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Introduction

To investigate the hydration mechanisms of cement or mortars samples, not only the solid phases but also the pore solution have to be analyzed well. Before setting, cements have a plastic consistency and the pore solutions are obtained by using an air pressure filtration device.

After setting high compressive pressure has to be applied to "squeeze out" the remaining pore solution. For that purpose this press (Fig. 1), which is able to apply forces up to 5000 kN, is used to obtain the pore solutions of hardened cement or mortar samples. Depending on the cement chemistry and the water to cement ratio, pore solutions can be obtained up to hydration times of 1 to 3 years.

Relevance for Our Field

If kinetics are disregarded, there is always an equilibrium between the ions in the pore solution and the solid phases, which is correlating to the solubility products of the cement phases. For kinetic reasons these equilibrium conditions never really occur, but the concentrations of the elements in the pore solution are above or below the equilibrium. By comparing measured concentrations with theoretically calculated data indicates if the solution is over- or undersaturated with respect to a certain solid phase and if this phase is thus about to be precipitated or to be dissolved. Consequently a change in the assemblage of solid phases can be predicted.

Measurement Principle

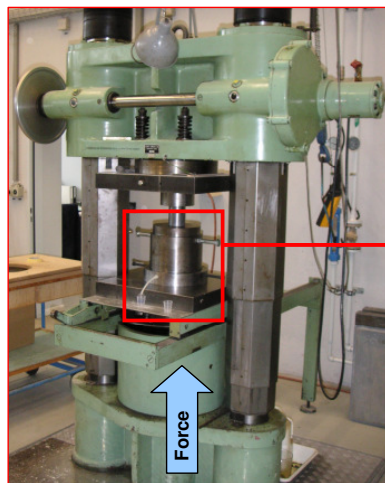


Fig. 1: Pore solution press

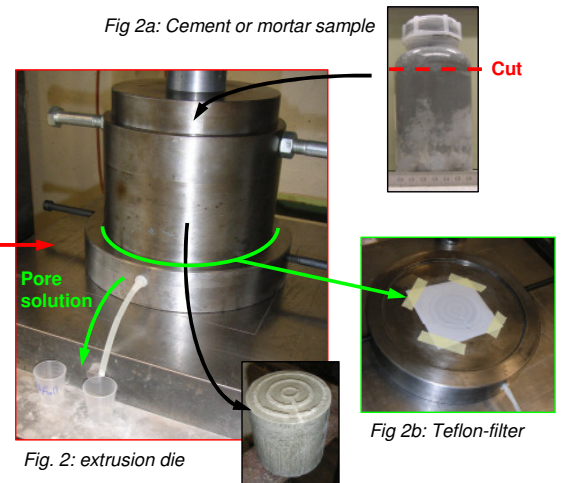


Fig. 2: extrusion die

Fig 2c: "squeezed out" cement sample

Measurement:

- Fix Teflon-filter at the bottom of extrusion die (Fig. 2b)
- Cut the head of the sample and remove the flask (Fig. 2a)
- Assemble extrusion die and put cement cylinder inside (Fig. 2)
- Use Proteus Software to slowly increase pressure
- Filtrate pore solution with syringe nylon filters (0.45 μm) before chemical analysis

Example

Analysis of the extracted pore solution by chemical analysis (e.g. ion chromatography):

- ➔ concentration of elements in pore solution (Fig. 3)
- ➔ calculation of degree of over- / undersaturation (saturation indices)
- ➔ Saturation indices show degree of saturation of the pore solution with respect to a certain solid phase:
 - saturation index > 0: Precipitation of solid phase
 - saturation index < 0: Dissolution of solid phase

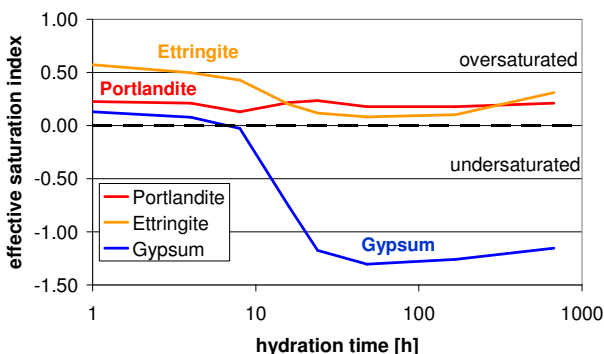


Fig. 4: Calculated saturation indices of a Portland cement pore solution during the first 28 days.

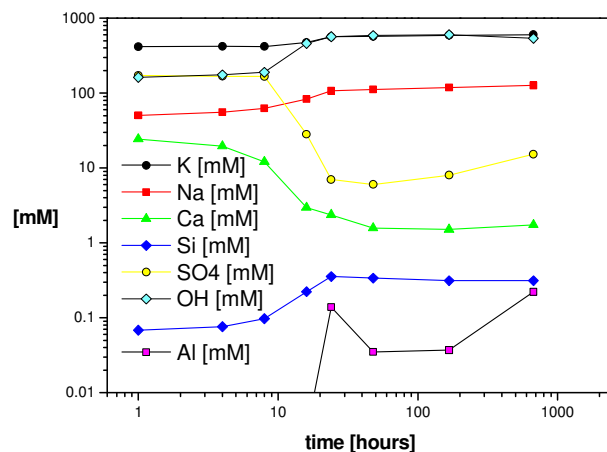


Fig. 3: Element concentrations of a Portland cement pore solution during the first 28 days.

Applications & Potentials

- Extrusion of pore solution of hardened cements and mortars even at old ages
- Chemical analysis of the pore solution
- Comparison of measured concentrations with theoretically calculated data
- ➔ Calculation of over- / undersaturation with respect to a solid phase

Limitations

- Amount of pore solution:
After some years the cement is so mature that no more pore solution is left
- Applicable pressure:
The applied force should not exceed 2500 kN, because the extrusion die might get damaged