Thermal behavior of different concrete mixtures with pozzolanic additions

Francesco SURICO
R&D Admixtures for Concrete
Mapei SpA , Italy
f.surico@mapei.it

Amedeo GREGORI
Civil Engineer
University of L'Aquila
L'Aquila, Italy
Amedeo.gregori@univaq.it

Roberto MARINO
Concrete technology
Independent consultant
Italy
r.marino.cc@alice.it

Federico LONGHI
R&D Admixtures for Concrete
Mapei SpA, Italy
f.longhi@mapei.it

Summary

The hydration process of cement is an exothermic chemical reaction; the evolution of heat generated during hardening of concrete causes, especially in structures and massive elements, differential contractions between the nucleus and the surface that might generate large thermal shrinkage cracks. The current study wants to identify the factors that allow to obtain the biggest reduction of the heat of hydration using the products with pozzolanic effect present on the market, such as GGBS, silica fume ad fly ash. The goal is to prepare a recipe with a proper proportion of pozzolanic materials able to reduce the heat of hydration of concrete through a reduction of the amount of cement but without affecting the long term compressive strengths. After identifying the best pozzolanic compound, this study wants to propose an analytical method to assign an efficiency factor to the powder mixture, in order to work out the amount of equivalent cement to replace. Thanks to adiabatic calorimetry it has been possible to experimentally evaluate the heat generated by a series of concrete samples designed with different amounts of pozzolanic materials. Comparing the best performance in terms of compressive strength and reduction of the heat of hydration, the most promising experimental product was identified. This product has been subsequently validated by field trial tests. Some field application of the final product that was performed in the several important construction site, will be showed and documented.

1. Introduction

Silica fume is a byproduct from the production of silicon and ferrosilicon alloys in electric arc furnaces. It consists of fine vitreous particles with a surface area on the order of 20.000 m²/kg and particles approximately one hundredth the size of the average cement particle [1]. Because of its extreme fineness and high amorphous silica (SiO_2) content, silica fume is a very effective pozzolanic material.[2][3] Standard specifications for silica fume used in cementitious mixtures are ASTM C1240[4], EN 13263[5]. Prior to the mid-1970s, nearly all silica fume was discharged into the atmosphere. After environmental concerns necessitated the collection and landfilling of silica fume, it became economically viable to use silica fume in various applications, as high-performance concrete production[8]. Silica fume is added to Portland cement concrete to improve its properties, in particular its compressive strength, bond strength, and abrasion resistance. These benefits derive from both the mechanical improvements resulting from addition of a very fine powder to the cement paste (filling properties) as well as from the pozzolanic reactions between the silica fume and free calcium hydroxide in the paste.[6] Addition of silica fume also reduces the permeability of concrete to chloride ions, which protects the reinforcing steel of concrete from corrosion, especially in chloride-rich environments.[7] Incorporating silica fume into concrete mixtures also reduces bleeding significantly because the free water is consumed in wetting of the large surface area of the

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