

Flocculation characteristics on a muddy tidal flat

Chao Guo¹, He Qing¹, Bram van Prooijen² and Wang Xianye¹

¹ State Key Laboratory of Estuarine and Coastal Research, East China Normal University, P.R. China
E-mail: chaoguo@ecnu.cn

² Department of Hydraulic Engineering, Faculty of Civil Engineering and Geosciences, Delft University of Technology, Delft, the Netherlands

Introduction

In the estuarine intertidal flats, the fate of suspended matter highly depends on flocculation processes. The relationship between floc size, settling velocity and the turbulent shearing and suspended sediment concentration (SSC) has been discussed in various estuaries (e.g. Manning, 2004; Pejrup and Mikkelsen, 2010). Despite this progress, there are still many issues unresolved. To gain more insight in the flocculation characteristics and their significance for the deposition of suspended sediment on the mud tidal flat, a field survey was carried out on a muddy tidal flat of the Westerschelde (the Netherlands). The prime objective was to evaluate the short-term variations of flocculation and de-flocculation over a full spring-neap cycle as well as the potential settling flux of suspended sediment.

Methods

The field observation was done on the muddy Kapellebank tidal flat in Westerschelde, the Netherlands (Fig. 1) for one month, from 28 April 2014 to 28 May 2014. The landform of this flat is simple with a small slope from the bank to channel. Tidal currents generate peak velocities of 0.45m/s and 0.35m/s during flood and ebb, respectively, with a maximum tidal range of 290cm during spring tide. Increased wind speeds were found over a period of 6 days, while the remaining period could be classified as calm.

A LISST-100C was used together with an ADV (Nortek 6.0MHz Vector), two OBS-3+ at 15 and 30cm above the bed, and a downward looking ADCP (Nortek 2.0MHz HR-Profiler). All the instruments were moored on the tidal flat to get synchronous information of hydrodynamics and sediment flocs. The sensor of the LISST was 15cm above the bed, and it was used to get *in situ* particle size distributions and the mean effective density and settling speed of flocs. The calculated floc effective density through the results of LISST and SSC include the effects of porosity and shape, however, their influences on settling velocity of flocs were only minor factors according to Lick and Huang (1993). Therefore we consider the settling velocity of floc through effective density by Stokes law as reasonable.



Fig. 1. Location of the measurement site.

Results

Fig. 2 shows a subset of the measurements during spring tide. A consistent variation of the floc size is found over a tidal cycle. The largest flocs were over $200\mu\text{m}$ and occurred at low turbulent shear stress at the turning of the tidal velocity from flood to ebb. The smallest flocs of around $60\text{--}70\mu\text{m}$ were found at maximum ebb velocity. Just before falling dry, a peak in southern velocity is found (most clear in the second and third tide). This peak can be attributed to large scale turbulent eddies at the interface between channel and flat. These velocities result in a local minimum in floc diameter. The flocculation and floc break-up were asymmetric in a tidal cycle. During the spring tides (Fig. 2), the fragile macroflocs break up to the stronger $60\text{--}70\mu\text{m}$ microflocs soon after the low turbulent shear. However, the time it took to form the macroflocs was twice or triple. The pattern was quite different during the neap tide, the time of floc break up was a little longer than sediment flocculation. The turbidity shows a close correlation with the shear stress due to tidal flow. For shallow water, waves will play a role as well.

Conclusion and outlook

A comprehensive data set was obtained recently at a muddy tidal flat in the Westerschelde, containing high-resolution hydrodynamic results and sediment characteristics. The patterns show a very consistent pattern for the different tides. Furthermore, clear correlations are found between hydrodynamic data and sediment data. A full interpretation of the data set is in progress and will be discussed in the full paper.

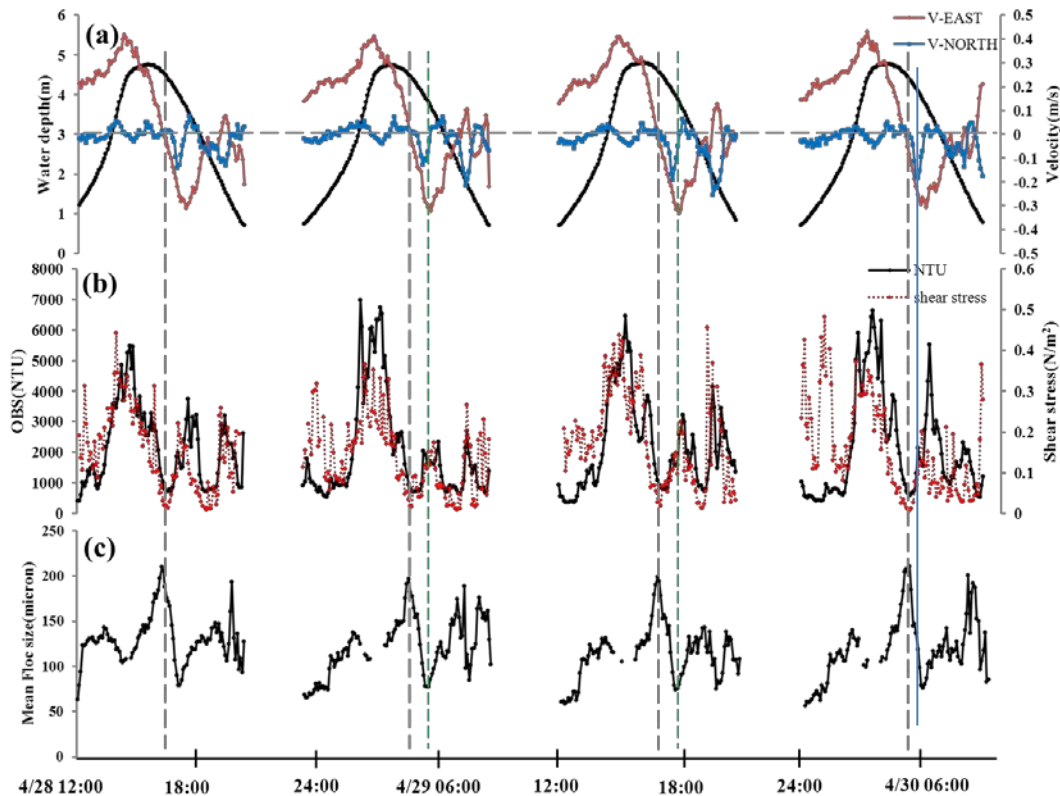


Fig. 2. Results during spring tides. (a) Depth (black line) and current speed of two directions (east and north), (b) NTU from OBS-3+ sensor (black line) and turbulent shear stress (red dotted line) and (c) mean floc size.

References

- Lick W. and H. Huang. 1993. Flocculation and the physical properties of flocs. Nearshore and estuarine cohesive sediment transport 21-39.
- Manning A.J. 2004. Observations of the properties of flocculated cohesive sediment in three western European estuaries. *Journal of Coastal Research* 41:70-81.
- Pejrup M. and O.A. Mikkelsen. 2010. Factors controlling the field settling velocity of cohesive sediment in estuaries. *Estuarine, Coastal and Shelf Science* 87(2):177-185.