Available online at www.sciencedirect.com

SCIENCE DIRECT®

Cement and Concrete Research 35 (2005) 1868–1869

Cement and Concrete Research

Discussion

Discussion of paper "Alkali–aggregate reaction in concrete containing high-alkali cement and granite aggregate" by Z. Owsiak ☆

P.E. Grattan-Bellew

Institute for Research in Construction, National Research Council Canada, Building M-20, Ottawa, ON, Canada K1A 0R6

Received 31 March 2004

This is an interesting paper in that it reports the occurrence of alkali–silica reaction (ASR) and the formation of secondary ettringite in concrete prisms stored at 38 °C and high humidity. To the best of my knowledge, this is the first report of the occurrence of secondary ettringite in concrete prisms made with an alkali–silica reactive aggregate cured in the laboratory at 38 °C. Lawrence [1] reported that 75 °C was the lowest curing temperature at which expansion due to delayed ettringite formation was reported. However, alkali–silica reaction and delayed ettringite formation are frequently associated in field concretes [2,3] and has also been reported in laboratory steam-cured concrete [3].

The cement used by Owsiak would be classed as a Type I ASTM cement. Scheetz et al. [4] concluded that based on current observations, delayed ettringite should not be a problem in concrete made with cements with typical chemical and mineralogical characteristics of Type I or II cements. On this basis, it is surprising that large amounts of ettringite were observed in the mortar bars made with granite aggregate.

The expansion curve shown in Fig. 2 of the paper does not exhibit the characteristic signature curve associated with

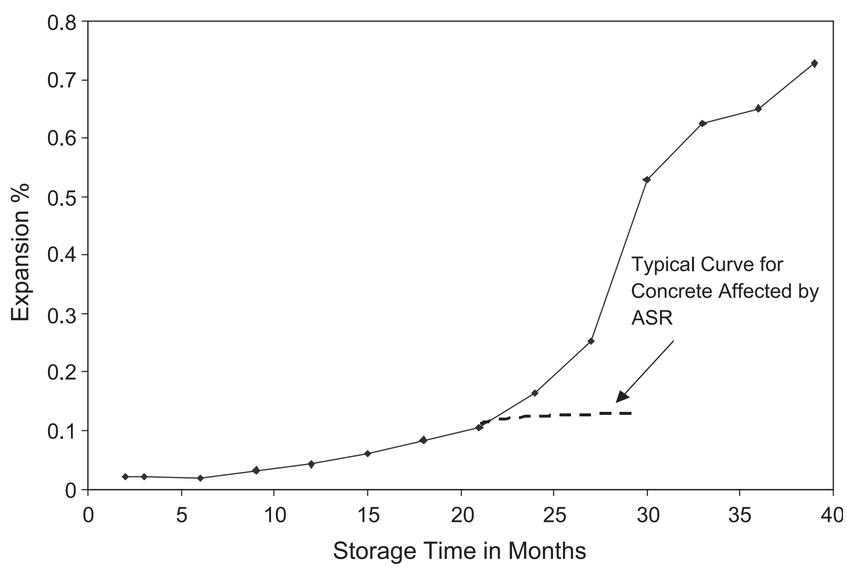

Fig. 1. Expansion curve from Fig. 2 of Owsiak's paper. The dotted portion of the curve shows what a typical expansion curve of concrete affected by a slowly expanding alkali–silica reaction would look like.

☆ Cement Concrete Research 34 (2004) 7–11.

E-mail address: p.grattan-bellew@sympatico.ca.

