Master 2 internship

6 months

Three-dimensional CFD simulation of scour around a bridge piles

Context

Erosion due to scouring processes around hydraulic structures is a very important topic in hydraulic engineering. Various studies have identified scouring phenomenon as a major cause for bridge failures [1] making its forecasting of outermost importance to assess bridge safety and resilience to extreme events. However, despite more than a century of active research its accurate prediction remains poor and its modeling is still a major challenge for civil engineers. Large scale sediment transport models typically used in engineering fail to provide relevant results as they are unable to correctly capture the complex three dimensional flow around the obstacle. This emphasizes the need for new models able to represent the flow locally.

The current difficulty to model scour has led to the development of a new sediment transport model sedExnerFoam, in collaboration between the LEGI and Artelia in the framework of the industrial chair Oxalia. The development started with the PhD of M. Renaud and the model, based on the CFD toolbox OpenFOAM, is open source. The computational fluid dynamics (CFD) approach allows for a better resolution of the hydrodynamics locally than classical geophysical sediment transport models and thus a better estimate of the shear stress exerted by the flow on the river bed. Coupled with a resolution of the suspended and bedload transport, the morphological evolution of the river bed is predicted by the model using the Exner equation.

Figure 3: LGV Sud Europe Atlantique bridge on the Dordogne river near Bordeaux. Source: Artelia

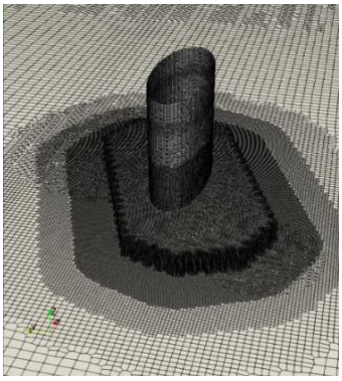

Figure 2: Numerical mesh of one of the LGV bridge pile. Source: Artelia

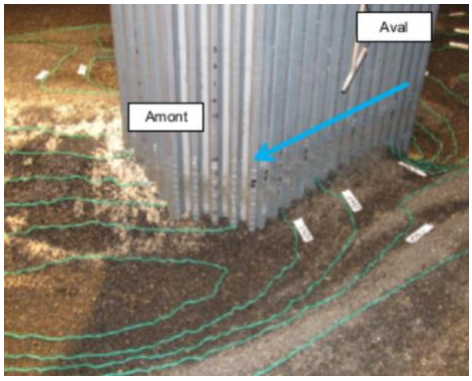

Figure 1: scour experiment on a reduced scale physical model of a bridge pile. Source: Artelia

Description

The objective of the internship is to perform numerical simulations of local scour around bridge piers using sedExnerFoam. The numerical simulations will be carried out on different configurations ranging from an idealized laboratory experiment to an actual engineering case.

The first task of the internship will be to study numerically the scour around a cylindrical pier, a classical benchmark for scour model. The experiment from Roulund et al. [2] will be used as a benchmark to evaluate the performance of the model. Various sensitivity analysis will be performed using different meshes, bedload models etc to identify the optimal parameters for scour simulations. This study will also serve to familiarize the candidate with sedExnerFoam pre and post-processing tools.

The second task will be focused on the study of scour around a real bridge piles studied by Artelia both numerically and using reduced scale physical models. Existing numerical and experimental data will serve as a guideline to assess sedExnerFoam model performances. The objectives of this task will be to illustrate the model capability to tackle real engineering problems and to identify the main model limitations.

Required Qualifications, Skills and Experience

- **Theoretical**: fluid mechanics, turbulence, sediment transport;
- Numerical: linux, CFD, an experience with openFOAM will be appreciated but is not mandatory, experience with Python and/or C++ is an advantage.

Supervision

- Matthias RENAUD (LEGI/UGA/GINP/ARTELIA)
- Dr. Julien CHAUCHAT (LEGI/UGA/GINP/CNRS)
- Dr. Ing. Olivier BERTRAND (ARTELIA)
- Dr. Ing. Cyrille BONAMY (LEGI/UGA/GINP/CNRS)

Contact

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Application deadline: Nov. 11th 2024

Practical Information

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Domaine Universitaire
38400 Saint-Martin d'Hères
France

ARTELIA
4 Rue Germaine Veyret-Verner
38130 Échirolles
France

- **Type of contract:** 6 months
- **Internship compensation**: approx. 600 €/month
- **Workplace:** LEGI laboratory in Grenoble, France, in close collaboration with ARTELIA.
- **Starting date:** February/March 2025

References

[1] Wardhana, K. & Hadipriono, F.Analysis of recent bridge failures in the United States, Journal of performance of constructed facilities. 17, 144–150 (2003).
[2] Roulund, A., Sumer B. M.,Fredsøe J., and Michelsen J.. Numerical and experimental investigation of flow and scour around a circular pile. Journal of Fluid mechanics, 70 534:351–401, 2005.
[3] Nagel, T., Chauchat, J., Bonamy, C., Liu, X., Cheng, Z., and Hsu, T.-J. (2020). Three- dimensional scour simulations with a two-phase flow model. Advances in Water Resources, 138:103544.