Characterization of ASR in concrete by X-ray tomography

Mahdieh Shakoori Oskooie[1,2,3], Michele Griffa[1], Andreas Leemann[1], Robert Zboray[2], Pietro Lura[1,3]

1 Concrete/Construction Chemistry Laboratory, Empa – Swiss Federal Laboratories for Materials Science and Technology, Dübendorf, Switzerland

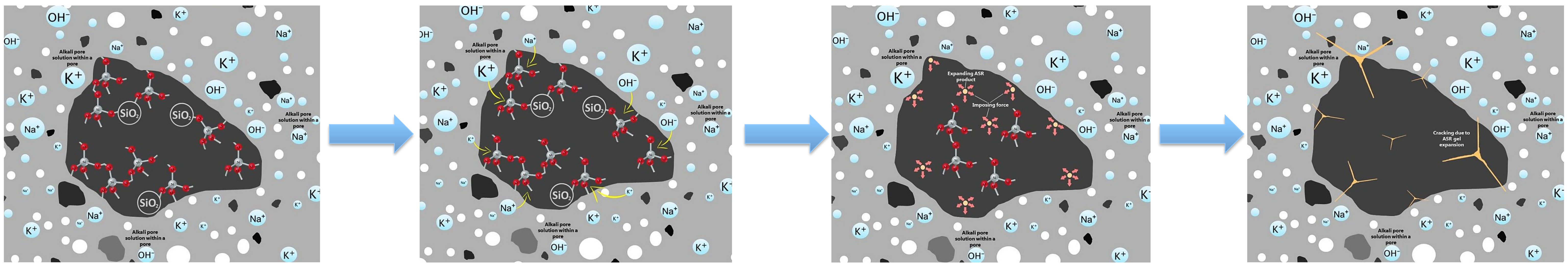
2 Center for X-ray Analytics, Empa – Swiss Federal Laboratories for Materials Science and Technology, Dübendorf, Switzerland

3 Institute for Building Materials, ETHZ – Swiss Federal Institute of Technology Zurich, Zürich, Switzerland

Empa Materials Science and Technology

ETH zürich

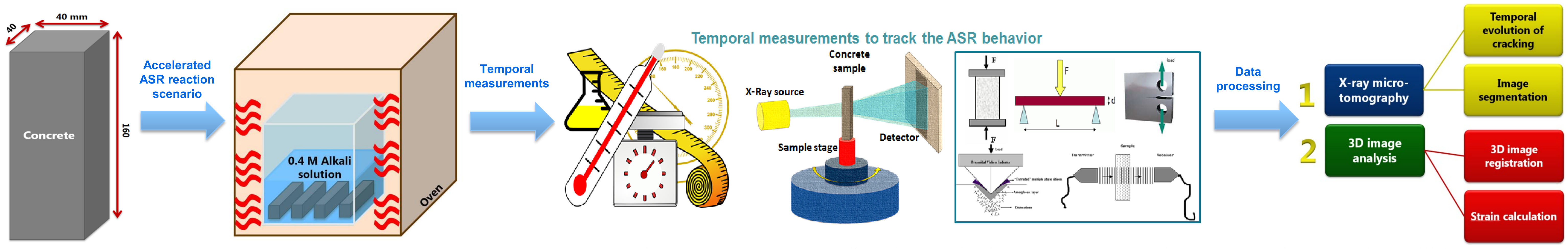
Introduction to Alkali-silica reaction damage in concrete



Alkali-silica reaction (ASR) is one of the most deleterious mechanisms in concrete structures since several decades [1-3]. Aggregate in within the concrete are surrounded by several pores filled with extremely alkaline pore solution. This pore solution can attack silicates within the aggregate and react.

As a result of this reaction with an extremely hygroscopic product is formed. This product imbibes water existing in the pores and swells which is called as ASR gel. The gel expansion imposes stress into the concrete structure and instigates crack formation after exceeding the concrete tensile strength.

