

## The central tower of the cathedral of Schleswig - New investigations to understand the alcali-silica reaction of historical mortars

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The damaging alcali-silica reaction leads to crack-formation and structural destruction at numerous, constructed with cement mortar, buildings worldwide.

The ASR-reaction causes the expansion of altered aggregates by the formation of a swelling gel. This gel consists of calcium silicate hydrate (C-S-H) that increases in volume with water, which exerts an expansive pressure inside the material.

The cathedral of Schleswig is one of the oldest in northern Germany. The first church was built in 985-965. The Romanesque building part was erected around 1180 and the Gothic nave at the end of the 13th century. The central tower was constructed between 1888 and 1894 with brick and cement mortar. With 112 meters, the tower is the second-largest church spire of the country of Schleswig-Holstein in northern Germany. Due to the formation of cracks and damages from 1953 to 1956 first restoration works took place. Further developments of cracks are making restoration necessary again today.

For developing a suitable conservation strategy, different investigations were done. The investigation included the determination of the pore space properties, the hygric and thermal dilatation and mercury porosimetry measurements. Furthermore, the application of cathodoluminescence microscopy may give information about the alteration process and microstructures present and reveal the differences between unaltered and altered mortars. An obvious relation between the porosity and the swelling intensity could be detected. Furthermore it becomes apparent, that a clear zonation of the mortar took place. The mortar near the surface is denser with a lower porosity and has a significantly lower swelling or dilatation.