Pergamon

CEMENT AND CONCRETE RESEARCH

Cement and Concrete Research 31 (2001) 161–162

Discussion

A discussion of the paper "The use of waste ceramic tile in cement production" by N. Ay and M. Ünal☆

John Bensted*, Juliet Munn

School of Crystallography, Birkbeck College, University of London, Malet Street, London WC1E 7HX, UK

Received 10 August 2000

Drs. Ay and Ünal have reported an interesting piece of work in utilising waste-glazed ceramic tile as a pozzolan in cement production with up to 35 wt.% of waste tile production ground in with Portland cement [1]. This use of waste ceramic tiles is environmentally friendly in that the waste tiles do not have to be dumped as an unusable waste material. The heat treatment of the raw clays, feldspars and quartz, fired at 1100–1200°C to produce the tile, destroys the actual crystalline structure of the argillaceous minerals to form an essentially amorphous or disordered aluminosilicate structure, perhaps with some ceramic bonding present.

Partially burnt clays are well-known pozzolans. Probably, the best known such pozzolan is metakaolin, which, when burnt at ca. 450–800°C, gives active pozzolanic properties [2] under optimum calcining conditions. From their composition and structure, the waste-glazed ceramic tiles described should be pozzolanic, at least to some extent.

RILEM-Cembureau tests for pozzolanicity were carried out on Portland cement–waste-glazed ceramic tile compositions and shown to give positive results for the presence of pozzolanicity. Compressive strength measurements were undertaken for up to 28 days. In order to demonstrate unequivocally the full benefits of pozzolanicity, it would have been preferable to carry out further compressive strength measurements at 56 and 91 days, respectively. At these later ages, the full benefits of pozzolanicity in producing additional C-S-H formation are more clearly recognisable. In addition, there did not appear to have been a base "blanket" Portland cement with 0 wt.% addition tested analogously to the Portland cement–waste-glazed ceramic tile combinations. Such additional testing would have been better for both demonstrating and quantifying the pozzolanic effects of the waste tiles in association with Portland cement.

There can be a problem with some laboratory tests based upon experimental methods of reacting calcium hydroxide with pozzolan. Such procedures assume that pozzolanicity is due to the reaction of calcium hydroxide with the pozzolan. In reality, pozzolanicity is actually due to reaction of the pozzolan with alkali hydroxides, which, in reacting with the pozzolanic material, destabilise the calcium hydroxide formed as a product of the hydration of the Portland cement component [3].

Chemical tests for pozzolanicity involving calcium hydroxide and a pozzolan, like the well-known Fratini–Rio test, really depend upon there being sufficient alkali in the pozzolan to activate it for effective hydraulic reaction. If there is insufficient available reactive alkali content in the pozzolan, then the supposed pozzolan is likely to fail such a test. However, if this material is truly pozzolanic in combination with Portland cement (of high alkalinity in water), then compressive strength measurements at 28, 56 and 91 days will indicate (in comparison with the 'blank' Portland cement containing no addition of the supposed pozzolan) whether the material is truly pozzolanic or not, since additional strength giving C-S-H is produced by the pozzolanic reaction.

Due to the high firing temperature for tile production in comparison with the decidedly lower temperature for formation of metakaolin with optimal pozzolanic properties, these waste-glazed ceramic tiles would not be expected to be as actively pozzolanic as metakaolin, due to the likely occurrence of some ceramic type bonding. Nevertheless, acceptable pozzolanicity for gen-

☆ Cem Concr Res 30 (2000) 497–499.

* Corresponding author. Catford, 23 Callander Road, London SE6 2QA, UK. Tel.: +44-20-8-698-9831; fax: +44-20-8-698-9831.

E-mail address: bensted.j@btinternet.com (J. Bensted).

PII: S0008-8846(00)00443-9

eral purpose cement usage (more comparable to the pozzolanicity shown by fly ash) should be given by the ground waster ceramic tiles. After all, metakaolin is roughly midway in pozzolanicity terms between condensed silica fume (microsilica), which is highly active, and fly ash. Although all these materials are pozzolanic, there is in reality no universal mechanism of pozzolanicity. Each pozzolanic type has its own distinctive reaction mechanism [3].

The work carried out by the authors [1] is a valuable contribution to cement technology, whereby such waste tiles can be employed as the pozzolanic component of general purpose Portland pozzolanic cements in an environmentally friendly way. Disposal to landfill of the waste tiles is avoided, and they can be employed in cement manufacture as extenders, thereby saving on the high energy costs of Portland clinker production.

References

[1] N. Ay, M. Ünal, Cem. Concr. Res. 30 (2000) 497–499.
[2] P.C. Hewlett (Ed.), Lea's Chemistry of Cement and Concrete, fourth ed., Arnold Publishers, London, 1998.
[3] J. Bensted, Pfa and the thaumasite reaction, Pfa in Construction Seminar, The Electricity Association, London, 2000, p. 17.