

Numerical simulation of the effect of creep on the phase's changes in concrete due to seawater exposition

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Abstract:

Seawater attack on concrete structures is a complex phenomenon due to the presence of multiple ions in seawater (such as sodium, chloride, magnesium, sulfate and calcium). A competition between two opposing phenomena (expansion/degradation and formation of protective layers) takes place¹. Each ion participates in the deterioration or the protection of the structure leading to a change in the phases² present in the cement paste.

Also, offshore structures are submitted to a sustained mechanical load which leads to creep deformations. The coupling with the chemical degradation is not well understood. Experimental tests need the development of specific devices and the analysis of the degradation can be done after the chemo-mechanical tests.

With the objective to follow the degradation during the test, the purpose of this study is to numerically simulate the effect of creep on the phase's changes in the cement paste due to the seawater chemical attack. The complexity and the originality of this model reside in the coupling of multiple phenomena at one time like the hydration process, the creep mechanism and the seawater attack which represents a coupling between multiple chemical reactions.

Simulations are done using the hydration code CemPP³, developed at GeM Centrale Nantes, and the finite element code Cast3M. Therefore a chemically attacked structure is submitted to a sustained load. Each phase formed or transformed is studied alone and creep is applied. The results of the creep effect on each phase formed and transformed show that the global creep on the material is highly dependent on the local creep in each phase; some of them have a high visco-elastic response while others have a negligible deformation. These results show that it is necessary to design concrete with cement paste which can be modified chemically with a large part of resistant products.

¹ Guillon E, Moranville M. (2004). *Physical and chemical modeling of portland cement pastes under seawater attack*. Cachan, France.

² De Weerd K, Justnes H, Geiker MR. (2014). *Changes in the phase assemblage of concrete exposed to sea water*. Cement and Concrete Composites.47:53-63.

³ Hilloulin B, Hilloulin D, Grondin F, Loukili A, De Belie N. (2016). *Mechanical regains due to self-healing in cementitious materials: Experimental measurements and micro-mechanical model*. Cement and Concrete Research. 80:21-32.