0008-8846/$ - see front matter © 2004 Published by Elsevier Ltd.
doi:10.1016/j.cemconres.2004.07.028

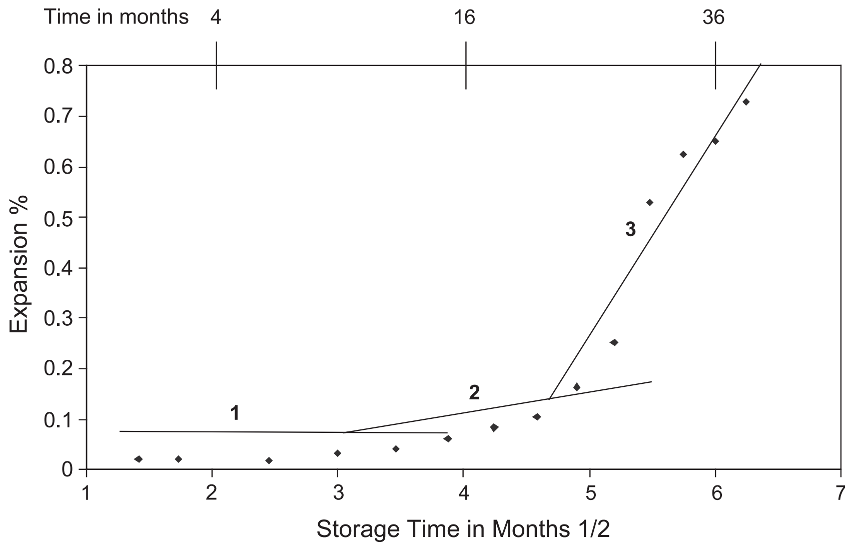

Fig. 2. Expansion curve from Fig. 2 of Owsiak's paper, replotted using the square root of time in months for the *x*-axis instead of time in months. The rates of expansion were obtained from the slopes of the three sections of the graph.

expansion of concrete, made with slowly expanding aggregates, such as granite, and subjected to accelerated curing in the laboratory. A typical expansion curve would show an initiation period of a few months, followed by a period when most of the expansion occurs. This might last between 1 and 2 years. Thereafter, the curve would flatten out. A dotted expansion curve, which would be characteristic of concrete affected by alkali–silica reaction, is superimposed on Fig. 2 of the above paper in Fig. 1.

An expansion curve can be linearized by plotting expansion against storage time expressed as the square root of time (Fig. 2). The graph can be divided into three portions: The first portion, lasting about 9 months, is the initiation period, with a rate of expansion of 6×10^{-3}%/month$^{1/2}$. This is followed by the main expansive phase of the alkali–silica reaction, with a rate of 40×10^{-3}%/month$^{1/2}$. The third phase has a rate of expansion of 440×10^{-3}%/month$^{1/2}$. The latter phase is not characteristic of concrete affected by alkali–silica reaction. This phase probably represents expansion due to delayed ettringite formation, which would lead to the formation of the large amount of ettringite that was observed in the concrete by the author. Assuming that this hypothesis is correct, it is evident that alkali–silica reaction preceded secondary ettringite formation. In an unpublished report, the present author also concluded that, in a case of field concrete, exhibiting evidence of both alkali–silica reaction and delayed ettringite formation, alkali–silica reaction occurred before delayed ettringite formation.

References

[1] C.D. Lawrence, Delayed ettringite formation: an issue, in: J.P. Scalny (Ed.), Materials Science of Concrete, vol. IV, Am. Ceram. Soc., 1995, pp. 113–154.

[2] T.N. Jones, A.B. Poole, Alkalisilica reaction in several U.K. concretes: the effect of temperature and humidity on expansion, and the significance of ettringite development, in: P.E. Grattan-Bellew (Ed.), Concrete AlkaliAggregate Reactions, Noyes Publications, Park Ridge, NJ, USA, 1987, pp. 446–450.

[3] S. Diamond, S. Ong, Combined effects of alkali–silica reaction and secondary ettringite deposition in steam cured mortars, in: E.M. Gartner, H. Uchikawa (Eds.), Cement Technology (Ceramic Transactions), vol. 40, American Ceramic Society, Westerville, OH, 1994.

[4] B.E. Scheetz, D.M. Roy, P.J. Tikalsky, T. Cavalline, Delayed ettringite formation and the influence of cement characteristics, Proc. 11th Internat. Congress on the Chemistry of Cement, Durban, South Africa, 2003, pp. 75–83.