Supplementary information for: "Migrating subaqueous dunes capture clay flocs"

Sjoukje I. de Lange[1*], Anne van der Wilk[1], Claire Chassagne[2], Waqas Ali[2], Maximilian P. Born[3], Kristian Brodersen[3], Antonius J.F. Hoitink[1], Kryss Waldschläger[1]

[1*]Environmental Sciences, Wageningen University, Wageningen, Netherlands.
[2]Faculty of Civil Engineering and Geosciences, Delft University of Technology, Delft, Netherlands.
[3]Institute of Hydraulic Engineering and Water Resources Management, RWTH-Aachen University, Aachen, Germany.

*Corresponding author(s). E-mail(s): sjoukje.delange@wur.nl; Contributing authors: anne.vanderwilk@wur.nl; c.chassagne@tudelft.nl; w.ali@tudelft.nl; born@iww.rwth-aachen.de; brodersen@iww.rwth-aachen.de; ton.hoitink@wur.nl; kryss.waldschlager@wur.nl;

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Introduction

In these supplementary materials, we discuss the preparatory experiments used to define the parameter space of the annular flume experiments (Text S1, Figure S1 and S2, Table S1). Furthermore, we provide additional figures regarding the transport of flocs (Figure S3), the dune geometry (Figure S4) and the relation between flocs and dunes (Figure S5).

Text S1: Preparatory experiments

To quantify the dose of flocculant that would generate the largest flocs, and which dose would create 'overdosing' [1, 2], settling column experiments were preformed (Figure S1). A liquid flocculant solution was prepared by dissolving the solid grains of flocculant ZETAG-8125 in tap water. The sediment used consisted of sand with a grain size (D_{50}) of 500 μm and 2% kaolin clay suspended in water. For each experiment 50 g of sediment (49 g of sand and 1 g of clay) was added to a 500 mL glass cylinder, the cylinder was then filled with water after which flocculant solution was added. Five different flocculant amounts were added, ranging from 1 10^4 to 5 * 10^4 g. The cylinder was then carefully turned upside down 10 times after which the flocculation process was observed. During the flocculation process the floc size, floc density and water turbidity were noted (Table S1). From this a rough estimation of the concentration of flocculant that would produce the biggest flocs was determined, which was later used to determine the concentrations of flocculant to be used in the annular flume. We observed that the water became mostly clear at a dosage of 0.5 mg of flocculant, when all clay particles formed flocs. Sand grains as used in main experiments (D_{50}) of 350 μm) did not participate in the flocculation process, and would settle quickly after the shaking of the column. Also smaller sand grain sizes (250 μm) did not flocculate.

The settling column experiments gave insight in the flocculation process for a situation without shear stress, however in the annular flume experiments the flocs would be subject to shear. To investigate what effect shear stress would have on the flocculation process, an experiment in a vertically-placed rotating wheel was set up (Figure S2). This wheel is a circular container that can spin on its axis back and forth at roughly 60 degrees, allowing the sediment to stay mobile. We observed that flocs interacted with the bed by being buried and re-entrained. As anticipated, flocs were smaller when exposed to shear [3, 4], yet the dosages determined under no shear, remained accurate. Despite the fact that the sand saltated, the sand was not incorporated in the flocs.

Finally, we tested if the method of mixing the sand, clay and flocculant impacted the final result. Erlenmeyer flasks were prepared in which the mixtures where mixed in various ways (i.e. order of adding the sediments, concentration of the flocculant solution). Initially, different mixing procedures for sand, clay, and flocculant yielded varying floc characteristic. Then, the flasks were kept in a roller shaker and were gently rotated for one hour. After one hour, the mixtures looked identical. This implies that the mixing method does not influence the final floc characteristics.

References

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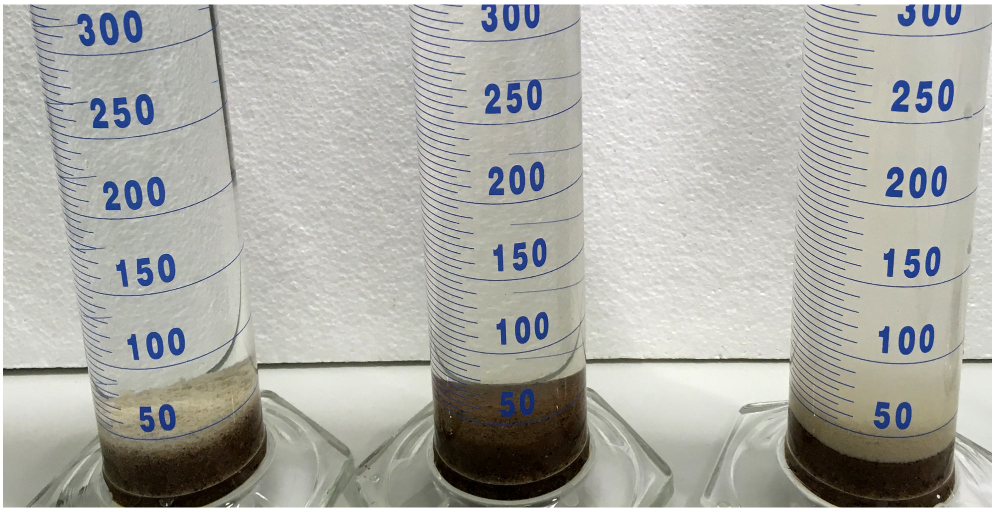

Fig. S1 Settling columns to test the flocculant concentration. left: cylinder with sand, clay and a high flocculant concentration. A large layer of flocs has settled. middle: cylinder with sand and flocculant. No flocs are observed. right: cylinder with sand, clay and a low flocculant concentration. The settled layers of flocs is less thick, and the water is mildly turbid.

