

Efficient segmentation of the concrete mesostructure from CT scans using contrast enhancers

P. Carrara, R. Kruse, L. De Lorenzis (Institute of Applied Mechanics) in cooperation with iBMB

Introduction

The concrete behavior depends on its mesostructure arrangement, that can be obtained using 3D imaging techniques such as the X-ray computed tomography (CT) [1].

Open issue

- The contrast between cementitious matrix and aggregates is too limited to easily identify the various phases (e.g., Fig. 4a):
the segmentation results very hard [1].

Goal

- Enhance the contrast between the cementitious matrix and the aggregates **by adding baryte ($BaSO_4$) powder into the concrete mix** facilitating thus the segmentation.

Methods

- Standard concrete is adopted as control mixture - w/c = 0.5, 370 kg/m³ of cement type CEM I 42.5 N, 1700 kg/m³ of aggregates with maximum aggregate size of 8 mm
- Mixtures are casted substituting a volume of 0.5-1.0-2.0-2.6% of the total aggregates with an equivalent volume of baryte powder (only aggregates between 0-0.25 mm are substituted)
- Compressive, semi-adiabatic calorimetric and ultrasonic tests are performed to ensure that the baryte does not affect the concrete behavior

Test results

Compressive tests

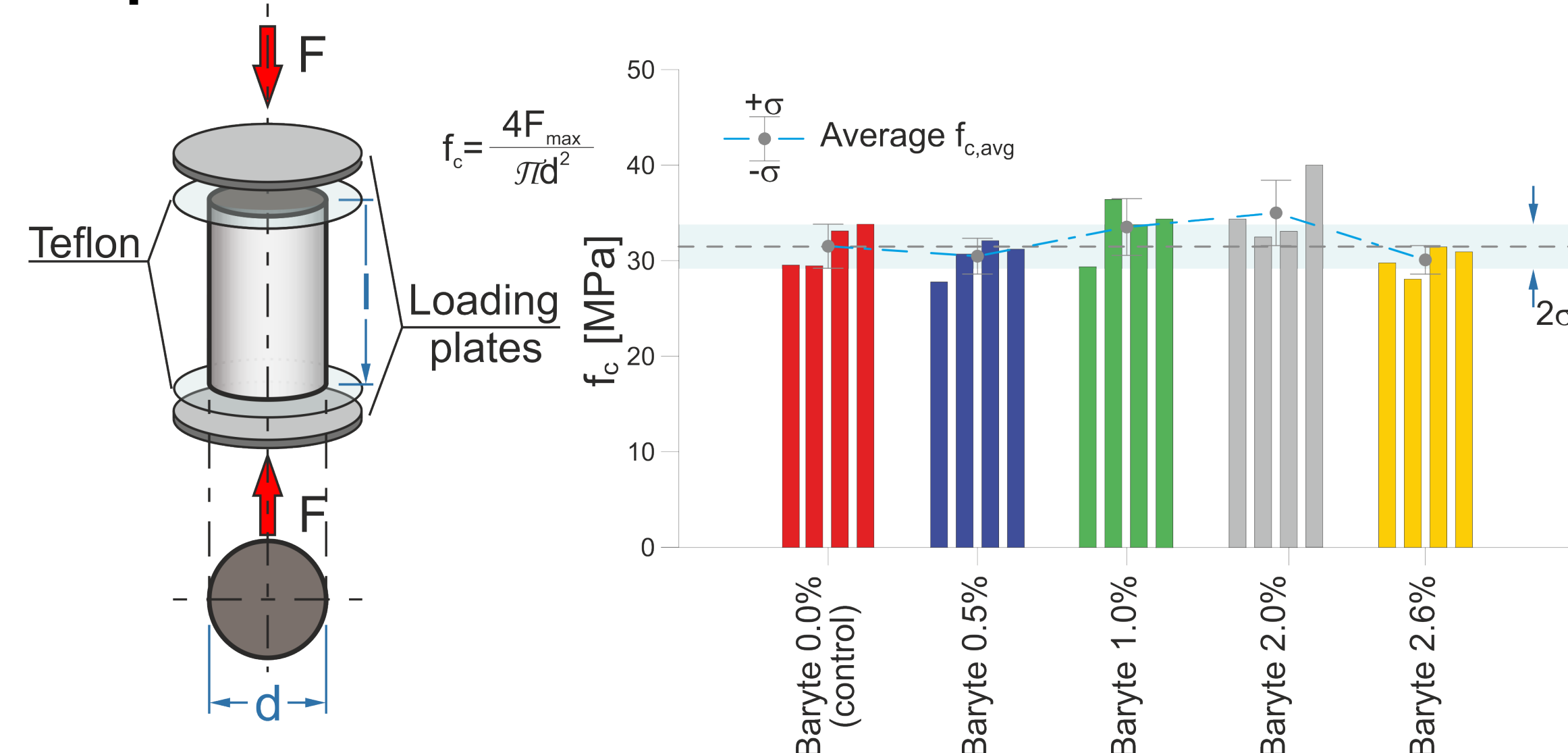


Fig. 1: Results of the compressive tests.

