Different suspended sediment concentration profiles in alternating versus steady flows

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As per the picture below, from Nielsen (1992), profiles of time-averaged suspended sediment concentrations in oscillatory flows tend, for fixed sediment parameters and similar velocity amplitude, to be upward convex for short oscillation periods, *T*, but upwards concave for longer periods (and steady flows) in the usual presentation of log(*c*) horizontal versus *z* linear, vertical.

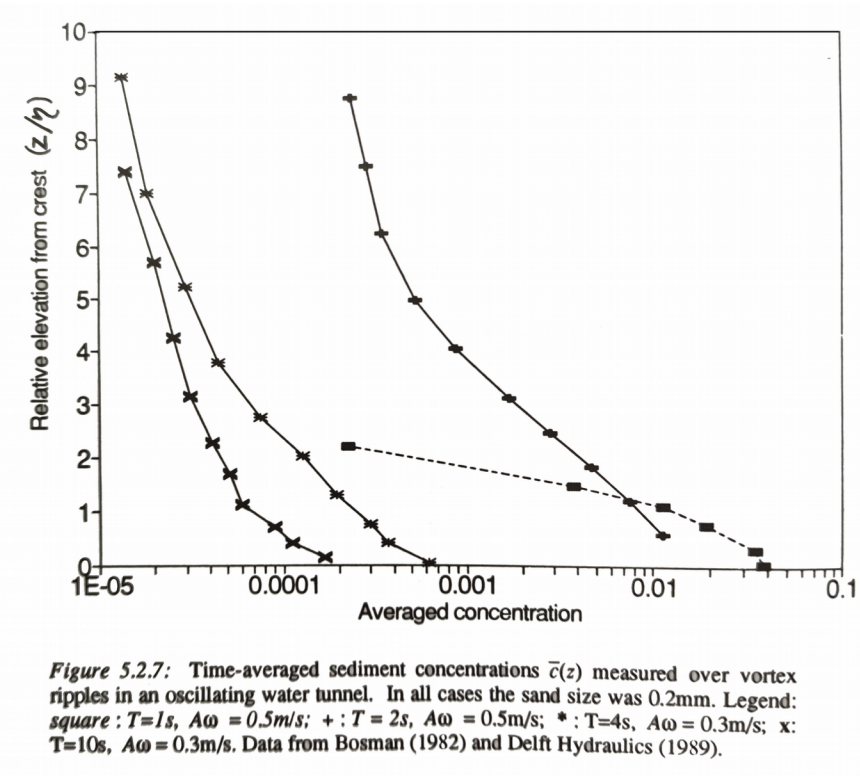

Figure 5.2.7: **Time-averaged sediment concentrations $\bar{c}(z)$ measured over vortex ripples in an oscillating water tunnel. In all cases the sand size was 0.2mm. Legend: *square* : *T=1s, Aω = 0.5m/s;* + : *T = 2s,* Aω = 0.5m/s; * : T=4s, Aω = 0.3m/s; x: T=10s, Aω = 0.3m/s. Data from Bosman (1982) and Delft Hydraulics (1989).**

Figure 1: Systematic trend of $\acute{c}(z)$ -shape from upward convex for short (1s) to upward concave for longer (10s) wave periods. From Nielsen (1992).

This qualitative transition of $\acute{c}(z)$ -profiles was suggested as an urgent research challenge in Section 7.6 of Nielsen (1992), but the challenge has so far remained unanswered. The paper is an attempt to explain this observation, via different interactions of co-rotating (Winant & Browand 1974) versus counter rotating (Cantwell & Coles, 1983) vortices in quasi- 2D flows: In 2D steady flows the vortices are co-rotating and can pair up and add their mixing capacity. In rapidly alternating flows, the vortices are counter-rotating and tend to cancel each-others mixing capacity. The destructive behaviour in alternating flows is also indicated by a rapid decrease of (vertical) turbulence intensity *w'*(*z*) with distance from the bed.

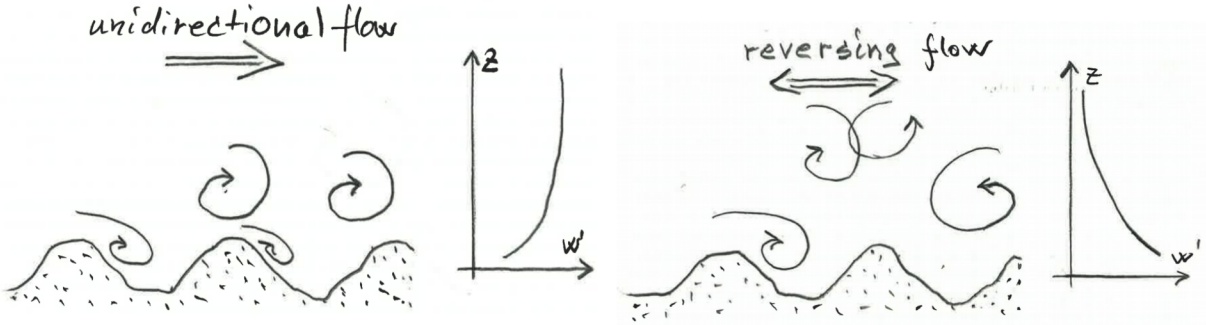

Figure 2: In 2D steady flows, vortices are born co-rotation. While, in reversing flows, equal numbers of counter-rotating vortices are formed. The latter seem to interact with rotation cancellation and strong energy dissipation.

REFERENCES

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Winant, C D & F K Browand (1974): Vortex pairing: the mechanism of turbulent mixing-layer growth at moderate Reynolds number. *J Fluid Mech, Vol 63, Part 2*, pp 237-255