Table S1 Overview of the preparatory experiments to determine flocculant concentration. The observed turbidity is expressed as T (Turbid): not possible to see through, MT (Mildly Turbid): possible to see through but with slight obscuration and discoloration of white background and C (Clear): White background not noticeably discoloured. Floc size and floc density are estimated via visual inspection.

Flocculant type	**solution added (mL)**	**total flocculant (g)**	**turbidity**	**floc size (μm)**	**floc density**
ZETAG-8125	0.1	0.0001	T	<100	Low
ZETAG-8125	0.2	0.0002	MT	100-400	High
ZETAG-8125	0.3	0.0003	MT	100-400	High
ZETAG-8125	0.4	0.0004	MT	>400	High
ZETAG-8125	0.5	0.0005	C	>400	High

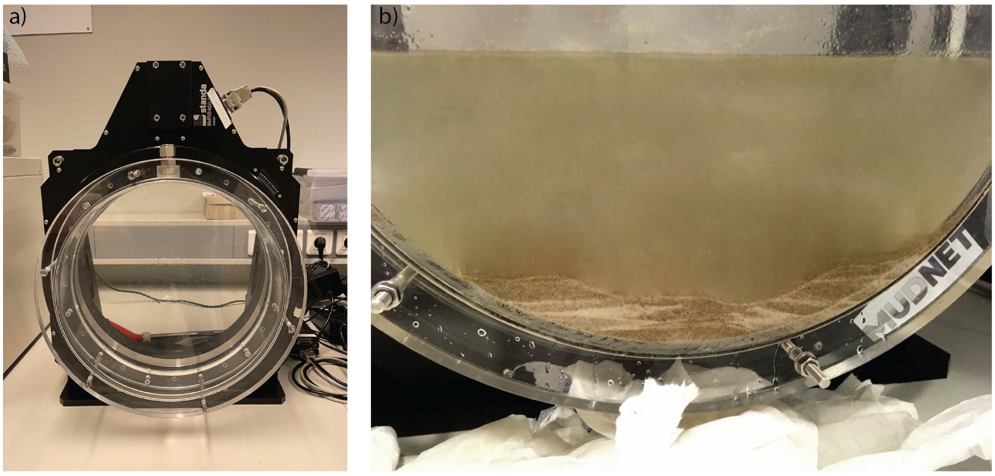

Fig. S2 Rotating wheel used in the preliminary experiments, to test the effect of shear on flocculated sediment.

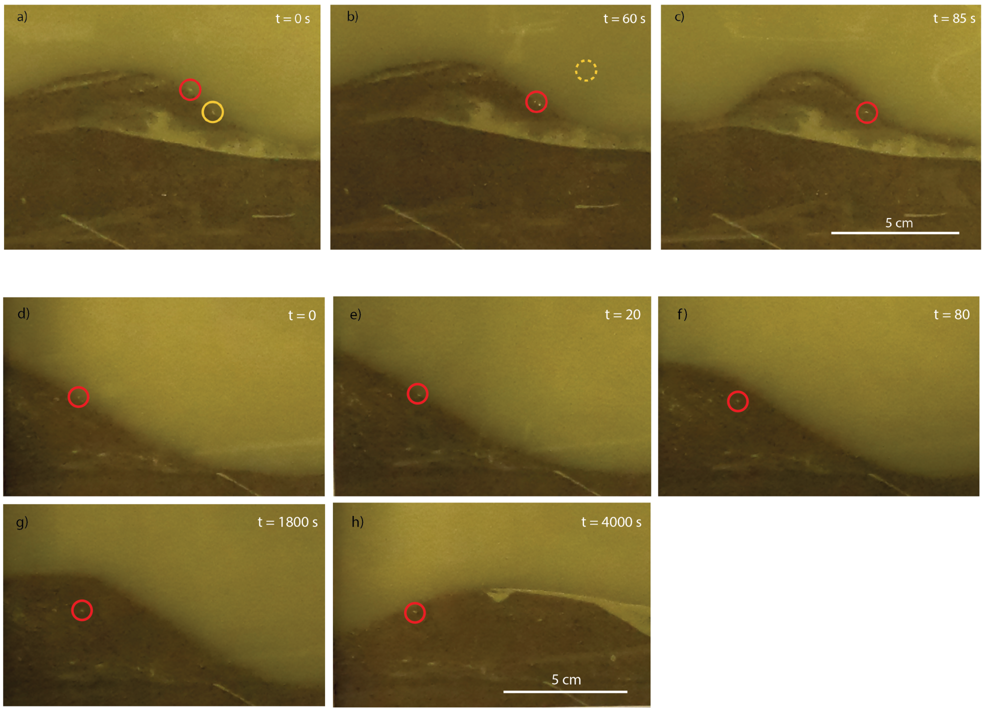

Fig. S3 The burial of individual flocs (red circle) and the resuspension of another floc (yellow circle).

