Boundary layer flow induced by waves with acceleration skewness

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Motivation

- Sand transport rates induced by sawtooth shaped waves are found to depend on **acceleration skewness** β (See Figure 1).
- Practical quasi-steady transport models where $\Phi(t) \propto \theta(t)^n$ predict zero net transport rates for these waves.
- New research at Aberdeen within the SANTOSS project focusses on sheet flow transport processes for flows with acceleration skewness.
- To understand better the fundamental processes, the first stage focusses on boundary layer flow over non-mobile fixed rough beds.

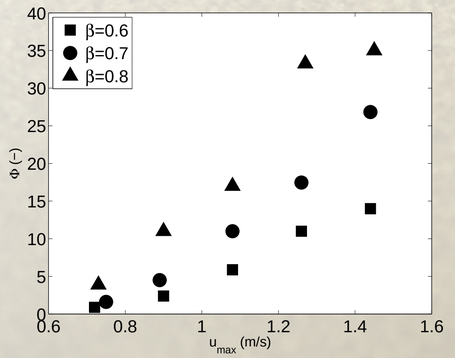

Figure 1: Sand transport rate for various degrees of acceleration skewness after Watanabe & Sato (2004).

Test facility

The Aberdeen Oscillatory Flow Tunnel (AOFT) has an overall length of 16 m with a glass-sided, rectangular test section 10 m long, 0.75 m high by 0.3 m wide (Figure 2).

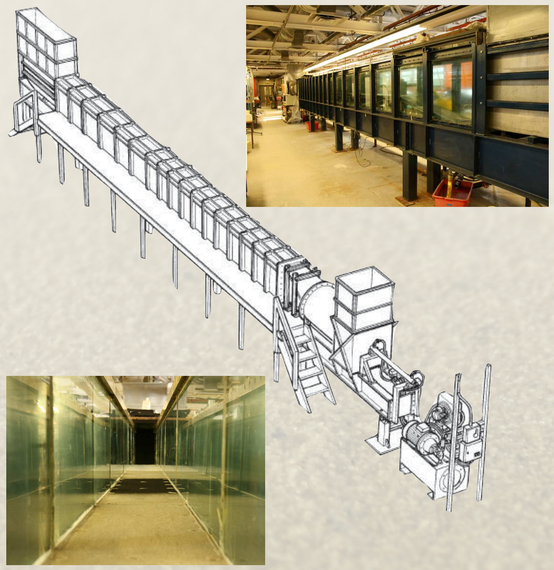

Figure 2: The Aberdeen Oscillatory Flow Tunnel

The AOFT is capable of generating flow amplitudes in the test section of 1.5 m with periods greater than 5 s. Sheet-flow conditions can be produced over a wide range of periods for typical sand sizes.

Fixed bed experiments

Velocities were measured using cross-correlation Particle Image Velocimetry (PIV) for flows of different period (5-7 s), amplitude (1-1.5 m) and acceleration skewness (0.5-0.75). The fixed bed consists of coarse sand with a median diameter of 0.44 mm. Velocity measurements were acquired for 50 consecutive wave cycles to obtain consistent results (Figure 3, 4)

Results

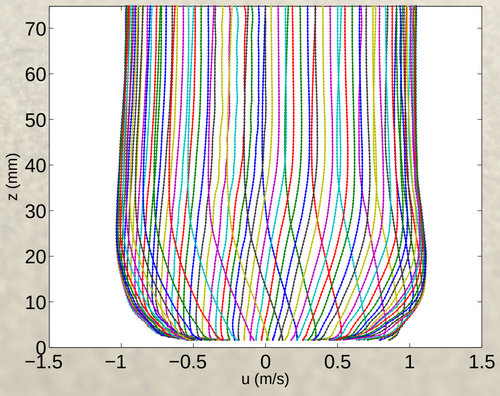

Figure 3: Ensemble averaged velocity profiles for the entire flow cycle over a fixed course sand bed ($D_{50} = 0.44$ mm) for a 7 s sawtooth flow ($\beta = 0.75$), measured with PIV at 12 Hz. The lowest measurement is at $z = 1.6$ mm where $z = 0$ corresponds to the top of the roughness elements.

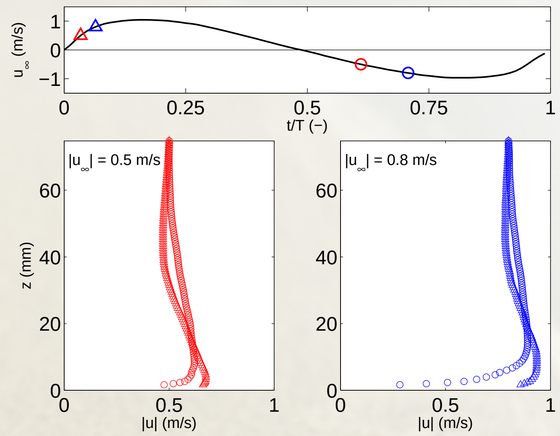

Figure 4: Velocity profiles for two selected phases with similar free stream velocities but different accelerations. Near bed velocities are higher when the flow acceleration is greater. These profiles imply higher shear stresses for stronger flow accelerations.

Future work

1. Continue fixed bed experiments for different bed roughness and various flow conditions.
2. Detailed measurements of velocities and concentrations for **mobile bed** sheet flow with accn. skewness.
3. Implementing acceleration effects in the practical transport model that is being developed within the SANTOSS project.

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