

# Bedform dynamics in mixed sand-clay-EPS substrates

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## Introduction

Understanding and quantifying sediment dynamics in coastal and estuarine environments remains challenging. This is particularly the case when including and considering the complexities of sediment mixtures, such as sand and clay and their biological mediation. Quantifying such mediation is key to parameterizing physical processes at the flow bed interface, which ultimately controls morphodynamics at local and regional scales (French, 2010). Moreover, understanding sediment movement is also vital for monitoring water quality, fate of pollutants, and the success of coastal dredging operations (Rao *et al.*, 2011). Fine sediments, which commonly exist in natural estuarine flow systems and are composed of fine silts and clays, with biological agents that have cohesive properties that modulate the complex interactions between flow, sediment transport and morphological evolution (Baas and Best, 2008). In morphodynamic investigations, the properties and influence of the substrate has largely been ignored, but can significantly impinge on the behaviour and dynamics of sediment transport, which ultimately influences and interacts with the form and the size of bedforms. Our existing flow and transport predictions for these environments are seriously impeded by an almost complete lack of process based knowledge of sediment behaviour consisting of complex mixture of cohesionless sand and biologically active cohesive muds. The work presented here forms a part of the UK NERC "COHBED" project which mainly aims to fill this gap in knowledge. Herein results from a set of controlled laboratory experiments, conducted using mixed cohesive and noncohesive sediment and Xanthan gum (as a proxy for the biological stickiness of Extracellular Polymeric Substances (EPS)), are presented and discussed.

## Experiment design

Experiments were undertaken at the University of Hull's Total Environment Simulator flume/wave tank facility [Fig. 1 ([www.hull.ac.uk/tes](http://www.hull.ac.uk/tes))]. The tank was sectioned into a 10 x 2m flume channel and filled with varying ratios of fine sand and kaolin clay, varying ratios of fine sand and EPS (Xanthan gum, a natural biopolymer) and varying ratios of sand, clay and EPS (Table I).



Fig. 1. Flume lab set-up at the University of Hull's Total Environment Simulator flume/wave tank facility.

Saline water (at 15 PSU) was used throughout the experimental set and was pumped to produce a constant unidirectional current with a depth-averaged flow velocity and depth in the test section that occupied the known dune regime for noncohesive sands. A total of 16 individual runs were

conducted lasting 10.5 hours for each, with continuous acoustic monitoring of the flow current and bed topography via automated traverse and profilers, with water and bed samples also taken every 30 minutes during the run.

Table I. Clay content of start, end, loss percentages in substrates of 16 runs

Run	Clay % at start	Clay % at end	Clay Loss by % of total mass	Clay loss by % of clay mass
1	18.15	16.8	1.35	7.4
2	14.11	12.09	2.02	14.3
3	12.67	11.26	1.41	11.1
4	11.92	7.56	4.36	36.6
5	9.77	9.53	0.24	2.5
6	8.87	8.21	0.66	7.4
7	4.74	1.85	2.89	61.0
8	1.93	1.25	0.68	35.2
9	20.86	17.70	3.16	15.15
10	17.70	17.39	0.31	1.75
11	17.39	15.09	2.30	13.23
12	12.02	10.51	1.51	12.56
13	9.89	9.19	0.70	7.08
14	6.77	6.15	0.62	9.16
15	4.83	4.08	0.75	15.53
16	4.65	3.35	1.30	27.96

### Methods and results

Suspended sediments were measured using a LISST100X (Laser In Situ Scattering and Transmissometry) using physical water samples. Grain size and concentration data has been analyzed using Matlab R2012b software creating a database from each of the 16 runs. Additionally, selected water samples were analysed using the LabSFLOC - Laboratory Spectral Flocculation Characteristics - instrument (e.g. Manning *et al.*, 2007), facilitating the measurement of the floc sizes and settling velocities using high resolution video technology (see Manning and Dyer, 2002), and thus enabling the determination of the densities of suspended particulates and flocs across each of the substrate mixtures. Thus the effects of varying suspended sands, clays and EPS within the substrate mixture on flocculation processes and suspended sediment dynamics were monitored throughout each of the runs.

Additionally, flow and turbulence structure were sampled at-a-point through a stacked profile of 5 ADVs, which sampled velocity at 25Hz. The bedform development was monitored throughout the experiments through side and plan view wide angle video and through ultrasonic ranging transducers spanning a 4.5 x 0.5m working section swath. The paper will present and discuss the detailed results, highlighting the influence of substrate characteristics on sediment transport, flocculation and bedform dynamics.

### References

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