



HAL
open science

The turbulence between geomechanics and vibroacoustics: what is common point?

Stéphane Bonelli, P.-O Mattei, F. Anselmet, M. Amielh, R. Borghi, U. Kristiansen, D Mazzoni, G Galeron, C Jeanniot, F Mercier

► To cite this version:

Stéphane Bonelli, P.-O Mattei, F. Anselmet, M. Amielh, R. Borghi, et al.. The turbulence between geomechanics and vibroacoustics: what is common point?. Fluid turbulence Applications in Both Industrial and ENvironmental topics, Jul 2019, Marseille, France. hal-02370392

HAL Id: hal-02370392

<https://hal.science/hal-02370392>

Submitted on 19 Nov 2019

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

The turbulence between geomechanics and vibroacoustics: what is common point?

S. Bonelli², P.-O. Mattei³
F. Anselmet¹, M. Amielh¹, R. Borghi³, U. Kristiansen⁴, D. Mazzoni¹
G. Galeron¹, C. Jeanniot^{2,3}, F. Mercier^{1,2}

¹Aix Marseille Univ, CNRS, Centrale Marseille, IRPHE, Marseille, France

²Irstea, Aix Marseille Univ, RECOVER, Aix-en-Provence, France

³Aix Marseille Univ, CNRS, Centrale Marseille, LMA, Marseille, France.

⁴NTNU, Acoustics Research Centre, Trondheim, Norway.

Abstract

This presentation covers more than 10 years of fruitful collaboration between Irphe, LMA and Irstea where our colleague and friend F. Anselmet played a central role. The presentation is organized in three parts. The first part deals with erosion of a cohesive soil by turbulent flow (F. Mercier PhD thesis). Work in progress concerning the acoustic emission of a turbulent flow in a soil is presented in a second part (C. Jeanniot PhD thesis). The last part is devoted to the interaction of a turbulent flow with acoustic sound wave inside a corrugated cylinder (G. Galeron PhD thesis) known as singing riser.

Dikes and levees are prone to failure through two erosion processes [1]: i) internal erosion, induced by concentrated seepage that takes off and transports soil particles through the embankment and its foundation, ii) surface erosion induced by overflowing. Erosion of a cohesive soil by turbulent flow is studied with Computational Fluid Dynamics (CFD) numerical modelling, based on the adaptive remeshing of the water/soil interface to ensure the accurate description of the mechanical phenomena occurring near the soil/water interface [2,3,4]. The erosion law governing the interface motion is based on two erosion parameters: the critical shear stress and the erosion coefficient. The model is validated by comparison with closed-form solution of simple problems. The numerical results are then compared to laboratory test results: the Hole Erosion Test, which reproduces the mechanism of tangential erosion of a soil by turbulent flow in a circular pipe, and the Jet Erosion Test which reproduces the erosion of soil by a circular impinging turbulent jet. The shear stress at the wall appears to be well-described by the $k-\varepsilon$ model while the pressure is better-described by the $k-\omega$ model.

One means to monitor internal erosion is passive Acoustic Emission (AE) monitoring. This monitoring involves acoustic transducers to passively listen for acoustic energy released from internal sources. We study the potential of this approach at the laboratory, on the Hole Erosion Test [1]. Turbulent pipe flow in the hole generates acoustic waves that propagate in the soil sample. Acoustic sensors (accelerometers) installed on the equipment allow to measure these signals. The analysis sheds light on acoustic frequencies characteristic of the internal flow, between 0-10 kHz. The vibratory responses are analyzed from the acoustic signal using Fourier transforms and Lorentzian functions. The correlation of both frequency and intensity with flow velocity and hole diameter is studied [5]. Using a simplified model of the sound field generated inside the test sample by a wall turbulent pressure field inside a cylindrical hole, it is easy to determine, at least theoretically, the characteristics of the flow (convection velocity, diameter of the inner pipe, power spectral density of the flow) that play that contribute to the acoustic response of the test sample.

