

Identification of alkali-reactive aggregates: some examples

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Alkali–aggregate reactions have been known for decades although the acceptance of their occurrence has been delayed in some countries until the 1990s. Potential reactivity has been identified in most of the rock types used as aggregates around the world. The most common reactive rocks are sedimentary (e.g. opaline sandstone) and metamorphic (e.g. gneiss). However, igneous rocks such as granites have also proved to be reactive in some areas and innocuous in many other regions. It has been concluded that the designation is not enough to label a rock as reactive and that microstructure is very often the determinant factor of reactivity. In the present study a summary is made on the state-of-the-art on alkali–aggregate reactions. Emphasis is given on the identification of potentially reactive aggregates based on petrographic methods. Examples from a large number of samples analysed in the scope of a research project are presented.

1. Introduction

Since the nineteenth century, concrete has been one of the most commonly used building materials. Its manufacture involves the mixture of the binder, coarse and fine aggregates, water for hydration, and additives to control workability and flow properties (EN 206: CEN (2007)). In the early 1900s it was recognised that concrete could deteriorate as a consequence of different mechanisms, affecting the good functioning and the service life of the structures. Alkali–aggregate reaction (AAR) is a deleterious chemical reaction in either mortar or concrete involving the hydroxyl (OH^-) ions associated with the alkalis sodium and potassium from Portland cement or other sources, with certain mineral phases that may be present in the coarse or fine aggregates (RILEM AAR-6.1: RILEM (2013d)) forming an alkali–silica gel which absorbs water and swells (Chatterji, 2005; Dent Glasser and Kataoka, 1981; Diamond, 1989; Garcia-Diaz *et al.*, 2006; Helmuth and Stark, 1992; Hobbs, 1988; Powers and Steinour, 1955). After AAR was observed in the 1930s in California (USA) for the first time, many other cases have been reported worldwide. As an example, AAR was accepted as an issue in the UK in 1971 (BRE, 2004; Sims, 1992), in Germany in 1960, in France in 1976 (Louarn and Larive, 1993), in Japan in 1983 (Nishibayashi *et al.*, 1992). As a generic term, AAR has been subject to several subdivisions. In 1975, Gillott attempted to divide AAR in the following three subcategories taking into account the reactive components involved and the reaction mechanisms (Gillott, 1975).

- Alkali-silica reaction (ASR): reactive constituents include meta-stable silica forms (e.g. opal, chalcedony, cristobalite, tridymite, and acidic volcanic glasses).
- Slow/late-expanding alkali–silicate/silica reaction: fine-grained and strained quartz along with disordered silica forms and phyllosilicates are considered to be the reactive phases in some sedimentary and metamorphic rocks and possibly in granitic rocks.
- Alkali–carbonate reaction (ACR): coarse grain-sized dolomite in dolomitic carbonate rocks is the reactive constituent.

Currently, AAR is considered to be divided into two groups (RILEM AAR-6.1: RILEM (2013d)): ASR and ACR. ASR is regarded as the most common AAR type on a worldwide basis, whereas ACR is much less commonly observed.

In the present study a review was made on the state-of-the-art regarding reactive forms of silica and some examples are presented on the identification of reactive aggregates by petrographic methods.

2. Conditioning factors for alkali–aggregate reaction

There are three requirements for ASR to occur (Fournier and Bérubé, 2000; Hobbs, 1988; Stark, 1981)

- (a) a source of alkalis (controlling the concentration of OH^- ions in the pore solution)