

## CONCRETE DETERIORATION – FORMATION CONDITIONS TRACED BY CRYSTAL WATER OF SULFATE MINERALS

Thaller, D.<sup>1</sup>, Mittermayr, F.<sup>1,2</sup>, Baldermann, A.<sup>1</sup>, Fischer, R.<sup>3</sup>, Leis, A.<sup>4</sup> & Dietzel, M.<sup>2</sup>

<sup>1</sup>Institute of Applied Geosciences, Graz University of Technology, Rechbauerstraße 12, 8010 Graz, Austria

<sup>2</sup>Institute of Technology and Testing of Building Materials, Graz University of Technology, Inffeldgasse 24, 8010 Graz, Austria

<sup>3</sup> Institute of Inorganic Chemistry, University of Technology, Stremayrgasse 9/IV, 8010 Graz, Austria

<sup>4</sup>RESOURCES – Institute for Water, Energy and Sustainability, Joanneum Research, Elisabethstraße 18/2, 8010 Graz, Austria

e-mail: daniel.thaller@student.tugraz.at

Concrete damage caused by secondary formation of hydrous sulfate minerals (e.g. thaumasite, ettringite and gypsum) may cause serious problems concerning the durability of concrete structures. Cracking due to volume dilatation and disintegration of CSH-phases significantly reduces the overall lifespan of affected structures, whereby high costs for servicing and renovation are incurring. Despite numerous reports, detailed knowledge of the reaction mechanisms and conditions for the formation of hydrous sulfate minerals in concretes is still lacking (NEVILLE, 2004).

In a recently performed study in Austrian tunnels damaged concrete was identified as a consequence of the thaumasite form of sulfate attack (TSA) (MITTERMAYR et al., 2013). The severe concrete damage was shown to be caused by a highly dynamic system of drying and wetting cycles by applying a multiproxy approach. Evaporation of interstitial solutions loaded by ground water has led to a massive increase of SO<sub>4</sub> concentration which triggered the formation of sulfate hydrate minerals.

For the present study the above described damaged concrete material containing thaumasite Ca<sub>3</sub>Si(OH)<sub>6</sub>(CO<sub>3</sub>)(SO<sub>4</sub>)•12H<sub>2</sub>O and gypsum CaSO<sub>4</sub>•2H<sub>2</sub>O was used. A novel approach by extracting the crystal water and analysing its isotopic signature is used to discover their formation conditions. The crystal water was extracted via a cold trap attached to a Schlenk line setup. δ<sup>2</sup>H and δ<sup>18</sup>O were measured by wavelength scanned cavity ring-down spectroscopy. As internal standards lab-synthesized gypsum and ettringite (Ca<sub>6</sub>Al<sub>2</sub>(SO<sub>4</sub>)<sub>3</sub>(OH)<sub>12</sub>•26H<sub>2</sub>O) were used.

The crystal water from 5 damaged concrete samples was successfully and quantitatively recovered. The δ<sup>2</sup>H and δ<sup>18</sup>O values yielded in -57.1 ±4.0 and -3.4 ±1.0 ‰, respectively. Compared to the average value of the local ground water (δ<sup>2</sup>H = -83.0 ‰; δ<sup>18</sup>O = -12.0 ‰) a significant discrimination of the light vs. heavy isotopes was found in the crystal water (MITTERMAYR et al., 2013). Ultimately evaporation degrees of highly concentrated SO<sub>4</sub> interstitial solutions (5000 up to 50000 mg L<sup>-1</sup>) can be validated from isotopic composition of crystal water tracing the individual formation conditions of damaging sulfate minerals.

MITTERMAYR, F., BALDERMANN, A., KURTA, C., RINDER, T., KLAMMER, D., LEIS, A., TRITTHART, J., DIETZEL, M. (2013): *Cem. Concr. Res.*, 49, 55-64.

NEVILLE, A. (2004): *Cem. Concr. Res.*, 34, 1275-1296.