



Influences of flocculation on bed properties
for fine-grained cohesive sediment

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ABSTRACT

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An understanding of the behaviour of newly deposited soil is important because of its direct applications in fields such as harbour siltation and storage of dredge slurries. In coastal regions the dominant mode for deposition of fine-grained cohesive material is through flocculation- the electrostatic aggregation of mud particles. The present study focuses on the measurement of both flocculation conditions and bed properties, towards the understanding of the influence of the former on the latter. A computerised laboratory setup, complete from sedimentation and flocculation to the long term consolidation allows each of these processes to be observed in instrumented perspex columns without the many variables present in an estuary. The bed deposition rates resemble those found in natural estuaries, and therefore this technique is a much improved method for examining natural processes than the method of slurry deposition, which is normally employed in soil mechanics.

An image acquisition and analysis system has been designed specifically for this work. Image sequences are analysed in real time to give information about the dimensions and concentration of the particles, and the particle velocities. Floc sizes increase as the particle concentration increases in the column. Increasing the concentration further leads to an overall hindering of the sedimentation rate and breakup of the flocs.

Images of beds formed through slow sedimentation clearly show aggregate features that are not present in slurry experiments. From low to medium sedimentation rates the bed height, normalised by the mass of sediment in the bed, increases. From medium to high rates of sedimentation, however, the normalised bed heights decrease. Overall slurry experiments have lower bed heights than slowly deposited experiments. Image analysis of the bed surface (top 0.5mm) has revealed that aggregates which are present immediately after deposition are broken down over tens of hours. The ISIS instrument has been modified to gather information about the resistance to erosion of the beds. A bed is more easily eroded after it has had a long period of consolidation. X-ray density measurements and imaging techniques are used to link the strength of the bed to biological factors.

X-ray bulk density and pore pressure measurements allow calculations of void ratio, porosity, and effective stress. Bender element apparatus has been constructed to measure shear stiffness of the soil, and bed strength measurements are made using a shear vane. It is found that variations in the sedimentation conditions have significant effects on bed density and on void ratio. These effects continue to be visible in the consolidated bed, even after an order of magnitude increase in the total vertical bed stress (equivalent to the range of metres of overburden pressure). The variations in the bed structure can have profound effects on bed strength. Methods to compare floc measurements to bed measurements are complicated by the inherent variation in floc data. Possible techniques include the use of solids volume fraction, fractal dimension and intrinsic sediment properties. The usefulness of each of these is assessed. It is suggested that it is the frequency at which the bed is bombarded by flocs, and not the properties of the flocs themselves, that largely determines the bed properties.

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Contents

Chapter 1 Introduction	7
1.1 General Background	7
1.2 Thesis Outline	10
1.3 Literature Reviews	11
1.4 Flocculation review	11
DVLO Theory	12
Collision Kinetics	15
Floc characteristics with consequences to the bed	17
1.5 Video imagery and analysis of flocs	20
1.6 Variation in flocs	23
Organic content	23
Turbulence/shear	24
Concentration	25
Salinity	25
1.7 Consolidation and bed processes	26
Creep	30
Intrinsic vs. Natural Sediment Properties	32
Development of Bed Stiffness and Strength	33
Chapter 2 Methods and Equipment	40
2.1 Settling column apparatus	40
2.2 X-ray density measurements	41
2.3 Porewater pressure	42
2.4 Hydraulic Gradient	44
2.5 Steady sedimentation system	44
2.6 Video System	47
Video camera	47
PC frame grabber	48
Illumination	49
Software	50
Analysis using the Matlab Image Analysis Toolbox	50
Settling velocities	53
Bender elements, Stiffness	54
2.7 Data Manipulation	58
Chapter 3 Soil Properties and Experiments	73
3.1 Soil Property Tests	73
3.2 Experimental Information	75
Slurry deposited versus slowly sedimented experiments	75
Setting up the experiments	75
Variation in sedimentation rate	77
3.3 Units and conversions	77
Chapter 4 Flocculation Characteristics	85
4.1 Introduction	85

4.2 Overall floc characteristics	85
Size and shape	85
Orientation, eccentricity and sphericity	87
Effect of turbulence on floc size	90
4.3 Concentration	90
4.4 Settling velocity and hindered settling	91
Effect of floc shape on settling velocity	94
4.5 Excess Density	95
4.6 Effects of salinity and pH	100
4.7 Conclusions	101
Chapter 5 Bed formation and external measurements	118
5.1 Description of settling and consolidating beds	118
5.2 Bed Height and dimensionless bed height	119
5.3 Effect of hydraulic gradient on flocculated beds	125
5.4 Bed deposition	126
5.5 Tracking the bed surface	127
5.6 Internal collapse	128
5.7 Conclusions	129
Chapter 6 Bed formation - internal measurements	147
6.1 Density profiles	147
Hydraulic Gradient	149
6.2 Void ratio, effective stress and time correlations	150
Analysis of peaks and troughs	153
6.3 Development of stiffness and strength	155
Bender element stiffness	155
Shear vane strength	156
6.4 Conclusions	157
Chapter 7 Erosion of Natural mud beds	174
7.1 Introduction	174
7.2 Erosion Experiments	175
7.3 Results	175
7.4 Biological features of the beds	180
7.5 Conclusions	182
Chapter 8 Influences of flocs on the bed	189
8.1 Floc formation, construction and deconstruction	189
8.2 Consolidation of the aggregates	190
8.3 Comparitive Measurements	192
Volume fraction and porosity	192
Fractal Interpretation	195
8.4 Creep and time dependent effects	198
8.5 Conclusions	201
Chapter 9 Conclusions and Future Research	210

9.1 Floc Properties	210
9.2 Influences of flocs on beds	211
9.3 Recommendations for future research	212
References	215