Experimental procedure and project aim

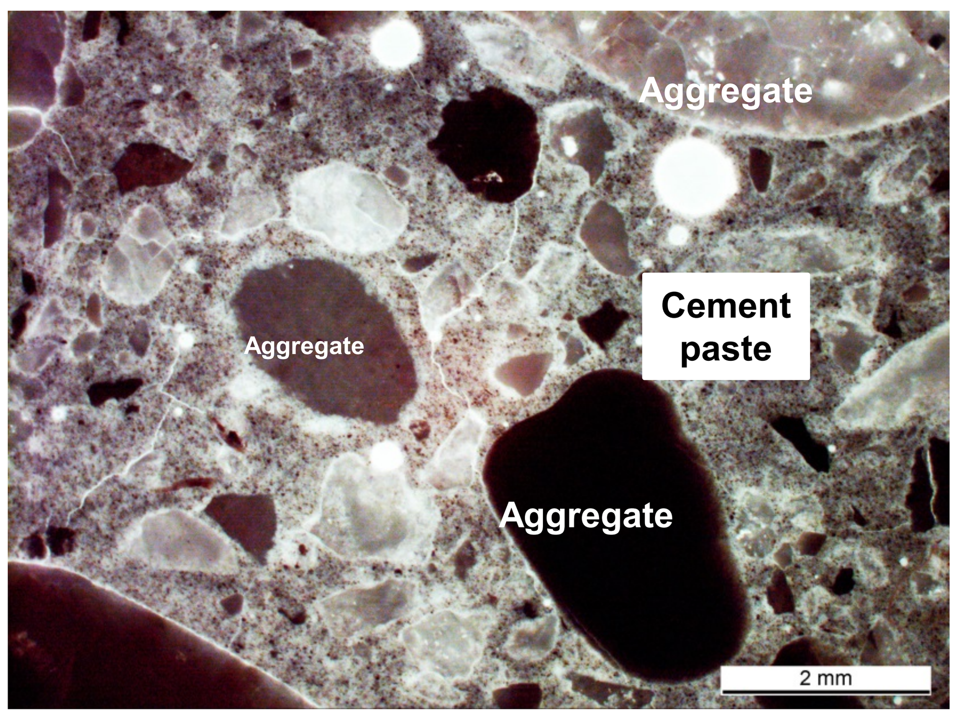


Several concrete prisms were casted and after 1day of curing, they were exposed in an accelerated ASR condition by immeresing in an alkali solution at 40℃.

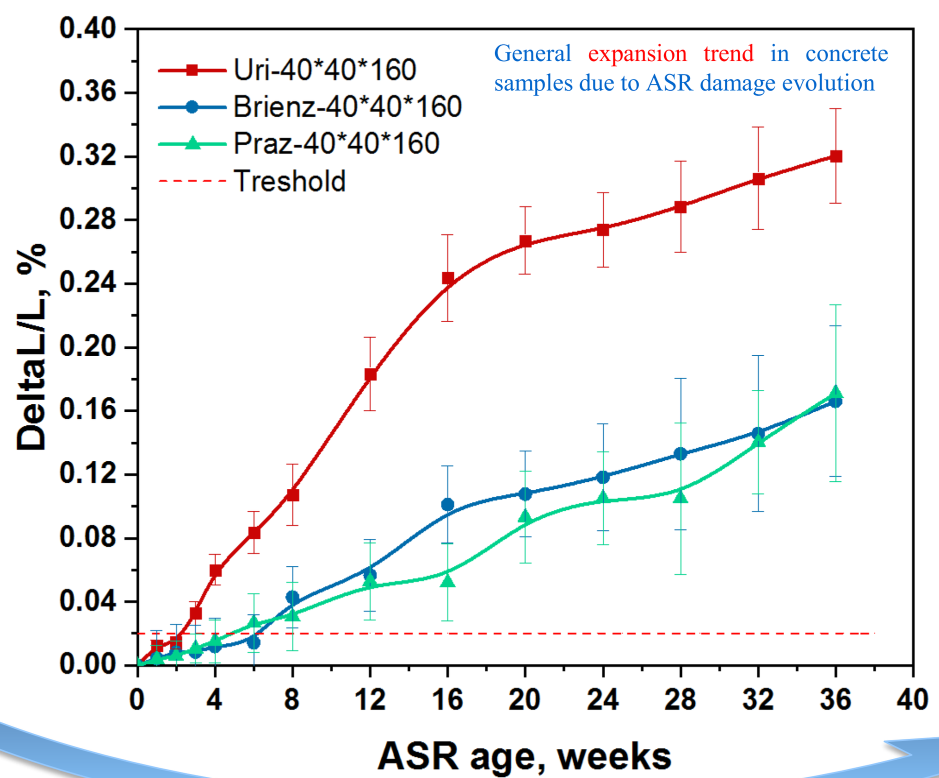
Temporal measurements (mass/length, mechanical properties and tomography) were performed every week or two weeks to track the effect of ASR damage on the concrete.

