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JOURNAL OF ZHEJIANG UNIVERSITY SCIENCE ABC

Enhanced understanding on incipient sediment motion and sediment suspension through oscillating-grid turbulence experiments

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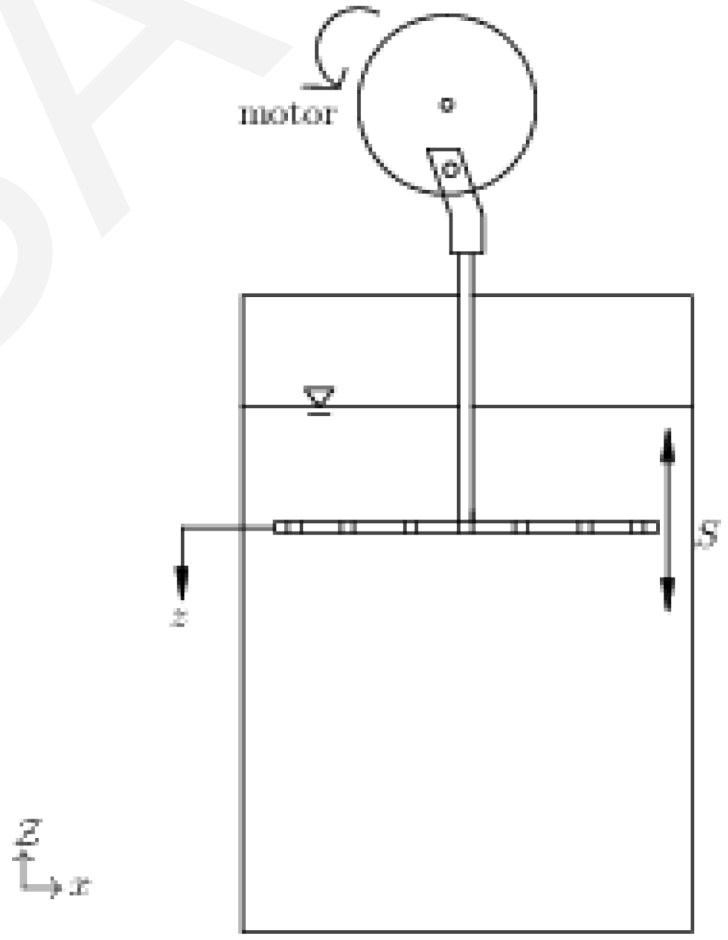
