Flow Velocity Field over a Granular Bed and Bedform Incipience

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Context

Studying shallow water flows on steep and granular beds is crucial for understanding the behavior of mountain streams. River bed dynamics are the key to exploring the development of alluvial environments [1]. These bedforms are mainly categorized according to the flow regime. One of the curious bedforms occurring under supercritical (or near-critical) flow conditions is called "antidune." Such bedform is characterized by a sinusoidal shape in phase with the water surface and usually migrates upstream [2] (see Figure 1).

Goal and Objectives

Our goal is to improve our knowledge of shallow flows on coarse-grained beds. We aim to measure velocity profiles over a granular bed while recording bed topography when the antidunes are being developed.

Required work

We propose analyzing the transition from the flat bed to the antidune sequence by varying the water discharge at a constant mean bed slope [3] or by increasing the bed slope. The project also includes processing the data obtained from imaging techniques.

The student will participate in the experimental work and write a final report (in French or in English) outlining the methods and procedures followed during the project and discussing the results.

Methodology

The experiments will be carried out in a 5.8-m-long, 4-cm-wide flume with a granular bed configuration, following the work conducted by Pascal [4]. Concerning the velocity measurements, we have already performed preliminary tests at LHE with an imaging technique based on backlight panels and a high-speed camera equipped with a macro lens [4]. Particle Tracking Velocimetry (PTV) or Particle Image Velocimetry (PIV) techniques will be used for the velocity measurements. As occasion requires, we may use X-ray imagery to capture the bed formations and tracer motions [5].

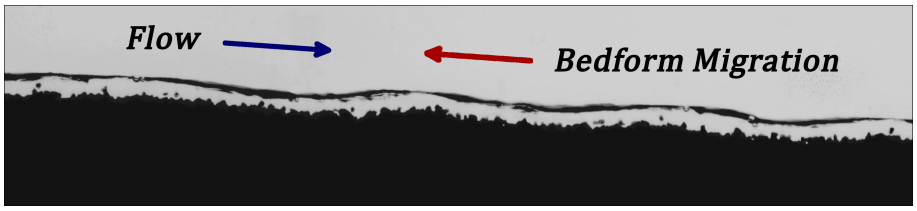

Figure 1: Antidune migration in a flume from the side view.

Prerequisites

The project requires some knowledge of the following:

- Hydraulics/Fluid Mechanics,
- Tools and programming languages for image processing (e.g. MATLAB/Python/Fiji).

References

1. Church, M. Bed material transport and the morphology of alluvial river channels. *Annual Review of Earth and Planetary Sciences* **34,** 325–354 (2006).
2. Kennedy, J. F. The Formation of Sediment Ripples, Dunes, and Antidunes. *Annual Review of Fluid Mechanics* **1,** 147–168 (1969).
3. Mettra, F. Morphodynamic mechanisms in steep channels: from local processes to large-scale evolution. Ph.D. thesis. *École Polytechnique Fédérale de Lausanne* (2014).
4. Pascal, I. Experimental study on bedload transport and antidunes: behaviour and interplay in steep turbulent streams. Ph.D. thesis. *École Polytechnique Fédérale de Lausanne* (2022).
5. Brunelle, C. *et al.* X-Ray Computed Tomography to Measure Bed Density in Sand Transport. *Journal of Hydraulic Engineering* **148** (2022).