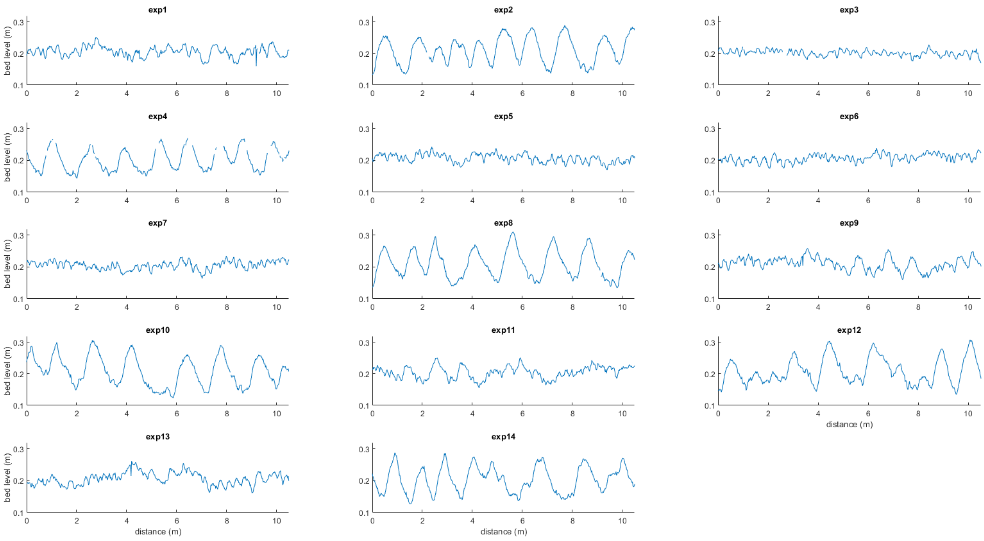

Fig. S4 Bed level profiles as taken by the StreamPro. Profiles are from beam 2 of the StreamPro, taken at the end of each experiment. Experiment numbers refer to Table 2 in the main manuscript.

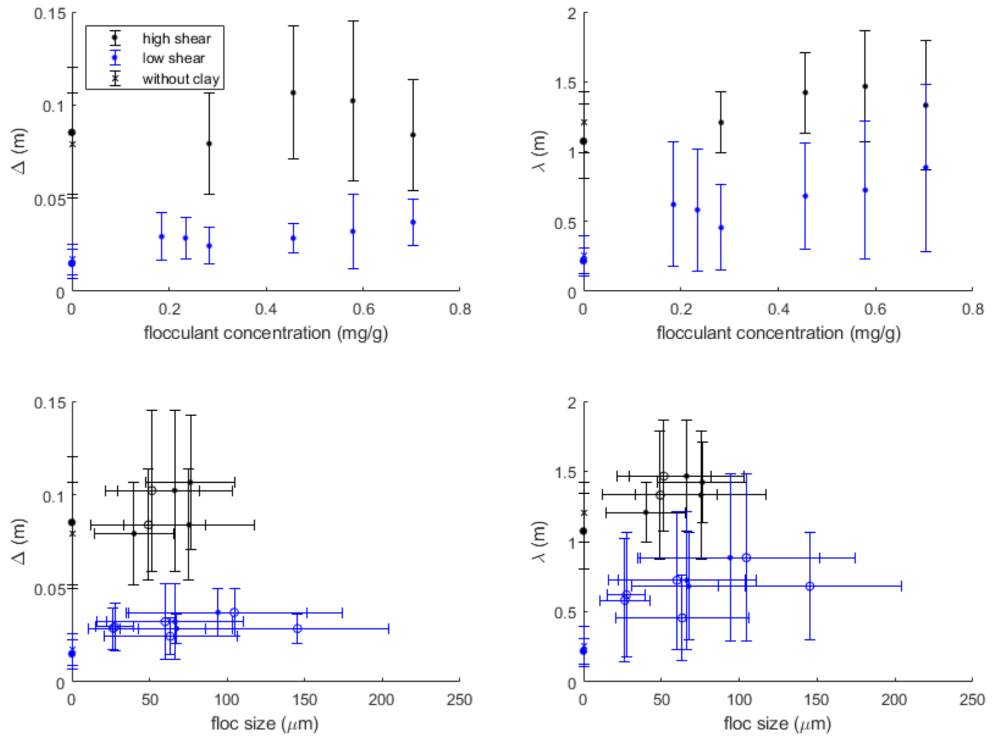

Fig. S5 The impact of flocculant amount (a-b) and floc size (c-d) on dune geometry (height Δ and length λ). Error bars indicate standard deviation. Marker with 'x' at flocculant concentration and floc size 0 indicates the experiments without clay, while the closed circle indicates the experiments with clay but without flocculant.