Cement & Concrete Composites 34 (2012) 110–118

Contents lists available at SciVerse ScienceDirect

Cement & Concrete Composites

journal homepage: www.elsevier.com/locate/cemconcomp

Compressive strength of HPC containing CNI and fly ash after long-term exposure to a marine environment

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ARTICLE INFO

Article history:
Received 29 June 2010
Received in revised form 8 June 2011
Accepted 17 August 2011
Available online 10 September 2011

Keywords:
Calcium nitrite
Fly ash
High performance concrete
Compressive strength
Marine environment

ABSTRACT

This study addressed the effect of calcium nitrite based corrosion inhibitor (CNI) and fly ash (FA) on the long-term compressive strength of high performance concrete (HPC). A 3^3 full factorial design was developed to evaluate the influence of CNI at addition rates of 0, 12.5 and 25 L/m^3 on the compressive strength of HPC manufactured with 8% silica fume blended cement in combination with 0%, 20% and 40% FA replacements and mixed at 0.29, 0.37 and 0.45 water to cementing materials ratios (w/cm). Standard 100 × 200 mm cylinders were prepared and tested for compressive strength at 28 days and 1 year. The 9-year old concrete specimens were obtained from small-scale reinforced concrete slabs that were exposed to a marine environment. Results indicate that the interaction of CNI and FA does not adversely affect the short and long term compressive strength of concrete. In fact, an enhancement on the compressive strength was observed in concretes containing such combination even after long-term exposure to a marine environment.

1. Introduction

The strength of concrete is one of its most important engineering properties because it not only reflects its mechanical quality, but in general it also provides an indication of its durability [1]. Calcium nitrite (CNI) has been used extensively in North America since 1978 to provide corrosion protection to the steel reinforcement [2,3]. Due to its chemical properties CNI enhances the compressive strength of concrete at an early age, and accelerates its setting time within the range recommended by standards [4,5]. However, it has been suggested that concrete in contact with high concentrations of calcium nitrite at relatively high w/cm could experience mortar deterioration [6]. Also, some studies have shown that the use of CNI in the presence of silica fume and fly ash can have a negative effect on the long-term strength of concrete [7,8]. Conversely, other studies have concluded that the CNI addition, alone or in combination with supplementary cementing materials, has a positive effect on the compressive strength of concrete at early and late ages [9–13].

To investigate this further, in this study the compressive strength of concrete prepared with CNI and fly ash after long-term exposure to a marine environment is investigated. This work is part of a larger program that evaluates the influence of CNI and fly ash on the corrosion protection of uncracked and cracked reinforced concrete [14]. A series of 27 mixtures with and without CNI in combination with fly ash and 8.2% silica fume, at 3 w/cm, were prepared and tested in compression at 28 days, 1 year, and after 9 years after exposure to a marine environment. Comparative results of the three ages studied are presented. The effects of the three main components of the mixtures, (i.e. w/cm, fly ash, and CNI) and their interactions, on the long-term compressive strength are also analyzed. To provide a better understanding of the influence of the main components of the mixtures on the compressive strength of concrete a brief discussion follows.

1.1. Water to cementing materials ratio

The properties of concrete are largely governed by the cementitious matrix and the strength of concrete is basically dictated by the capillary porosity, which is a function of the w/cm and degree of hydration of the cement particles. A high w/cm concrete contains a larger capillary pore space than a low w/cm concrete. This effect has an important influence on the strength of the hardened paste, which is the dominant factor in the strength of concrete. In other words, the strength of concrete mainly resides in the strength of the paste [15].

In concrete containing CNI, the w/cm is a factor that influences not only the corrosion inhibition properties but also the compressive strength. It has been reported that at w/cm below 0.50 the

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doi:10.1016/j.cemconcomp.2011.08.007