The alkali-silica-reaction is a chemical reaction between silicon dioxide in concrete aggregates and alkali hydroxide in the concrete pore solution. The resulting alkali silicate gel has an expanding effect and can lead to concrete damage. Silicon dioxide dissolves in strong hydroxide solutions. The speed of this process depends on the crystalline state of the silicon dioxide and on the type of hydroxide solution.

There are no absolutely inert aggregates. All aggregates react with the hardened cement paste to a greater or lesser extent. The solubility of silicon dioxide depends on the pH value, temperature and crystallinity of the SiO₂ modification. While the increase in the solubility of crystalline SiO₂ (quartz) is approximately linear as the pH value rises, a disproportionate increase is seen in the pH value range of 10 – 14 with amorphous SiO₂, which is found in stone containing opal (e.g. flint, opal stone). The pH value of the pore solution in concrete or mortar is between 12.5 and 14 due to alkalis, and causes the increased solubility of the silicon dioxide.

Osmotic pressure developed by the viscous alkali silicate gel causes the actual damaging process of the alkali-silica-reaction (also known as “concrete cancer”). Swelling pressure up to 20 N/mm² may develop, significantly exceeding the centric tensile strength of concrete and thereby leading to concrete cracks and spalling.

Signs of expansion are only seen in compact concrete. In porous concrete on the other hand, the swelling pressure caused by the gels is dissipated through the pores.

In 1982-1984 as the founding years of Dennert Schaumglas GmbH (renamed to Dennert Poraver GmbH in 1988), the alkali-silica-reaction was analysed in detail since experts were asking for scientific studies to confirm the safe use of Poraver expanded glass in cement-based systems.

The German Centre of Competence for Construction (Deutsches Institut für Bautechnik DIBt) in Berlin, Germany also requested extensive studies to approve the use of Poraver® in concrete, since it was known that glass in concrete can cause damage due to the alkali-silica-reaction.

Under the leadership of Professor Dr. Wierig, the Institute for Material Research at Hanover University conducted a comprehensive series of tests. These were summarised in the study reports of 8 November 1982 and 30 May 1985 (long-term tests up to 3 years were taken into account here).

In 1996 the Bauhaus University Weimar, Faculty of Civil Engineering under the leadership of Professor Dr. Stark also conducted extensive studies of the alkali-silica-reaction after the separating agent in the production of Poraver® expanded glass granulate was changed from powdered limestone to kaolin. All studies at Weimar University are summarised in the research report dated 4 November 1996.
**INFLUENCE OF EXPANDED GLASS GRANULATE ON THE ALKALI-SILICA-REACTION**

Use of Poraver® expanded glass in cement-based systems

### SUMMARY OF TESTS

Production of 10 test mixtures (9 of them with high structural density and one porous) with various Poraver® grain sizes and cement content between 200 and 600 kg/m³. Highly alkaline sodium hydroxide (NaOH) was added to some mixtures in order to increase the pH value. In comparative mixtures, Duran glass pieces were used as aggregates in concrete.

In addition to normal storage conditions with 20°C and 65 % relative humidity, storage at 30°C and 95 % relative humidity which promotes the alkali-silica-reaction was chosen, as well as changing storage conditions. After a period of 7, 28, 56, 90, 120, 150, 180 and 360 days, the following measurements were taken on the test specimens:

- Solidity, ultrasonic transmission time, carbonisation, tensile tests and visual inspections, also using a microscope.
- The characteristics of Poraver® were examined according to DIN 4226 (lightweight aggregates) as well.

### RESULTS

Poraver® expanded glass meets all requirements of the DIN 4226 (after 2002: DIN EN 13055) standard for lightweight aggregates.

**After an observation period of up to 3 years, signs of expansion which are characteristic for the occurrence of a damaging alkali-silica-reaction were not seen in any cases. No hairline cracks, edge spalling, drops of gel or other peculiarities were noted either.**

On prisms produced under otherwise identical conditions with Duran glass as aggregates on the other hand, significant signs of expansion were noted.

The development of solidity (bending tensile strength and compression strength) was also tested on the mortar prisms and concrete cubes with Poraver® expanded glass granulate, and the ultrasonic transmission time was measured. Based on the results, one can conclude that there are no internal structural changes or loosening related to the storage time.

### CONCLUSION

All of the studies that were conducted provide scientific proof that Poraver® expanded glass granulate is suitable as an aggregate for mortar and lightweight concrete.

Around 625,000 tons of Poraver® – corresponding to more than 2,000,000 cubic metres – were produced from 1984 to 2014, and used with absolutely no damage, mainly in cement-based products such as mortar, plaster, concrete or adhesives.

### CONTACT

**DENNERT PORAYER GMBH**
Mozartweg 1, 96132 Schlüsselfeld
Phone +49 9552 92977-0, Fax +49 9552 92977-26, E-mail info@poraver.de

www.poraver.com