Semi-adiabatic calorimetry

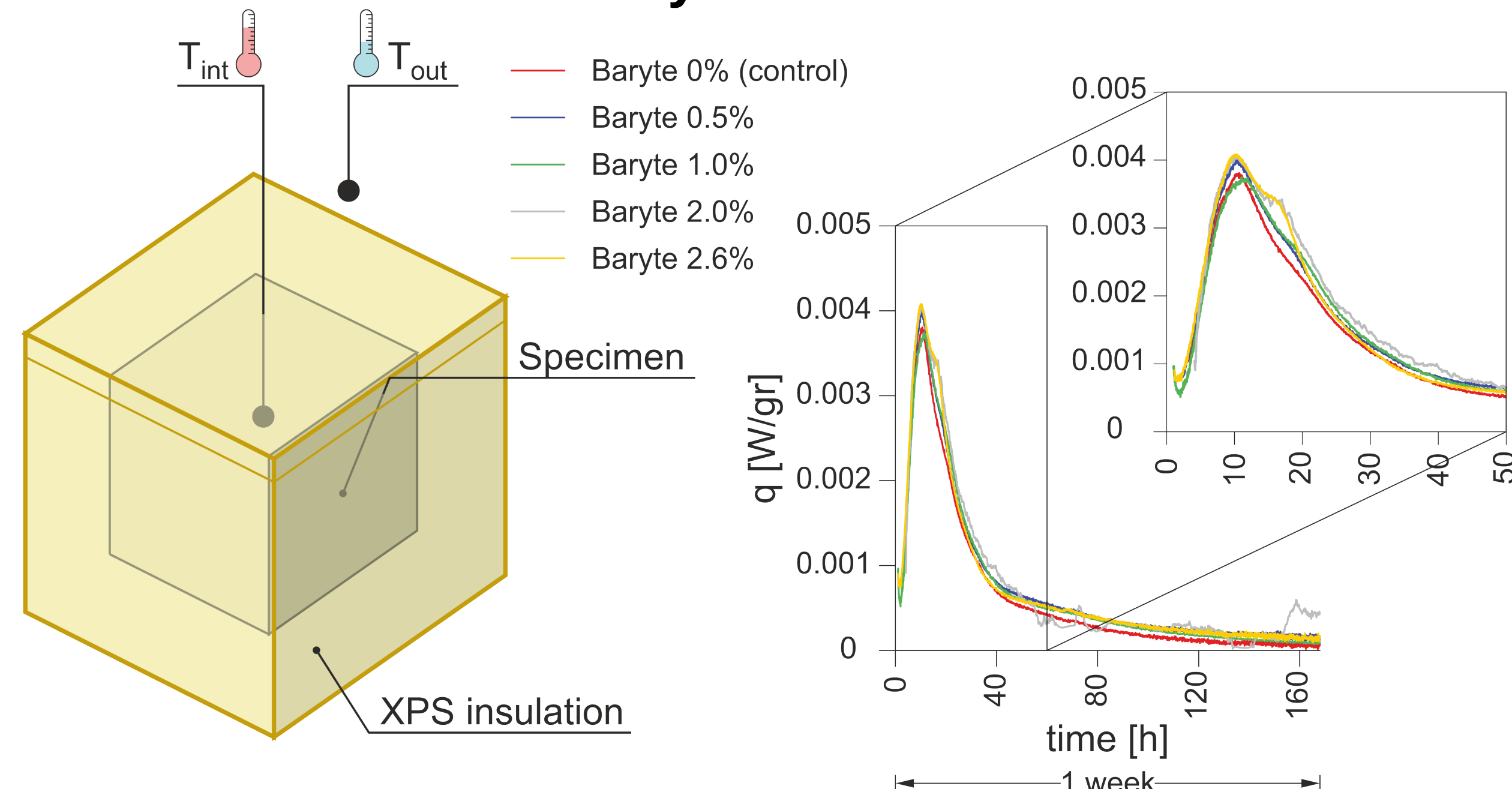


Fig. 2: Results of the semi-adiabatic calorimetry