# PhD thesis proposal- China Scholarship Council (CSC)

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| **Title** | Contribution of ultrasonic and vibration-based NDT techniques for the characterization of internal swelling pathologies in concrete |
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**Description**

As part of a diagnostic and / or prognosis strategy for the lifespan of concrete structures, the use of non-destructive testing (NDT) techniques can be decisive to allow reliable regular monitoring. It will be the only possible option when the core sampling is prohibited. This thesis will focus on the detection and characterization of internal swelling reactions (ISR) in concrete using ultrasonic and / or vibration-based NDT techniques. Three techniques will particularly be studied, namely:

- Acoustic Emission (AE);
- Time reversal applied to a reverberant cavity (TR) ;
- Nonlinear acoustic by free (NIRAS) or imposed (NRUS) resonance.

Accelerated swelling tests under controlled temperature and humidity conditions will be carried out on small specimens as well as on medium size concrete elements.
The non-destructive tests will be supplemented by mechanical and physico-chemical characterization tests as well as by expansion measurements on small specimens. Monitoring of the deformations of medium size concrete elements by optical fibers is considered also.
The observables deduced from the non-destructive tests will then be linked to the indicators deduced from models in order to identify their law of variation according to the level of damage of the tested elements. Repeatability and reproducibility tests will therefore be carried out for this purpose.

**Short description of the techniques developed during the thesis**

- Acoustic emission (AE) is a non-destructive passive technique, which consists in recording transient elastic waves resulting from the release of elastic energy during internal processes in a material such as the creation of microcracks. Thanks to a network of sensors positioned on the surface of the element to be auscultated, it is possible to determine the evolution state of a given reaction and also to localize the microcracks at the origin of acoustic emissions [Boniface et al., 2020] By means of an inverse analysis of the collected waveforms, it is also possible to identify the type of damage [Laurens and Kacimi, 2009, Nguyen-Tat et al, 2018] or even quantify the severity of damage of structures.

- The second technique that will be developed during the thesis is time reversal in a reverberant cavity (TR). Given the wide variety of applications of the RT technique, we propose to work more specifically on the temporal reversal in a reverberating cavity inspired from the work of [Granger, 2006] on concrete. A sensor will emit an ultrasonic wave which will be picked up by a network of

sensors fixed on the surfaces of the cavity (corresponding in this case to the elements to be auscultated). The received signals are then returned temporally and re-transmitted to the initial source. This method has notably shown its effectiveness in the characterization of the self-healing of a UHPC and its application to the characterization of the development of ISR seems a priori to be relevant. The originality compared with the approach of [Granger, 2006] is that embedded sensors will be used instead of surface sensors.

- The last technique concerns the free (NIRAS) or imposed (NRUS) nonlinear resonance spectroscopy technique. Experimental devices for carrying out NRUS and NIRAS tests were developed at LMDC during the Master internship of [El Zohby 20] and the obtained results confirmed the trends observed in the literature, namely great sensitivity to damage creation. We propose to apply these techniques to characterize the damage generated by ISR.

In a more global context, these non-destructive tests are not limited to characterize only damage induced by ISR but any type of damage in a concrete member.

**References**

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