Université Gustave Eiffel | LABORATOIRE GEOEND GÉOPHYSIQUE ET ÉVALUATION NON DESTRUCTIVE

PennState

Master Student Internship Opportunity

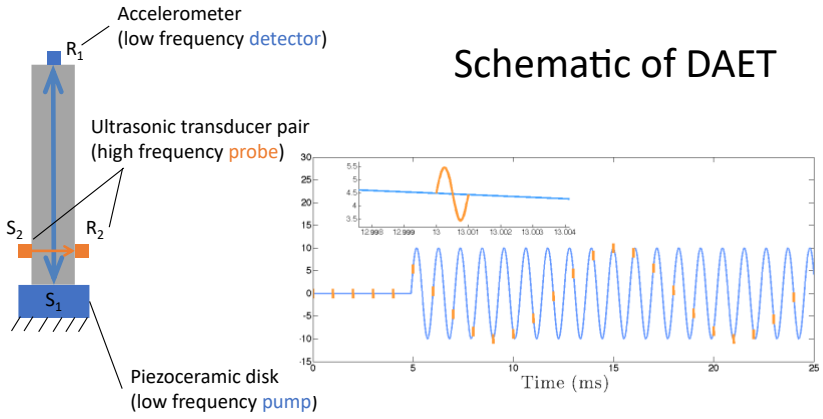
Frequency-Dependency of Nonlinear Acoustic Properties of Concrete:
an experimental multi-physics approach

Overview and Background: This internship provides a unique opportunity to take part in an international Franco-American collaboration involving a fundamental study of the nonlinear acoustic properties of concrete. Nonlinear acoustics/ultrasonics is an emerging field in nondestructive evaluation of cementitious materials, which promises higher sensitivity to incipient microscopic damage (microcracking) – compared to conventional (linear) acoustic/ultrasonic testing techniques e.g., (Jin et al., 2019).

We will employ Dynamic Acoustoelastic Testing (DAET), one of the methods for local characterization of nonlinear acoustic parameters of concrete (Shokouhi et al., 2017), which are sensitive to microscopic defects. A pump and probe approach, this method relies on measuring the dynamic strain-dependency of materials elastic properties through monitoring the evolution of wave speed and amplitude during and after pumping. DAET can yield both classical and non-classical (or hysteretic) nonlinear acoustic properties. One fundamental question to answer is: How/why would the frequency of the dynamic strain pumping affect the measured acoustic proprieties? The answer to this question has significant implications in upscaling the laboratory observations to field applications concerning the nonlinear acoustic monitoring of concrete structures.

Key words: Nondestructive evaluation, DAET, Nonlinear acoustics/ultrasonics, Concrete

Research Objectives: We aim to unravel the frequency-dependency of nonlinear acoustic properties of concrete materials by conducting a systematic study that involves a series of DAET experiments (with pumps of increasing frequency) combined with measuring the modulation of concrete's electrical properties. This study builds upon and extends our previous work (Rivière et al., 2016) on rocks under confining pressure indicating the



Schematic of DAET

frequency-dependency of hysteretic nonlinear acoustic properties. The simultaneous measurement of electrical properties would help constrain the experiments in terms of changes in moisture content, which may play a key role in the observed phenomena.

Background and Training: This project provide multi-disciplinary training in instrumentation and experimental design, nonlinear acoustic/ultrasonics, electrical measurements, signal processing, data analysis through programming, and technical writing/presentation. The candidates are expected to have a good background in mechanics and be familiar with high-level programming languages (such as Python and MATLAB).

Duration: 4-6 months
Location: You will be joining the multi-disciplinary group GéoEND, located in a research campus of the Université Gustave Eiffel south of the Nantes metropolitan area.

Contact: If you have any questions or require further information, please do not hesitate to contact Parisa Shokouhi (parisa@psu.edu) who is a visiting professor from Penn State, Pierric Mora (pierric.mora@univ-eiffel.fr), and Odile Abaraham (odile.abraham@univ-eiffel.fr). We would ne happy to discuss further details of the internship and the project with you.

Successful candidates may have the opportunity to continue towards a PhD degree in the United States (Penn State) or in France, at the Université Gustave Eiffel, pending the availability of related funds.

References:

Jin, J., Xi, W., Riviere, J., Shokouhi, P., 2019. Single-Impact Nonlinear Resonant Acoustic Spectroscopy for Monitoring the Progressive Alkali–Silica Reaction in Concrete. J Nondestruct Eval 38, 77. https://doi.org/10.1007/s10921-019-0614-5

Rivière, J., Pimienta, L., Scuderi, M., Candela, T., Shokouhi, P., Fortin, J., Schubnel, A., Marone, C., Johnson, P.A., 2016. Frequency, pressure, and strain dependence of nonlinear elasticity in Berea Sandstone. Geophysical Research Letters 43, 3226–3236. https://doi.org/10.1002/2016GL068061

Shokouhi, P., Rivière, J., Lake, C.R., Le Bas, P.-Y., Ulrich, T.J., 2017. Dynamic acousto-elastic testing of concrete with a coda-wave probe: comparison with standard linear and nonlinear ultrasonic techniques. Ultrasonics 81, 59–65. https://doi.org/10.1016/j.ultras.2017.05.010