tests following [2].

Ultrasonic tests

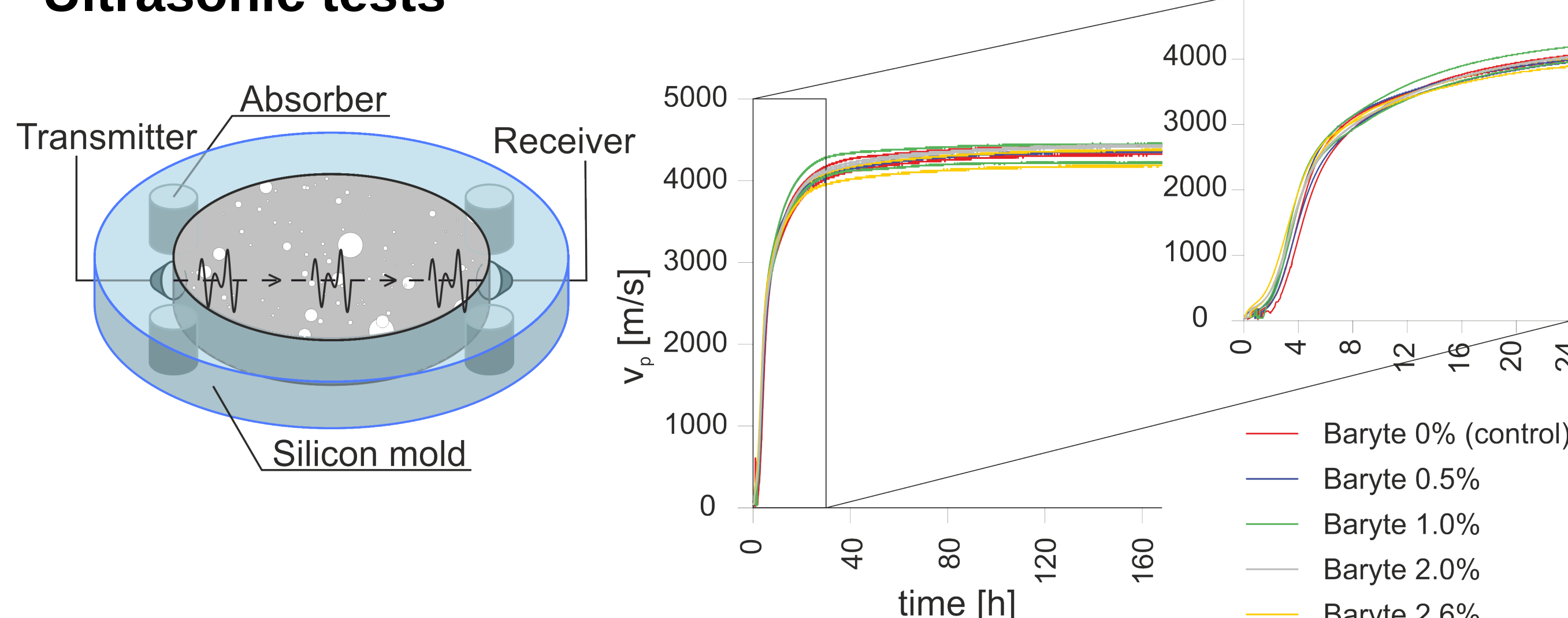


Fig. 3: Results of the ultrasonic tests.

