ALKALI-SILICA REACTION; READY-MIXED CONCRETE PRODUCERS' VIEW POINT

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ABSTRACT

The authors briefly discuss positive and negative effects of alkali in concrete. They draw attention to the fact that although the reliability of methods for estimating the possibility of alkali-silica reaction (ASR) is dubious, they are used for rejection of aggregates even when experience in service does not confirm the laboratory evaluation. This results in an unjustified increase in the cost of the projects. One of the possible resolutions of the problem is the setting up of database on ASR in different areas. The database will be used for making decisions on the potential reactivity of aggregates.
Keywords: alkali-silica reaction, concrete durability, ready-mixed concrete.

INTRODUCTION

The problem of ASR appears to be one of the most attractive in the field of concrete durability or even concrete technology judging from the number of publications and conferences held. But the problem is still far from resolution. "Unanswered questions remain", says the 'Guide to Durable Concrete' by the American Concrete Institute (ACI 201.2R-92). Courtier (1990) notes: "After all, he (an engineer) needs a solution now, problem solved - not as a continuing study".

POSITIVE AND NEGATIVE EFFECTS OF ALKALI

Swamy (1992) notes correctly that although aggregates are grouped for deleterious and innocuous, "it might even more realistic to say that perhaps and probably, there are no aggregates that are completely unreactive although they may remain, and appear to be so for a long, long time". Let us say that all alumina and silica aggregates react with alkalis, the difference is only in the alkali (NaOH or KOH) concentration, moisture and temperature conditions.

From the above paragraph, one cannot take the extreme view that all aggregates are deleterious. For instance, all portland cements with or without supplementary cementing materials will deteriorate with time (earlier or later) in sea water under unfavourable temperature conditions especially if this deterioration is accelerated by increasing the concentration of salts in laboratory testing. However, concrete is being used and will be used in marine structures.

Idorn and Roy (1985) report on the advantageous effect of alkalies on the rheology of concrete containing mineral admixtures. They also point out the effect in densifying the microstructure of the cement paste in hardened concrete. Wang and Gillott (1992) demonstrate the similarity of alkali-silica reaction and reaction of silica fume with calcium hydroxide. This also does not mean that engineers should go from one extreme to another by considering ASR as innocuous. In some cases, it results in cracks formation which leads to an increase in permeability, consequent corrosion of reinforcement and deterioration of structures (Mehta 1994).

DEFICIENCY OF TEST METHODS

ASR is a time-dependent phenomenon which could occur often after several decades of good performance (Swamy 1992). The reaction requires accelerated testing methods, to allow the prediction of concrete behaviour, in terms of ASR, in the future. ASTM C 33 [4] says: "A number of methods for detecting potential reactivity have been proposed. However, they do not provide quantitative information on the degree of reactivity to be expected or tolerated in service. Therefore, evaluation of potential reactivity of an aggregate should be based upon judgment and on the interpretation of test data and examination of concrete structures containing the combination of fine and coarse aggregates and cements for use in the new work."

Limitations of existing test methods on ASR are discussed in many different publications (ASTM C 33-93, Bérubé & Fournier 1992, Hooton 1994, Idorn *et al.* 1992, Diamond & Ong 1994, Mehta 1994, Tordoff 1990, others). In our opinion, among major limitations are the following:

- all criteria, which divide aggregates as innocuous and deleterious, are ad hoc and suitable only for types of aggregates within certain geographical regions (Bérubé & Fournier 1992)
- two main tools of acceleration of the reaction, namely, *(a)* an increase in alkalinity by addition of alkali to the mix water (Diamond & Ong 1994) and *(b)* an increase in temperature during specimens storage (Idorn *et al.* 1992 and Tordoff 1990) could result in incorrect evaluation. Diamond and Ong (1994) have found that the addition of alkali to augment alkali content in cements "does not result in the expected augmentation of the OH^- ion concentration, and much or all of the dissolved alkali hydroxide is immediately converted to alkali sulphate by reaction with gypsum." They conclude "that the ability to simulate a high alkali cement by adding alkali hydroxide to a low alkali cement are illusory." When the testing is carried out at elevated temperatures, Tordoff (1990) notes that "at the higher temperature the viscosity of the gel is lower and results suggest that this increased mobility more than offsets the increased tendency to crack induced by the more rapid rate of reaction."

HOW THE PROBLEM OF ASR IS BEING RESOLVED IN PRACTICE

Unfortunately, ASR confuses many engineers. They worry less about carbonation of concrete containing fly ash and slag or sulphate resistance of piles made from straight cement concrete (although sulphate attack is always deleterious in contrast to ASR) than they do about ASR. To resolve this problem they are satisfied with results of test methods which very often give an unreliable estimate. Sometimes, they are so *diligent* that they specify monthly testing on ASR. One wonders what they would do if in one month aggregate failed to be assessed as innocuous but the concrete had been already placed.

ADDITIONAL EXPENSES HAVE TO BE JUSTIFIED

Gerwick (1994) notes correctly that additional expenses could be needed for enhanced durability of major concrete structures. But this cannot lead to the conclusion that society is willing to spend any amount of money or just more money. Additional expenses have to be justified. Engineers, should evaluate:

- the consequences of the rejection of aggregates only on the basis of laboratory testing (whereas the field experience with this aggregate does not show problems) and increase in the cost of the project due to aggregate cartage from another source
- the consequences of the restrictions on alkali content in cements when supplementary cementing materials are used
- whether it is worth introducing additional frequency of testing for ASR and what to do with these results

etc.

We, engineers, have to be responsible to society for our decisions.

RECOMMENDATIONS

Since the test methods for the evaluation of potential reactivity have limitations, attention should be given to the detection of ASR in structures in service. The authors propose the organisation of a Commission on ASR under the jurisdiction of local concrete institutions (for instance, in Australia, the Concrete Institute of Australia) which will record (through consulting engineers, authorities and the concrete industry) and analyse cases of ASR in different areas of the country. This will help to systematise the cases of ASR, to establish relationships and to find out the most dangerous combinations. It is understood that the definite prediction of ASR in future structures on the basis of evaluation of ingredients and service conditions is subject to different opinions but in the case of recorded deteriorations in structures in service, ASR can and must be determined explicitly. Of course, judgement of new sources can only be made on the basis of laboratory testing (Shayan 1991).

When a decision to reject aggregates (which have been used in concrete for some years) in terms of potential ASR has been made only on the basis of laboratory results, engineers should submit evaluations of other solutions and prove that this is the cheapest one. Generally speaking, this approach should relate to all engineering decisions.

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