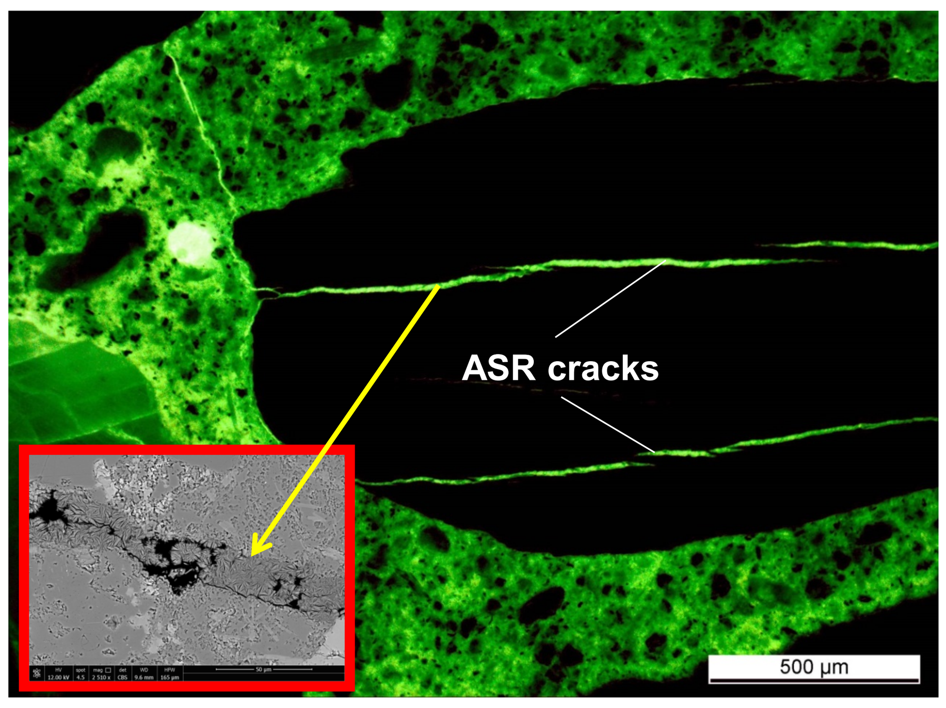
A 3D image processing procedure will be employed to analyze the tomography results and quantitatively calculate the structural movement in concrete samples and crack evolution **(project aim)**.

Results and future perspectives

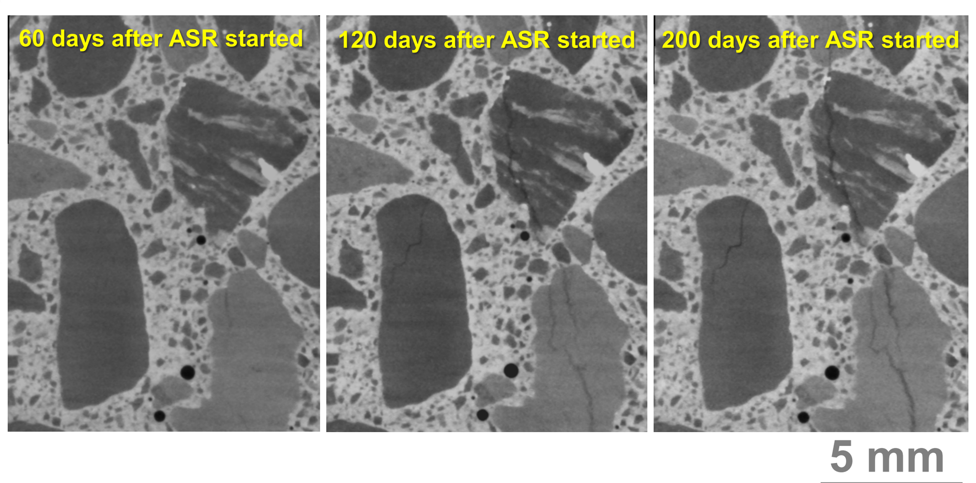


An example of optical microscopy (OM) image showing the general microstructure of the concrete samples. Aggregates are distributed within a homogenized cement paste.