The last part of this presentation is focused on a phenomenon often encountered in flow carrying pipes, since flow instabilities caused by geometric features may generate acoustic signals and thereafter interact with these signals in such a way that powerful pure tones are produced. A modern example is found in the so-called "singing risers", or the gas pipes connecting gas production platforms to the transport network. But the flow generated resonance in a fully corrugated circular pipe may be silenced by the addition of relatively low frequency flow oscillations induced by an acoustic generator.

Two experiments are reported here, aimed at investigating in more detail the coupling between the flow in the pipe, the acoustically generated flow oscillations and the emitted resulting noise, are performed in a specifically designed facility.

In the first one [6,7], a rectangular partly transparent pipe using glass walls enables us to use optical techniques to describe in detail the flow field in the corrugation vicinity, in addition to more standard hot-wire anemometry and acoustic pressure measurements with microphones, with and without the acoustically generated low-frequency oscillations. This allows us to show that the sound field not only has its origin close to its entry but also that a mitigation using low-frequency acoustic field allows to limit the amplification by wave superposition of the various reflected wave packets.

In the second experiment reported here [8,9], a Flow-Induced Pulsations (FLIP) test was performed in a 6" internal diameter and 18-meter-long flexible pipe. This riser was equipped with upstream and downstream measuring couplers on which were fixed hot wire velocity sensors, pressure sensors and microphones. A series of tests was conducted for various internal pressures and flow rates. We present a time-frequency analysis of the signals resulting from these tests as well as a correlation study between the various sensors. We observed that the signals measured in the whistling condition showed significant temporal and frequency fluctuations. We were able to show that the frequency fluctuations were related to the geometry of the riser. In addition, these analyses made it possible to show that the whistling exists at transverse acoustic frequencies of the riser while propagating at the convective velocity of the flow.

As a conclusion, we can conclude that the unique common points of all these studies, was our turbulent colleague F. Anselmet that must be warmly thanks for be a unique link between us and who permitted all these works to exist.

References

- [1] Bonelli S. (edt), *Erosion in Geomechanics Applied to Dams and Levees*, Wiley/ISTE, 388 p., 2013.
- [2] Mercier F., Bonelli S., Pinettes P., Golay F., Anselmet F., Philippe P. (2014), Comparison of CFD simulations with experimental Jet Erosion Tests results, *J. Hydraul. Eng. ASCE*, Vol. 140, N°5.
- [3] Mercier F., Golay G., Bonelli S., Anselmet F., Borghi R., Philippe P. (2014), 2D axisymmetrical numerical modelling of the erosion of a cohesive soil by a submerged turbulent impinging jet, *The European Journal of Mechanics - B/Fluids*, Vol. 45, pp. 36-50.
- [4] Mercier F., Golay F., Bonelli S., Anselmet F., Borghi R., Philippe P. (2015), Numerical modelling of concentrated leak erosion during Hole Erosion Tests, *Acta Geotechnica*, Volume 10, Issue 3, pp 319-332.
- [5] Jeannot C., Mattei C., Anselmet F., Bonelli S., Acoustic measurements on the Hole Erosion Test, EMI International Conference, Lyon, July 3-5, 2019.
- [6] M. Amielh, F. Anselmet, Y. Jiang, U. Kristiansen, P.-O. Mattei, D. Mazzoni & C. Pinhède (2014), Aeroacoustic source analysis in a corrugated flow pipe using low-frequency mitigation, *Journal of Turbulence*, 15:10, 650-676, DOI: 10.1080/14685248.2014.928412
- [7] G. Galeron, D. Mazzoni, M. Amielh, P.-O. Mattei, F. Anselmet. Experimental and numerical investigations of the aeroacoustics in a corrugated pipe flow. TI 2015 - 4th-International Conference on Turbulence and Interactions, Nov 2015, Cargèse, France.
- [8] P.-O. Mattei, M. Amielh, J.-P. Roques, A. Karnikian, G. Galeron, M. Décuupère et D. Charliac. Analyse expérimentale du sifflement d'un riser industriel, CFA'18, 23-27 Avril 2018.
- [9] G. Galeron. Résonances acoustiques dans un tube corrugué sous écoulement. Thèse de doctorat de l'école Centrale Marseille, Mai 2018.