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Discussion

Reply to the discussion by J. Bensted and J. Munn of the paper "The use of waste ceramic tile in cement production"☆

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The authors appreciate J. Bensted and J. Munn's discussion. They have raised a number of useful points that should be addressed.

Pozzolanic properties of ceramic tiles conform to ASTM C618 [1] and TS 25 [2]. ASTM C618 and TS 25 cover the specifications for natural pozzolans set by the ASTM and Turkish standards. In experimental works, the Portland cement into which waste tile was added and the Portland cement with 0% wt waste tile were observed together. Experimental results of Portland cement specimens with 0% wt waste tile addition were between limits of standards. So, the results are not given in the paper; 7 and 28 days compressive strength measurements of these samples are 21 and 32.5 N/mm^2, respectively.

Strength of Portland cement containing a pozzolan increases as it ages [3]. Compressive strength at 56 and 91 days are not measured, because there was an increase at 7 and 28 days strength values of waste tile added Portland cement. As mentioned by Bensted and Munn, 56 and 91 days compressive strength measurements are planned and then results will be published.

The reaction between pozzolan and calcium hydroxide is called the pozzolanic reaction. As stated in standards $Ca(OH)_2$ is used in laboratory testing. Pozzolan particles or surfaces naturally react with alkalies such as Ca^{2+}, K^+, Na^+ and the product of the reaction is C-S-H. If alkali hydroxides excluding calcium react with pozzolan, would there not be different products other than C-S-H? If there is not enough Ca^{2+} in the surrounding, other alkali ions will react with pozzolan and alkali silica gel is the product. The effect of this reaction in cement is different from the pozzolanic reaction [4].

The clay minerals have a crystal structure and in raw form do not posses pozzolonic properties. However, by heat treatment such as calcinating at around 700°C to 900°C, clays become highly pozzolanic. The optimum calcination conditions for kaolinite-type clays are 700°C for 1 h; for illite and montmorillonite type of clays, the optimum calcination conditions are 800°C for 1 h. The most common means of thermal treatment for clays has been to calcine them in rotary kilns. The length of time for calcination is around 1 h, although longer periods, up to 2 h have been used [5].

In the experimental work, ceramic tiles used are fired in roller furnace for 35–40 min (total time between enter and exit). Holding time at 1100–1200°C is very short. Particles are sintered with liquid phase sintering. Liquid phase is a kind of silica glassy phase. According to the XRD investigations, crystalline phase (quartz and sometimes mullit), alkali alumino silicates, and amorphous phase have been determined. Instead of low temperature and long holding time in literature for calcination of clays, high temperature and shorter times are applied while firing tiles. The experimental results showed that tiles have pozzolonic properties.

In conclusion, nowadays tiles are produced mostly in roller furnaces with fast firing. So that, ground waste tiles can be employed in Portland cement.

References

[1] ASTM C 618, Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Porland Cement Concrete, 1994 Annual Book of ASTM Standards.
[2] TS 25, Tras, Turkish Standards Institute, Ankara, Turkey, 1975 (in Turkish).
[3] P.K. Mehta, P.J.M. Monteiro, Concrete, Structure, Properties and Materials, Second ed., Prentice-Hall, New Jersey, 1993.
[4] S. Urhan, Puzolonik Tepkimelerin Kimyasi, T.Ç.M.B. Çimento Bülteni 31 (326) (1992) 10–14.
[5] T.Y. Erdogan, Admixture for Concrete, Middle East Technical University, Ankara, Turkey, 1997.

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