Materials and Design 32 (2011) 1501–1507

Contents lists available at ScienceDirect

Materials and Design

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

Properties of self-compacting concrete containing class F fly ash

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ARTICLE INFO

Article history:
Received 29 March 2010
Accepted 24 August 2010
Available online 31 August 2010

Keywords:
A. Concrete
E. Mechanical
G. Destructive testing

ABSTRACT

An experimental program was carried out to study the properties of self-compacting concrete (SCC) made with Class F fly ash. The mixes were prepared with five percentages of class F fly ash ranging from 15% to 35%. Properties investigated were self-compactability parameters (slump flow, J-ring, V-funnel, L-box and U-box), strength properties (compressive and splitting tensile strength), and durability properties (deicing salt surface scaling, carbonation and rapid chloride penetration resistance).

SCC mixes developed 28 day compressive strength between 30 and 35 MPa and splitting tensile strength between 1.5 and 2.4 MPa. The carbonation depth increased with the increase in age for all the SCC mixes. Maximum carbonation depth was observed to be 1.67 mm at 90 days and 1.85 mm at 365 days for SCC with 20% fly ash content. Also, the pH value for all the mixes was observed to be greater than 11. Deicing salt surface scaling weight loss increased with the increase in fly ash content except with mix containing 15% fly ash. At 365 days age, the weight loss was almost consistent for all percentages of fly ash varying between 0.525 and 0.750 kg/m^2. SCC mixes made with fly ash exhibited very low chloride permeability resistance (less than 700 and 400 Coulomb) at the age of 90 and 365 days respectively.

1. Introduction

Self-compacting concrete (SCC) is considered as a concrete which can be placed and compacted under its self weight with little or no vibration without segregation or bleeding. It is used to facilitate and ensure proper filling and good structural performance of restricted areas and heavily reinforced structural members. It has gained significant importance in recent years because of the advantages it offers [1–6]. SCC was developed in Japan [1] in the late 1980s to be mainly used for highly congested reinforced structures. Recently, this concrete has gained wide use in many countries for different applications and structural configurations. SCC can also provide a better working environment by eliminating the vibration noise.

Such concrete requires a high slump that can easily be achieved by superplasticizer addition to a concrete mix and special attention has to be paid to mix proportioning. Since SCC often contains a large quantity of powder materials which is required to maintain sufficient yield value and viscosity of the fresh mix, hence reducing bleeding, segregation and settlement. As, the use of a large quantity of cement increases cost and results in greater temperature rise, the use of mineral admixtures such as fly ash, blast furnace slag, or limestone filler could increase the slump of the concrete mix without increasing its cost.

Previous studies have shown that the use of mineral admixtures such as fly ash and blast furnace slag could increase the slump of the concrete mix without increasing its cost, while reducing the dosage of superplasticizer needed to obtain similar slump flow compared to concrete made with Portland cement only [7]. Also, the use of fly ash improves rheological properties and reduces the cracking potential of concrete as it lowers the heat of hydration of the cement [8]. Studies have shown that fly ash replacement up to 30% results in a significant improvement of the rheological properties of flowing concretes [9,10]. Kim et al. [9] studied the properties of super flowing concrete containing fly ash and reported that the replacement of cement by 30% (40% for only one mix) fly ash resulted in excellent workability and flowability. Other researchers [10] evaluated the influence of supplementary cementitious materials on workability and concluded that the replacement of cement by 30% of fly ash can significantly improve rheological properties. The use of fly ash reduces the demand for cement, fine fillers and sand [11], which are required in high quantities in SCC. Moreover, the incorporation of fly ash also reduces the need for viscosity-enhancing chemical admixtures. The paper investigates the making of SCC more affordable for the construction market with various percentages of fly ash of the total powder content. The FA SCC has higher water-to-cementitious materials ratio, ranging from 0.41 to 0.45, a slightly higher total mass of cementitious materials of 550 kg/m^3 with 15–35% fly ash of total powder content. The superplasticizer content was below 2% of the total powder content (cement + fly ash) for all the mixes. Such concrete

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doi:10.1016/j.matdes.2010.08.043