Alkali-Silica Reaction

Summary

When reactive aggregates have to be used in construction, the addition of Elkem Microsilica is a way of reducing or eliminating the expansion caused by alkali-silica reaction (ASR, also sometimes called AAR – Alkali Aggregate Reaction) in concrete. ASR is a process whereby alkali silicate gel forms and afterwards expands on absorption of water. This expansion may cause crack formation throughout the entire volume of concrete. In recent years increasing attention has been given to problems associated with ASR. This is due to a number of instances of ASR attack and the identification of reactive aggregates in many countries.

Alkali-silica reactions

ASR is a reaction between alkalis, Na_2O and K_2O (found in cement or added to the concrete), and reactive, siliceous mineral components of the aggregates. There has to be moisture present in the concrete in order for the reaction to take place. The reaction product is an alkali-silicate gel which on absorption of water will expand and generate hydraulic stresses which may cause cracking. (Figure 1).

For ASR to take place requires:

- High alkali content of the concrete, normally contributed from the cement, i.e. the cement has to contain a sufficiently high level of alkalis. An upper limit of 3 kg of Na_2O-equivalent per m^3 is often given in the literature as sufficient to prevent attack.
- Access to moisture, minimum 75% RH is required.
- Other factors which will affect the ASR attack include the amount of reactive aggregates and the grain size of the aggregates.

Elkem Microsilica will suppress ASR as follows:

- Elkem Microsilica will bind free alkalis early, already in the fresh or plastic concrete. (Figure 2).
- Elkem Microsilica will reduce the permeability of the concrete and thus limit the penetration of moisture or external alkalis.
- Elkem Microsilica allows a reduction in the cement content without affecting the strength of the concrete, thus the alkali contribution from cement can be reduced.

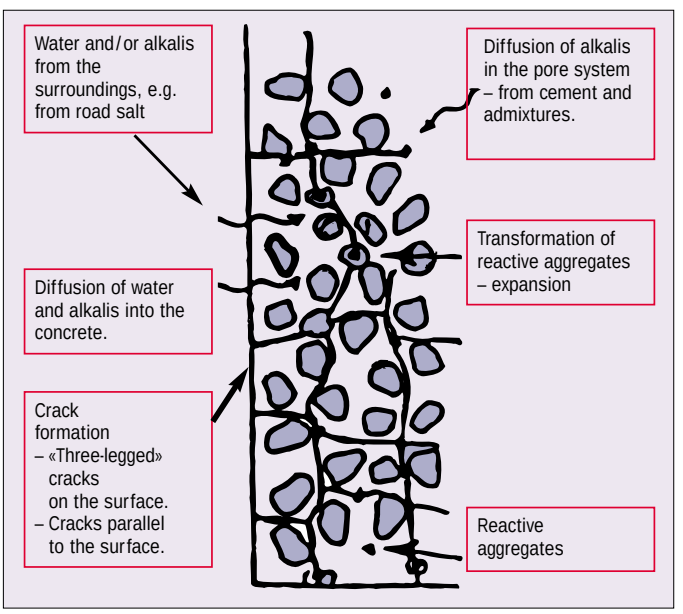

Fig. 1 Schematic diagram of ASR attack. From reference (1)

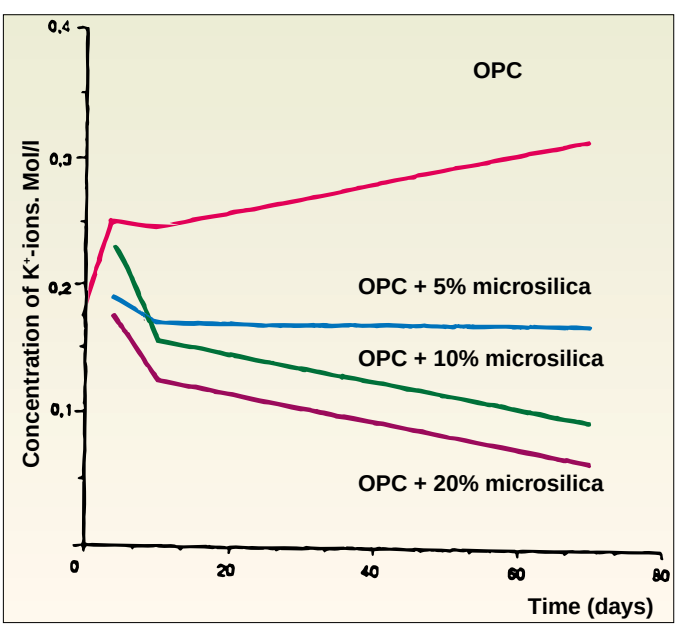

Fig. 2 Effect of microsilica on the alkali content in cement paste. From reference (4)

