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Alternative blended cement with ceramic residues: Corrosion resistance investigation on reinforced mortar

Maria Chiara Bignozzi *, Stefano Bonduà

Dipartimento di Ingegneria Civile, Ambientale e dei Materiali, Università di Bologna, Via Terracini 28, 40131 Bologna, Italy

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ABSTRACT

Blended cements are largely used for concrete: they are usually considered cements with a low environmental impact, as they require less clinker than ordinary Portland cement (OPC). Different constituents can be used as supplementary clinker component usually leading to cement with high resistance to outdoor environment. Polishing residue (PR), coming from porcelain stoneware tiles production, can be successfully used as new constituent for blended cement, however its action for enhancing the durability of cement matrix must be assessed. With this purpose, electrochemical tests (half cell potential, impressed voltage and linear polarization techniques) have been carried out on steel reinforced mortar samples, prepared using a 25% PR based cement and 100% OPC as binder and exposed to a 3.5% NaCl solution. The corrosion resistance results and microstructure analysis highlight better durability performances for PR based cement than those exhibited by OPC, mainly for curing time >28 days.

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1. Introduction

The use of blended cements is growing very fast as a consequence of the massive energy consumption and large CO_2 emissions released throughout Portland cement clinker production. Blended cements include all the cements where Portland cement clinker is partially replaced by a different constituent such as calcium carbonate, pozzolan, fly-ash, blast-furnace slag, etc. The content of supplementary constituent usually ranges between 18 and 30% of the cement, but the European standard EN 197-1 "Composition, specifications and conformity criteria for common cements" [1] allows the introduction of higher amounts. Pozzolan, fly-ash, blast-furnace slag, silica-fume exert hydraulic action in combination with Portland cement clinker, leading to cements with improved durability properties as high resistance to water aggression, sulfate and chloride attacks, carbonation reaction, etc.

Many new supplementary constituents have been proposed in the last years [2]: they usually derive from waste of different nature (ground glass [3,4], matt waste [5,6], rice husk ash [7], municipal solid waste incinerator bottom ash [8,9], ferroalloy industry waste [10,11], ceramic sludge [12], etc.). Their introduction in cement production aims to reach energy and costs saving, conservation of natural and not renewable resources, environmental protection with less waste landfill disposal, etc. Moreover, the performances of new constituents strongly depend on their average size and chemical/mineralogical composition: materials with high content of silica in the amorphous state and average dimension <10 μm may exhibit an active role in cement hydration reactions thus contributing in mechanical strength development, usually at long curing time.

Recently, polishing residue (PR), coming from porcelain stoneware tiles production, was successfully investigated as new constituent for innovative blended cement [12]. PR is the solid part of the relevant sludge formed during porcelain stoneware polishing step. This operation is performed on fired tiles by abrasive devices made of silicon carbide (SiC) and magnesium-based (MgOHCl) binder. In Europe, polishing sludge is classified as not hazardous waste (European Waste Code 10.12.99), but the presence of some compounds (CaO, MgO, SiC and chlorine compounds coming from the abrasive tools) prevents sludge re-introduction into the ceramic production cycle compromising a closed loop recycling. Italy (the 3rd world tile producer [13]) disposes to landfill more than 20,000 ton of polishing sludge every year.

In the previous work [12], mortar samples prepared with PR based blended cement, made up by 75 wt.% of CEM I 52.5 R and 25 wt.% of PR, exhibited good mechanical properties and compact microstructure due to the formation of calcium silicate hydrate (C-S-H) and K-rich-alumino-silicate-hydrate (K-A-S-H) gel structures. PR chemical/pozzolan activity towards portlandite was ascertained by different analytical characterizations (thermal analysis, scanning electron microscopy and EDS analysis), however durability tests were not carried out on the investigated binder.

It is commonly accepted in international standards and national laws that durability assessment is one of the most important issues for a building material and cement choice that can play a very important

* Corresponding author. Fax: +39 051 2090322.
E-mail address: maria.bignozzi@unibo.it (M.C. Bignozzi).

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