CT-scan images

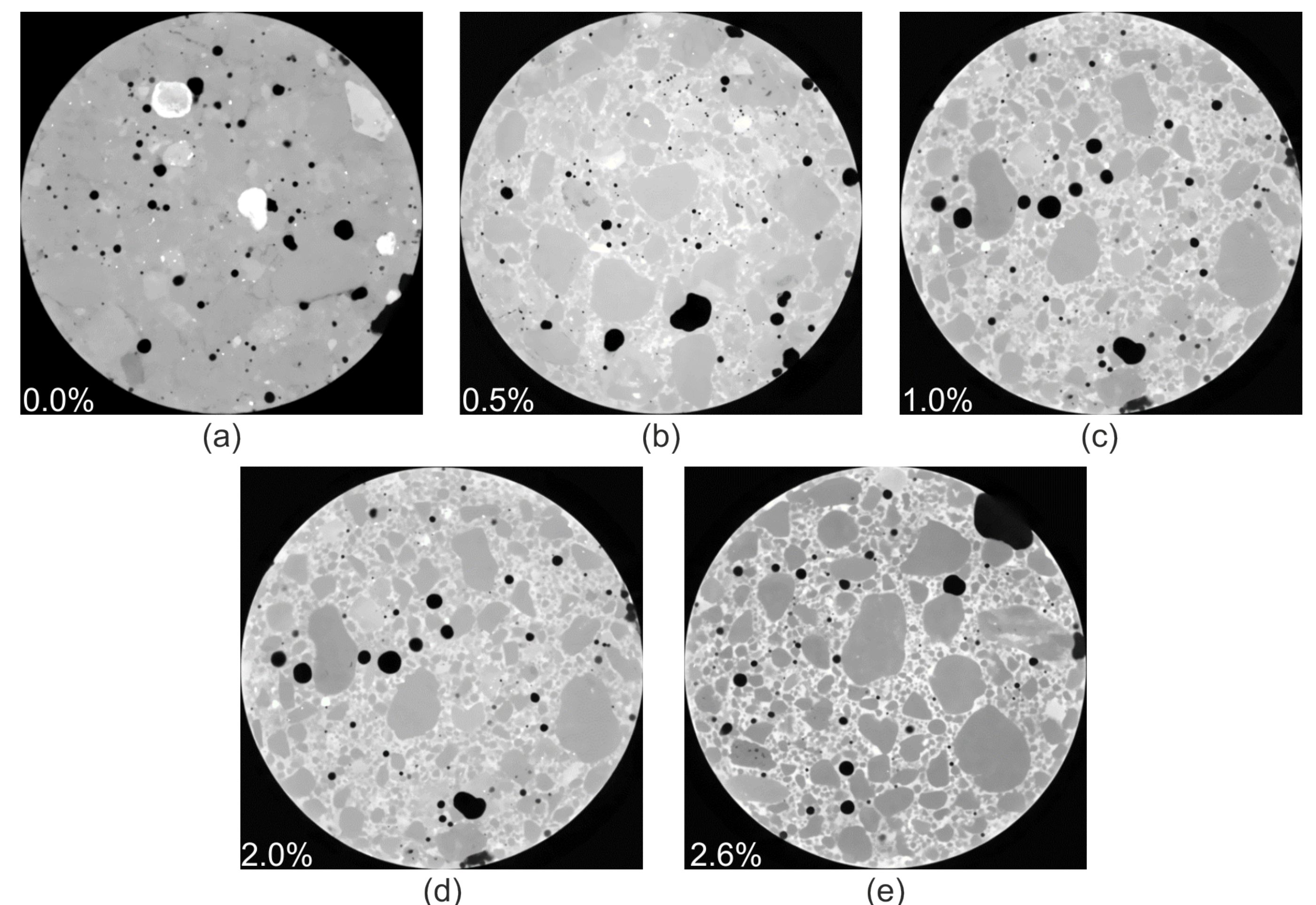


Fig. 4: CT scan projections of tested specimens: (a) control mixture (plain concrete – note that the contrast between aggregates and binding matrix is clearly insufficient to distinguish the two phases), mixture with baryte content of (b) 0.5%, (c) 1%, (d) 2% and (e) 2.6% (here the contrast is enough to easily distinguish aggregates and binding matrix).