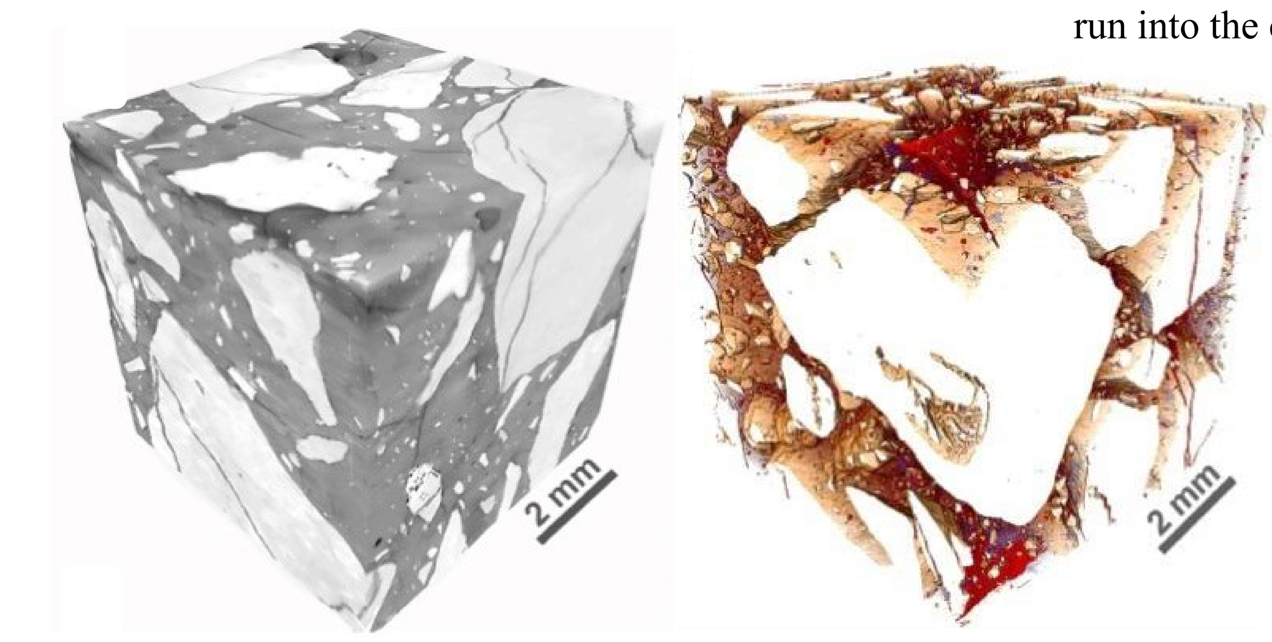




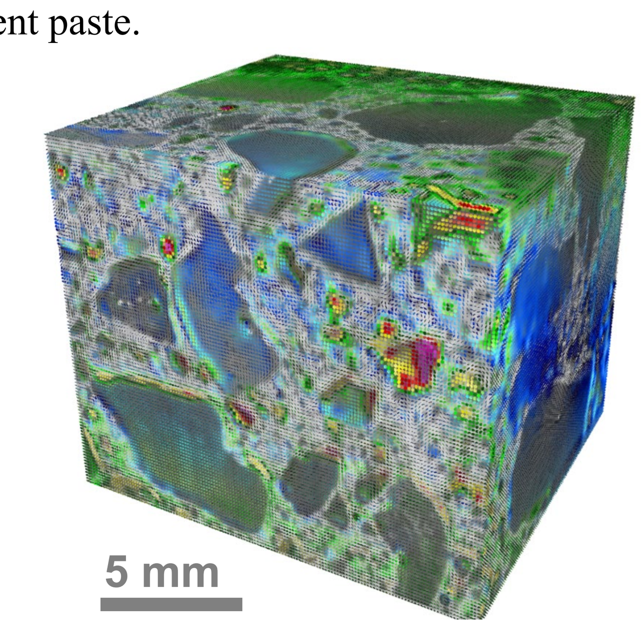
An example OM image showing the generation of ASR cracks in the expanded concrete structure. The ASR cracks are obvious within the aggregates and they have run into the cement paste.



An example of temporal tomography results, illustrating the ASR crack evolution (growth) in a one typical cross-sections of concrete sample. The cross-sections are chosen from the volumetric (3D) temporal tomography data of exact same sample.

