P15: Validation of modeling with respect to drying and shrinkage

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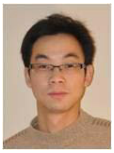


A native of China, Xiaomeng WANG got his Ph.D. in Structures and Materials from the Université Paris-Est in France in 2012. He started to work at Sika Technology AG / EPFL in October 2012.

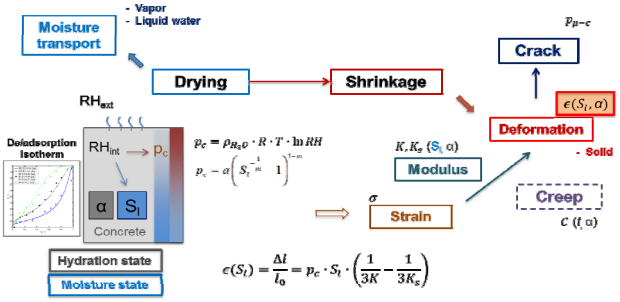
Project description

Context

Moisture transport in concrete can lead to severe hygral deformation and may even cause cracking. This compromises durability of concrete and is therefore highly undesired. Better knowledge on the basic mechanisms determining hygral volume stability of concrete will help developing efficient strategies for mitigation of excessive deformation and cracking. Project 15 (theme C) aims at utilizing and validating of models for water transport developed in "theme A projects" in systems where Shrinkage and Cracking upon shrinkage is notable.

Objectives

- Stage 1: Predictive modeling of shrinkage and cracking based on a set of empirical data linking degree of hydration(α) and partial saturation (S_l) of mortar to its mechanical properties (p_i).
- Stage 2: Use results of theme A&B projects for predictive modeling

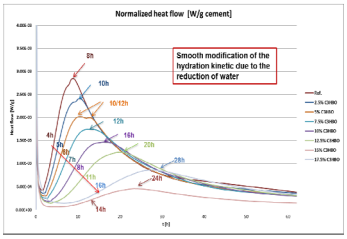


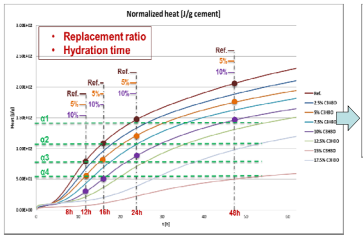
Project results

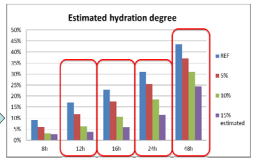
Method for assessing early age material properties through solvent replacement

- In order to assess a comprehensive $p_i(\alpha, S_l)$ data set, cement hydration has to be stopped and partial saturation adjusted prior to the tests for mechanical and transport properties. This is a delicate task especially during early age cement hydration.
- Conventionally, to stop hydration, water is removed from hydrating cement performing solvent exchange after certain time of curing. In this project we replace water by isopropanol *before mixing,* which limits the degree of hydration of the system through limited availability of water.

Influence of the water-isopropanol replacement on hydration kinetics



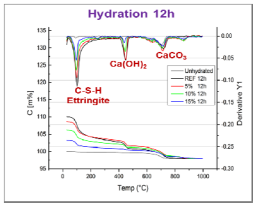


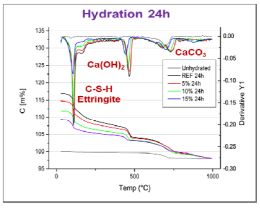


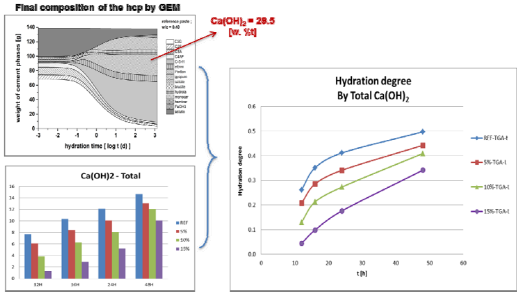
Representative combinations:
Isopropanol: {0%, 5% 10% 15%}
Curing time : {12h, 16h, 24h, 48h}

- Replacement of water by isopropanol lead to minor hydration heat due to the reduction of the hydration reactions, corresponding to equivalent lower hydration degree.

Estimation of hydration degree







What I am planning to do for the remaining time

Measurement of mechanical and transport properties

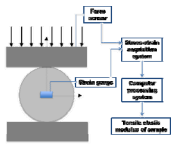
Stop hydration at desired hydration degree → **Humidity conditioning to desired saturation degree** → **Mechanical and other tests**

Replacement of water by isopropanol

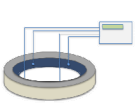
- Influence of the isopropanol on the microstructure by SEM and continue XRD on paste samples.
- Efficiency of the water-isopropanol replacement in mortar by Calorimetry.

Replacement of cement by inert solid

Brazilian test



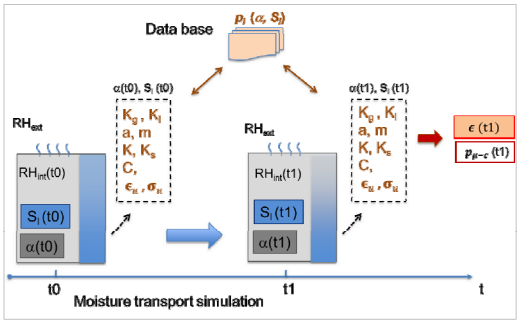
Restrained steel ring test



Measurement of the moisture transport properties

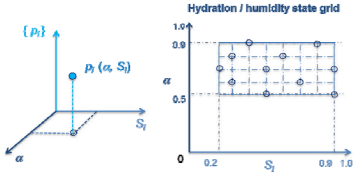
FE Analysis of the drying-shrinkage process

- Transport model + $p_i(\alpha, S_l)$ database



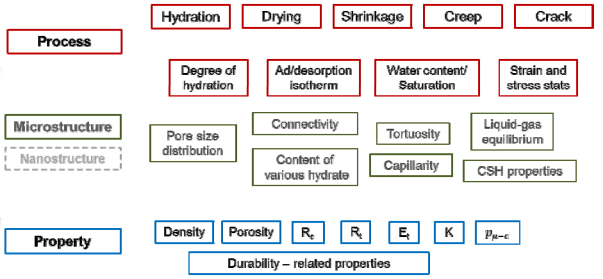
Open questions

- How is the competition between the hydration and early drying ?
- What is the best method to assess the $p_i(\alpha, S_l)$ data set ?
- What is the best technique to stop hydration at early age?
  - Is the water-isopropanol replacement the best solution?
  - In what extent the technique to stop hydration will modify the microstructure and other properties of the material?



- How to minimize the influence of the stiffness of the steel ring in the shrinkage test?

- What are the most relevant properties for drying shrinkage and cracking?



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