Segmentation procedure

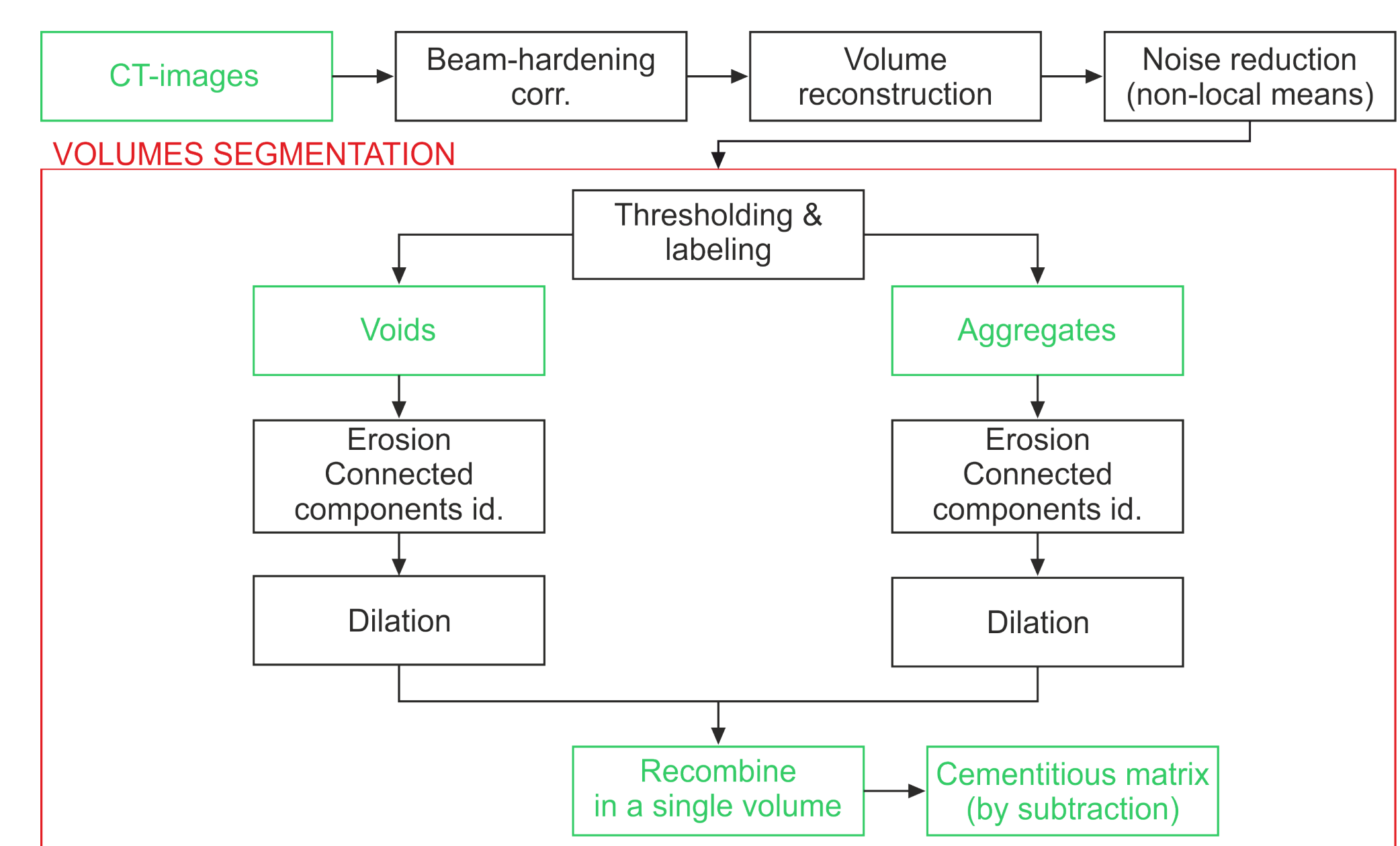


Fig. 5: Flowchart of the adopted segmentation procedure. Note that phase identification relies only on thresholding.

