Transverse slope effects in morphodynamic models

Current transverse slope predictors are based on a specific sediment transport mechanism, but are used in morphodynamic models where all processes act in combination. As a result, current models need to be calibrated on existing morphology.

Experiments in annular flume

Objective: quantify slope effects for a large range of flow conditions and sediment characteristics, to obtain parameters for morphodynamic models that cover all sediment transport modes and bedform regimes.

Secondary flow in the annular flume

An analytical flow model is developed to predict near-bed streamwise and normal flow velocities at any combination of lid and floor rotation. This model assumes that shear stresses and centrifugal forces caused by lid and floor rotation are balanced by frictional forces of the lid and the walls of the flume. The model is calibrated on flow velocity measurements with a Vectrino (acoustic Doppler velocimeter).

Uniform sediment


Constant helical flow intensity (Un/Us), increasing sediment mobility (Θ)

Constant sediment mobility (Θ), decreasing helical flow intensity (Un/Us)

Slope effects show different trends for fine and coarse sediment

Slope effects are in the same order of magnitude as existing predictors

Conclusions

- Slope effects vary for fine and coarse sediment, since bedforms and sediment transport mode have a strong influence.
- Results are in contrast with the tendency to increase slope effects in current morphodynamic models.
- Bend sorting is obtained as a function of transverse slope, with the objective to improve sorting functions in morphodynamic models.

Poorly sorted sediment

Grain sorting as function of transverse slope

Next step: comparison with field data

Measure sediment volumes over the radius for 4 experiments with varying transverse slope and sediment mobility. Colors indicate grain size.

Bend sorting:

\[
\text{Bend sorting} = \frac{r_{\text{in}}}{r_{\text{out}}} \times \exp\left[\left(\text{D}_{50} - \text{D}_{95}\right) \times \frac{\text{d}z}{\text{dx}}\right]
\]