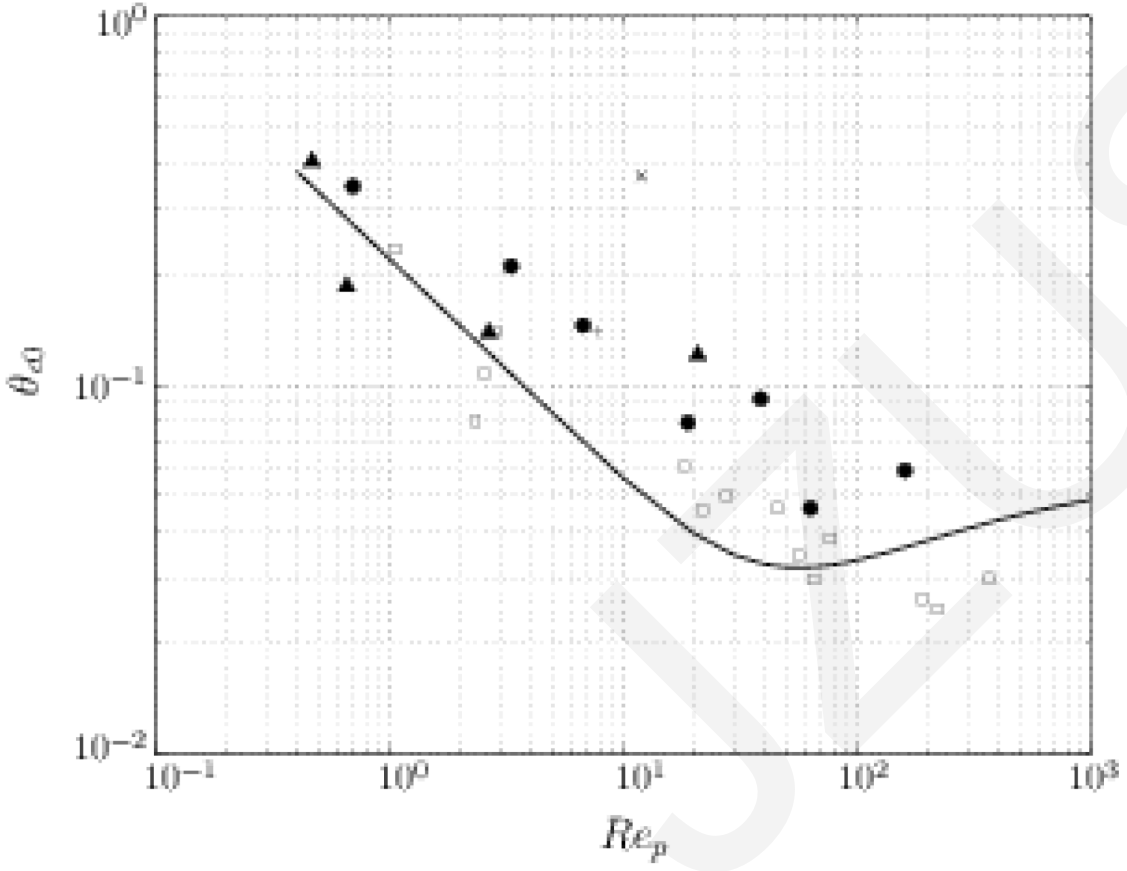
Cite this as: Wan Hanna Melini WAN MOHTAR, 2017. Enhanced understanding on incipient sediment motion and sediment suspension through oscillating-grid turbulence experiments. *Journal of Zhejiang University-SCIENCE A (Applied Physics & Engineering)*, 18(11):882-894. http://dx.doi.org/10.1631/jzus.A1600659