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Conclusions

The use of Elkem Microsilica will help to suppress ASR when added at a rate of 5 to 15 % of the cement weight. (Figure 3).

A prime example of using microsilica for ASR protection is Iceland, where the entire production of cement contains 7 to 10 % microsilica in order to reduce the ASR attack caused by the combination of highly reactive natural aggregates and local high alkali cement. (Figure 4).

Trial mixes to determine the necessary level of microsilica addition are recommended.

References

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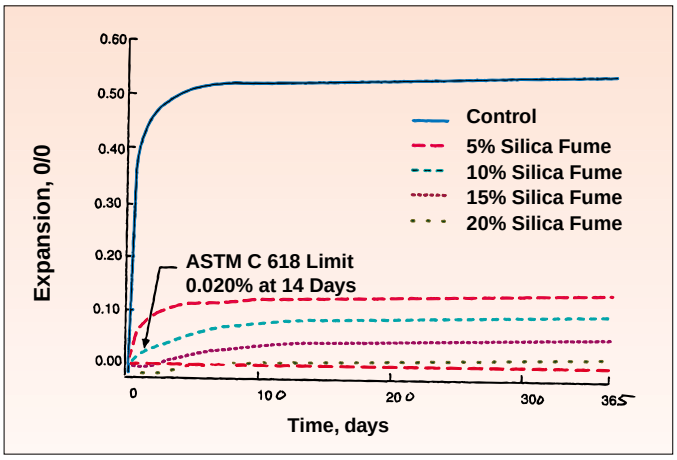

Fig. 3 Expansion of ASTM C 441 Pyrex mortar bars with various silica fume contents. The alkali content of the control cement was 1.17% Na_2O equivalent (adapted from Hooton, 1993)

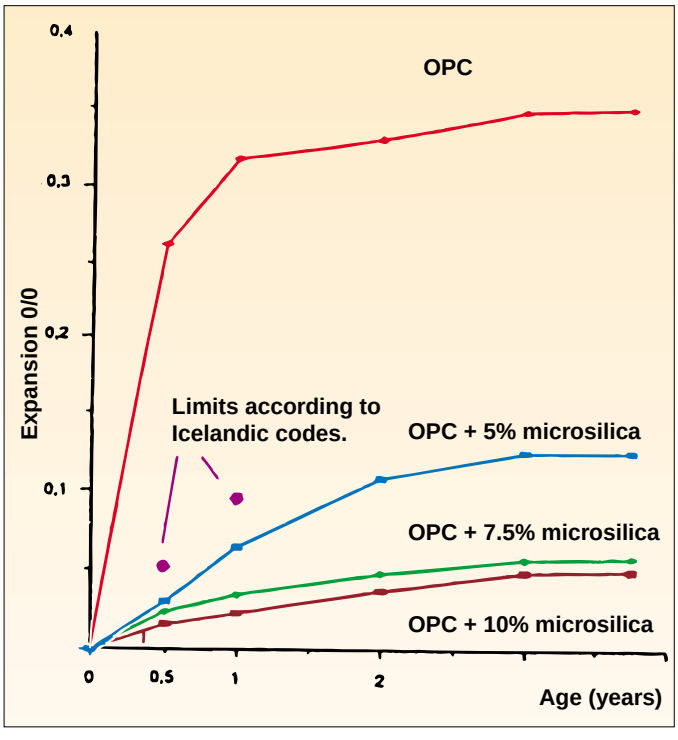

Fig. 4 Expansion in mortar prisms with Icelandic standard Portland cement and Hvalfjord sand. Based on ref. (2)

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