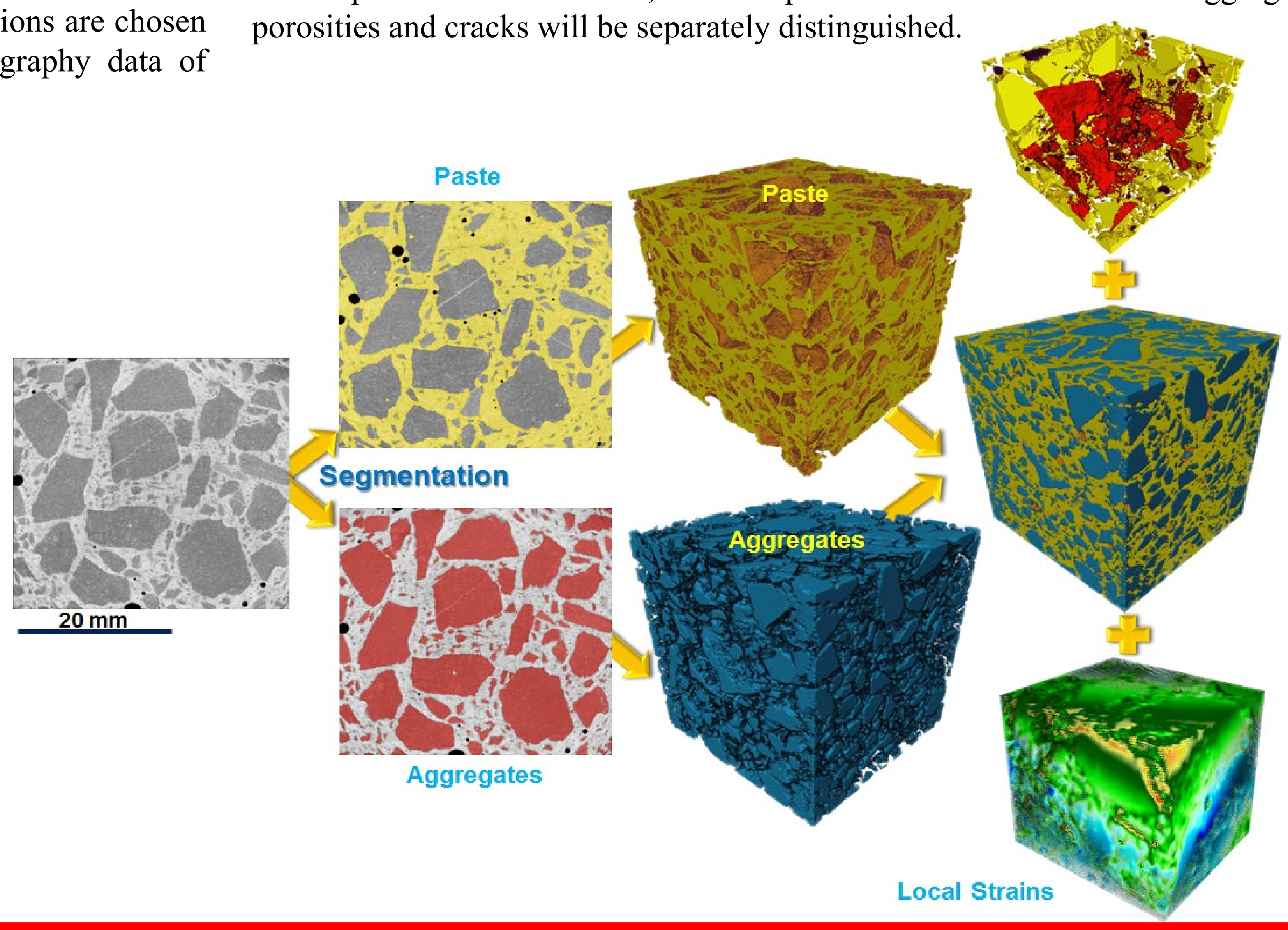


After every tomography the results will be processed and “volume segmentation” will be performed. As a result, different phases in the concrete such as aggregates, porosities and cracks will be separately distinguished.



Finally, the segmented data from all temporal measurements will be compared using “image registration” techniques and the strain amounts will be calculated quantitatively.

After image processing on temporal 3D tomography data, the quantitative results regarding the movement of any component (segmented parts) in the concrete will be available. These data could be directly used in a finite element modelling (FEM) to observe the stress fields in the structure and predict the ASR damage mechanism.



References

1. Fournier and M.-A. Bérubé, Can. J. Civ. Eng., 2000, 27, 167–191.

2. E. STANTON, ENR., [McGraw-Hill], 1987.

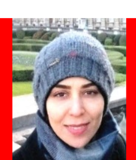
3. A. Leemann and P. Lura, Constr. Build. Mater., 2013, 44, 221–227.

Collaborations

EPFL

Aknowledgment

FNSNF SWISS NATIONAL SCIENCE FOUNDATION



Contact
Mahdieh Shakoori Oskooie
mahdieh.shakoorioskooie@empa.ch
+41 58 765 6005