Oscillating-grid turbulence (OGT) apparatus as tool

- OGT has been widely used to investigate the effect of turbulence on geophysical phenomena such incipient sediment motion and sediment resuspension.
- The grid turbulence can be modelled as statistically homogeneous and isotropic flow, which allows relatively complete statistical information to be provided by fewer measurements than is required for the classical shear flows.

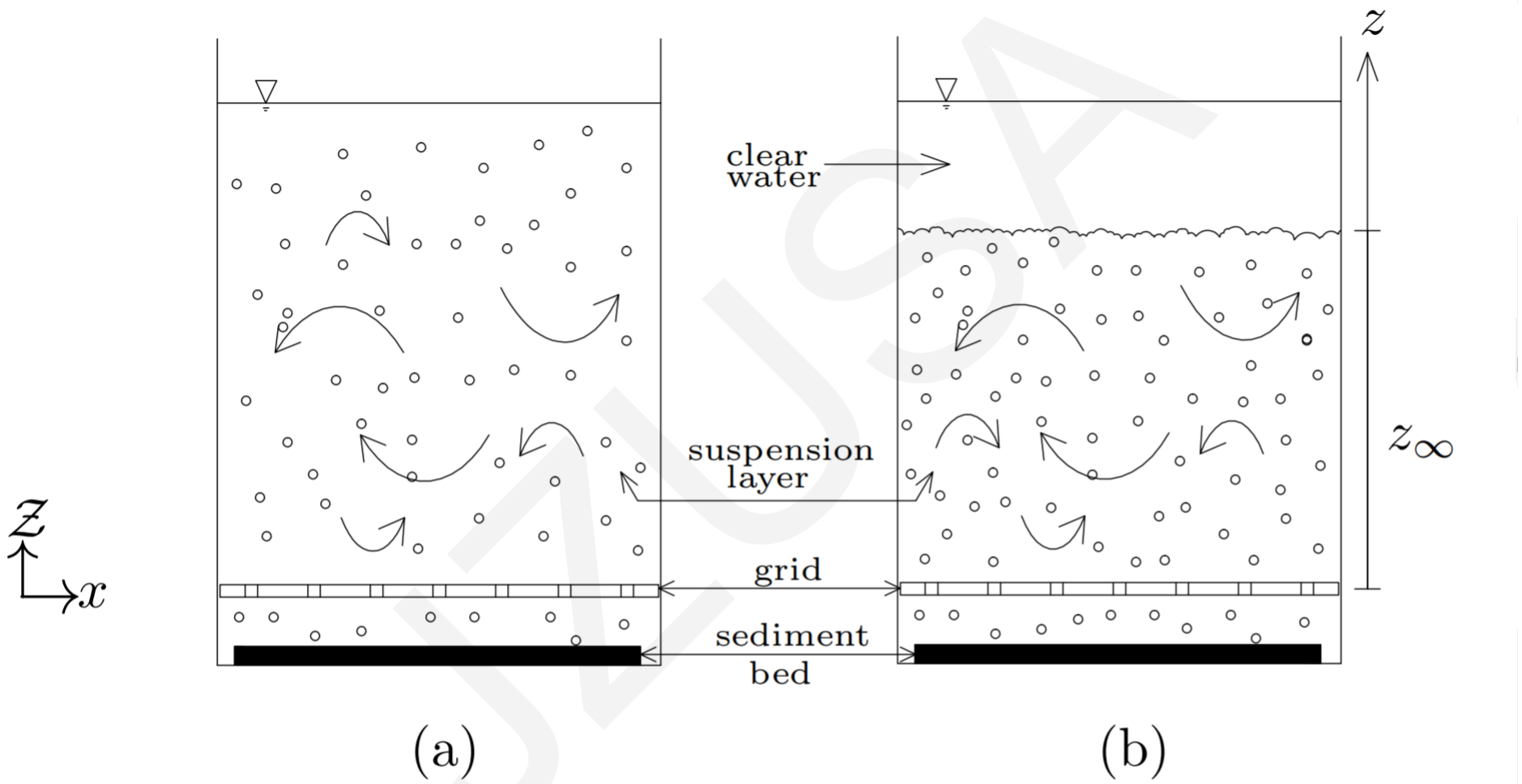


Incipient sediment motion



Threshold criteria obtained using grid turbulence experiments show a qualitative similarity with the trend predicted by the standard Shields curve for the hydraulically smooth and transition regions. Although the turbulence characteristics differ from those observed in the open channel flows, data shows a consistent trend with the curve obtained from channel flow studies.

Sediment resuspension



A typical oscillating-grid experimental setup for sediment resuspension, where the grid is placed at the bottom of the tank. Plots show suspension layer (a) without lutocline and (b) with the formation of lutocline. Circular arrows and dots represent turbulence and concentration of suspended particles, respectively.

The formation of lutocline

can be determined using

$$z_\infty = f\ell^2 \left[\frac{g' w_T C_\infty}{A\rho_s}\right]^{-1/3}$$

where C_∞ denotes the steady-state on concentration, l = 0.1z is the turbulent integral length scale and A is an empirical value, often taken as 3.6.

The effect on settling velocity

The settling velocity not only depends on the sediment size but turbulence structure plays an important role.

Conclusions

- Turbulent fluctuations do play a significant role in the incipient sediment motion. For smaller sediments, that is within the hydraulically smooth region, θ_c is monotonically increased as the sediment size gets smaller and almost reached a constant value for a bigger sediment size.

- The method of oscillating-grid has been found to be more rigorously done for the sediment resuspension including to investigate the formation of lutocline, the turbulence modified settling velocity, concentration profile within the suspension layer and consolidation of sediment. The concentration profile within the suspension layer, which defines the formation of lutocline, is inter-related with the sediment characteristics and the turbulence structure. The particle settling velocity ω_T, which directly contribute to the Richardson and Stokes numbers is the crucial parameter and highly influenced by the sediment size distribution and fluid motions