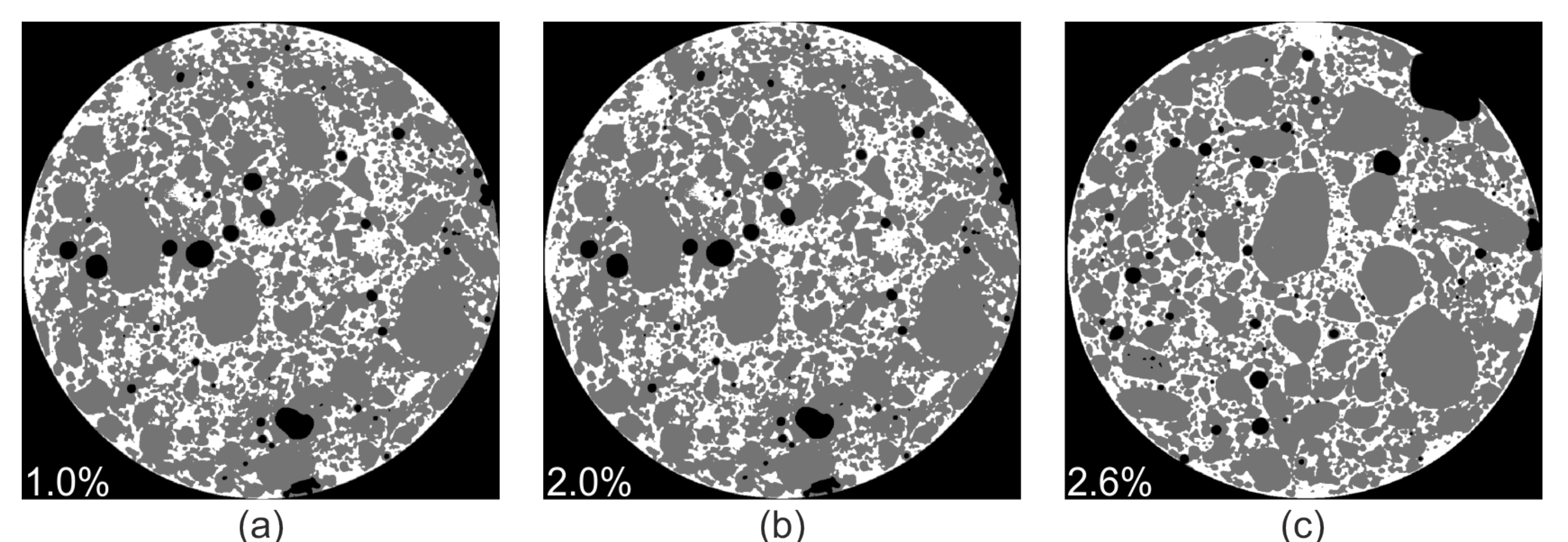


Fig. 6: Segmented images: mixture with baryte content of (a) 1%, (b) 2% and (c) 2.6%.

Conclusions

- The addition of baryte does not influence the mechanical parameters nor the hydration process of concrete.
- Baryte addition clearly improves the contrast between aggregates and matrix.
- Adding 2-2.6% of baryte allows for an easier but still reliable segmentation, even when a very simple algorithm is used.

References

- P. Carrara, T. Wu, R. Kruse, and L. De Lorenzis. Towards multiscale modeling of the interaction between transport and fracture in concrete. RILEM Letters, (1) 94-101, 2016.
- EN 196-9. Method of testing of cement – Part 9: Heat of hydration: semi-adiabatic method. 2010

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