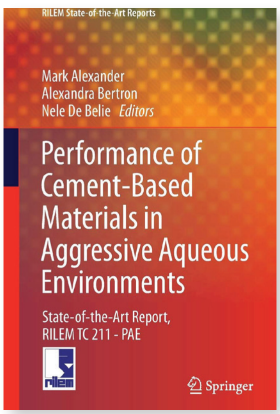
# RILEM UPDATE

The following "STAR in a Nutshell" is a brief overview of the contents of the State-of-the-Art Report (STAR) of RILEM Technical Committee 211-PAE, "Performance of cement-based materials in aggressive aqueous environments" (2013) Alexander M., Bertron A., De Belie N. (Eds.), Springer. The purposes of this "STAR in a Nutshell" is:

1. to provide some initial guidance to a non-expert reader,
2. to inspire more comprehensive reading of the STAR,
3. to clarify the relevance of the contents before downloading the full STAR for further details (https://www.springer.com/gp/book/9789400754126).

## STAR in a nutshell 211-PAE
## "Performance of Cement-Based Materials in Aggressive Aqueous Environments"




Concrete is a multiphase, porous, strongly basic material. The pH of the interstitial solution is approximately 13 which is beneficial and essential to protect embedded steel from corrosion. The characteristics of the pore network, dimensions (usually between $10^{-9}$ and $10^{-5}$ m) and connectivity of the capillary porosity determine the transfer of aggressive species inside the matrix. In the case of aqueous environments, the main form of degradation relates to the alteration of the hydrated cement compounds due to ion exchanges, additions, or substitutions. The chemical reactions and physical mechanisms lead to a breakdown of the matrix microstructure and weakening of the material.

All aqueous solutions should be considered aggressive to cement-based materials, from pure (ion-free) waters (leading to leaching) to highly saline solutions (leading to ion addition and exchange reactions). Here, the emphasis is on the following groups of aggressive agents: 1) sulfates, 2) magnesium, 3) pure waters and strong acids, 4) ammonium nitrate and 5) organic acids.

1) External sulfate attack (ESA) often arises from an increased sulfate concentration in the service environment. The effects of the chemical reactions between sulfate and solid hydration compounds of cement is generally the formation of expansive products that lead to cracks.

2) The attack by the magnesium ion is particularly noteworthy, as it can cause a complete disintegration of the C-S-H in the long term. Damage in real structures manifests in the form of loss of adhesion and strength, rather than expansion and cracking that is commonly observed in laboratory tests.

3) Highly alkaline Portland cement is easily attacked by pure water and acidic solutions. The degradation is due to the leaching of cementitious materials, resulting in higher porosity and loss of strength.

4) Even though ammonium nitrate, a commonly used fertilizer, may cause severe degradation in fertilizer factories or in storage silos, it still represents a very scarce risk for concrete structures. Ammonium nitrate is actually used in laboratories to simulate leaching in accelerated conditions.

5) The metabolism of the micro-organisms in the effluents from agricultural and agrofood industries produces organic acids, whose attacks are of variable intensity but cause the progressive deterioration of concrete together with the formation of biofilms on its surface.

A fully coupled thermal-hydro-mechanical (THM), multi-ionic chemical model involves numerical and computational efforts that are challenging. Some RILEM Technical Committees are currently focusing on these aspects.

There are degrees of arbitrariness in turning the theoretical information about aqueous attacks into specifications or codes for practical purposes. The engineering community is still awaiting reliable tests for many concrete durability properties for performance prediction, mathematical models of deterioration that can be applied in practice, and a probabilistic approach to durability design.