

1 Alkali-silica reaction as one example of chemical reaction in building materials

Chemical reactions between corrosive media and porous material take place on the material surface as well as in the interstice volume.

Damage on buildings



pedestrian bridge: built up 1976 broke down 2012

Alkaline concrete pore solution reacts with SiO₂ in several aggregates. The reaction product, a gel can damage the concrete concerning to its volume.

Process:

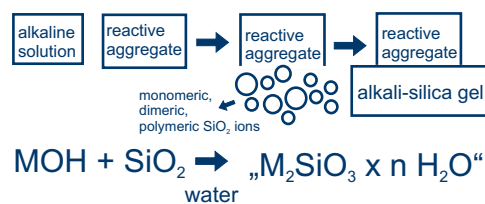


Fig. 1: Alkali-silica reaction (asr) in concrete causes cracks and loss of durability.

Testing methods

The only way to predict the lifetime of building materials are usually costly and time-consuming experiments.



Fig. 2: Specimen to investigate the asr potential for suspicious buildings

Measuring the strain of concrete prism is one method to predict the durability of concrete due to asr.

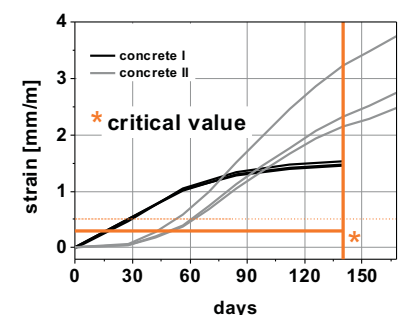


Fig. 3: Results of testing two different kind of concrete mixtures

2 Numerical Simulation of damages on building materials by corrosion processes

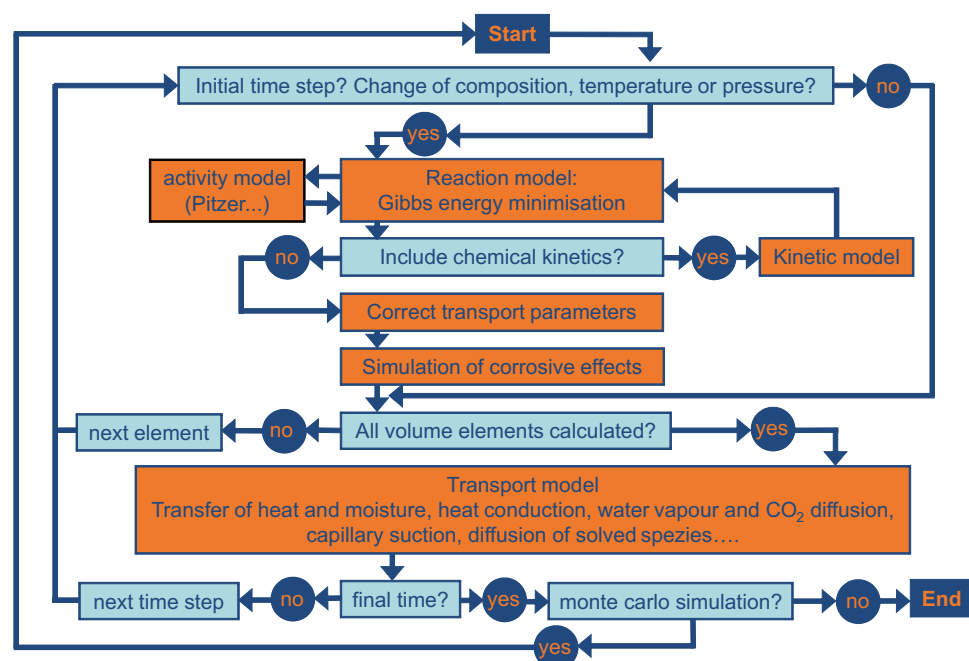


Fig. 4: Basic structure of the simulation model

The software TransReac is a versatile instrument for the numerical simulation of corrosion in porous building materials.

It is based on a reaction model (Gibbs Energy Minimization) and a transport model combined with a numerical simulation, incremental in time and space.

$$G^{P,T} = \sum_i^N (\mu_s^{P,T} + R \cdot T \cdot \ln(x_i \cdot \gamma_i))$$

4 Results

How much silica dissolves in an alkaline solution out of aggregate?

corrosive media: alkaline solution
concrete pore solution
KOH pH 13

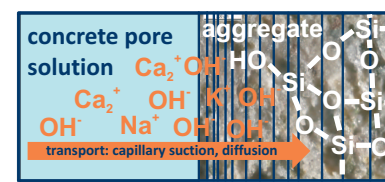


Fig. 5: 1D model (alkaline solution attacks aggregate)

porous material: silicious aggregate
sandstone
greywacke

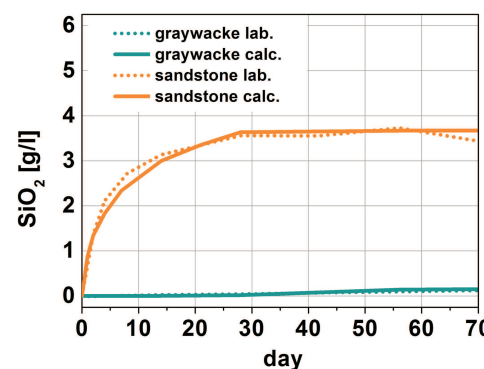


Fig. 6: Comparison of calculated dissolution of silica in two different aggregates (greywacke and sandstone) with experimental results of dissolution test methode

3 Variables

Material parameters based on literature and database

- Pitzer parameters
- thermodynamic data

- kinetic parameters

Boundary conditions

- temperature
- time

Experimentally determinated material parameters

- material composition
- Porosity
- ion diffusion coefficients

- In future numerical simulation of asr can supply and partly replace corrosion experiments in laboratory.

Acknowledgement

The project is founded by the DFG and the experimental results of the dissolution test were obtained by the group of Prof. Hüniger (Cottbus).