylene fibers.

1. INTRODUCTION

Concrete pavement is mostly used for road surfaces, bridge decks, airfield runways and parking lots. Concrete pavement endures dynamical loads and subjects to rigorous environment. In recent years, the research and development in the field of cementitous materials have been focused increasingly on their durability and service life. Obviously concrete pavement also requires good durability as well as strength. Durability of this kind of pavement includes frost resistance, impact resistance, permeability and abrasion resistance [1].

The freezing and thawing is one of the major problems of the concrete pavements in cold climates. Numerous studies on the frost resistance of concrete have been carried out to improve the durability and to prolong the service life of concrete in the world [2-4]. Many of these investigations have shown that durability parameters are especially related to the concrete air void system and to the bond between the aggregates and matrix [5].

It is commonly believed that mineral admixtures can significantly improve permeation-related durability of concrete, and air entrainment can enhance frost resistance, although it also causes a reduction in strength of concrete [6].It is also reported that pozzolans could make microstructure of concrete more compact and improve frost resistance [7]. The effect of pozzolans is mainly to improve the interfacial transition zone, resulting in a reduction in porosity of this zone [8].

On the other hand, recently, nanotechnology has attracted considerable scientific interest due to the new potential uses of particles in nanometer (10^{-9}m) scale. Nanotechnology has brought possibilities to use nano-particles in order to improve the operation of construction materials in recent decades. Nanotechnology is defined as the understanding, control and restructuring of matter on the order of nanometers to create materials with fundamentally new properties and functions. Nano-particles are particles with dimensions between 1 to 100 nanometers.

The nano scale size of particles can result in dramatically improved properties from conventional grain-size materials of the same chemical composition. Thus industries may be able to re-engineer many existing products and to design new and novel products that function at unprecedented levels. When ultra-fine