

## Mechanism of Alkali-Silica Reaction and Expansion

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(Summary by AALBORG PORTLAND)

### SUMMARY

Professor Sidney Diamond reported on the existing knowledge of the reaction mechanisms, referring to his article »Mechanism of Alkali-Silica Reaction and Expansion«, which is to be published in Journal of ACI.

1. Alkali-silica reaction depends primarily on the pH-level, i.e. the  $\text{OH}^-$  - concentration and not the  $\text{Na}^+$  - or  $\text{K}^+$  - concentration (cf. Vivian).
2. The physical properties of the gel forming depend, however, on the  $\text{Na}^+/\text{K}^+$  - concentrations (swelling mechanisms).
3. pH in the pore fluid of concrete may vary from 12.5 (corresponding to saturated calcium hydroxide) up to 13.3. This variation corresponds to an alteration of the  $\text{OH}^-$  - concentration from 0.04 N to 0.30 N. It seems likely that there is a reaction threshold in the pH-value.

S. Diamond is looking for a suitable method of isolating pore fluid from both fresh and hardened concrete.

4.  $\text{Na}^+/\text{K}^+$  is present in cement partly as sulphates and partly as impurities in clinker minerals. The sulphates dissolve rapidly but do not increase pH effectively (sulphates are neutral salts, but increase the solubility of calcium hydroxide, partly by an ordinary ion strength effect and partly by binding of sulphate ions in hydration products.) On the other hand, Na/K bound in clinker minerals dissolve slowly, but increase pH effectively. The total effect will depend on the w/c-ratio.
5. The various types of reactive aggregate may well look much alike - they are built up of small crystals (d approx. 300 Å), surrounded by a pore system that may be partially or totally filled up with amorphous silica. The solubility of  $\text{SiO}_2$  depends on pH. The amorphous silica will be rapidly dissolved, so that the attack occurs through the pore system. These conditions do not apply to pyrex glass.
6. The swelling of the formed gel is the deleterious process. It is related to osmosis, but does not require an intact membrane. The mechanism creating the pressure is osmosis, but the pressure is mechanical, not osmotic.
7. The reaction need not result in expansion. For example, expansion will not occur in a »dry«, porous system, or if the quantities of reactive aggregate and/or Na/K are too big or the size of the reactive aggregate is reduced. The boundary value for this diameter was previously specified as 300 mesh (53  $\mu\text{m}$ ), but investigations have established expansion with aggregate sizes right down to 20  $\mu\text{m}$ .
8. Expansion can be prevented by the use of low-alkali cement, pozzolans or the addition of lithium salts (and perhaps barium salts).