Self-weight consolidation tests of the Río de la Plata sediments

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Introduction

As it is described in Been and Sills (1981) sediment particles and flocs suspended in the water column settle down as the flow velocity reduces. As material accumulates on the bottom, the pore space between the particles decreases and the water is expelled. This process is known as self-weight consolidation of the deposit. As the consolidation progresses, the sediment particles stop to behave as isolated particles in a suspension and start to behave as a soil where particle-particle interactions are relevant. Due to the large vertical deformations observed during the consolidation process, a simple laboratory 1D vertical test is usually used to analyse consolidation characteristics under motionless conditions (Migniot, 1989; Been and Sills, 1981; Samadi-Boroujeni *et al.*, 2005). In this article we describe the sedimentation and self-weight consolidation tests carried on cohesive sediments extracted from five different locations in the Río de la Plata river-estuarine system (Fig. 1 left panel). The tests focused on the influence of mud composition, initial concentration and salinity on the self-weight consolidation process.

Methodology

Three 2m height and 0.088m diameter Plexiglas columns with measuring tapes were placed at our Laboratory (Fig. 1 right panel). At the beginning of each test the column was filled with a mixture of cohesive sediment and water. During the sedimentation-consolidation experiment the clear-muddy water interface and the bed-muddy water interface positions were registered over an extended time period.

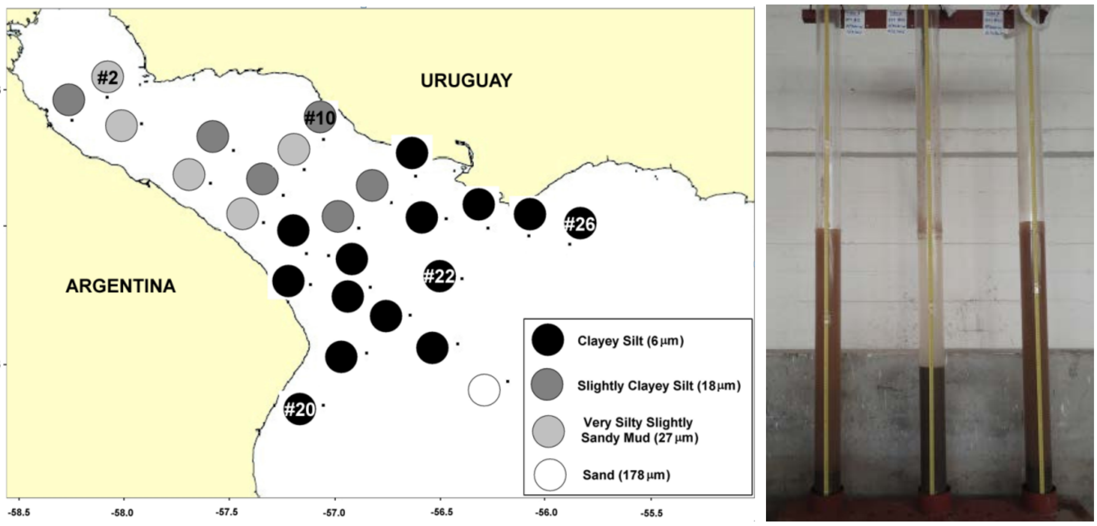

Fig. 1. Left panel: The Río de la Plata and sediment samples classification, numbers indicate the samples selected for this study. Right panel: A view of the consolidation columns at IMFIA.

Table I. Test main characteristics

Test name	Initial concentration C0 [g/l]	Initial column height [m]	Experiment duration [days]	Mud sample	Mud composition % sand	% silt	% clay	R= %clay / %silt	Salinity [g/l]
e1t1	98	1.011	23	#22	1	68	31	0.45	0
e1t2	91	0.944	21	#22	1	68	31	0.45	0
e1t3	62	0.933	22	#22	1	68	31	0.45	0
e2t1	100	1.003	162	#2	19	71	9	0.13	0
e2t2	100	0.973	162	#26	0	66	33	0.50	0
e2t3	100	1.032	162	#10	1	86	14	0.16	0
e3t1	100	0.957	65	#20	0	56	44	0.77	0
e3t2	100	0.966	53	#20	0	56	44	0.77	18
e3t3	100	0.962	51	#22	1	68	31	0.45	18

The main parameters of the experiments are presented on Table 1. Nine experiments were performed with the same initial suspension height (approximately 1m). Experiments e1t1, e1t2 and e1t3 were performed with the same mud sample (#22) but different initial suspension concentration. Experiments e2t1, e2t2, e2t3 and e3t1 were performed using different mud samples (#2, #10, #20, #26) but with the same initial concentration. Finally, experiments e3t2 and e3t3 repeated the conditions of experiments e3t1 and e1t1 but with a 18 g_{NaCl}/l salinity.

Results

The bed-muddy water interface position for some of the tests is presented in Fig. 2. The right panel of Fig. 2 shows that the consolidation process depends on sediment composition, particularly on the fine fraction. For silty samples (more than 70% silt/clay, e2t1 and e2t3) the interface moved down very fast and the obtained curves show a clearly distinct behaviour when they are compared with the ones obtained for finer samples (e1t1, e2t2, e3t1). Finer samples present a slowly initial sedimentation stage followed by a long consolidation stage, extends for several days, with a decreasing rate (e2t2, e3t1). Comparing these last two tests we can see that the initial sedimentation stage is essentially the same, while the second stage shows a higher consolidation rate for the sample with a higher clay content. The third stage shows the same consolidation rate for both sediments with a longer extension for the finer sample. The e3t1 test did not reach the fourth stage.

Finally, the role of salinity on the sedimentation and consolidation process of two different samples (e3t2, e3t3) was studied. The results are shown on the left panel of Fig. 2, floc formation was visually observed during these tests. The results show that the salinity modifies the extension of the first stage maintaining the rate during the second and third stages. Nevertheless, the deposit height at the end of these two tests is greater than the one obtained in the test without salinity, showing a clear influence of floc properties on these last stages. Regarding tests with different initial concentrations (not presented here) the results showed the decrease of the initial concentration produced an increment of the sedimentation front velocity during the initial stage and essentially the same overall characteristic during the other stages.

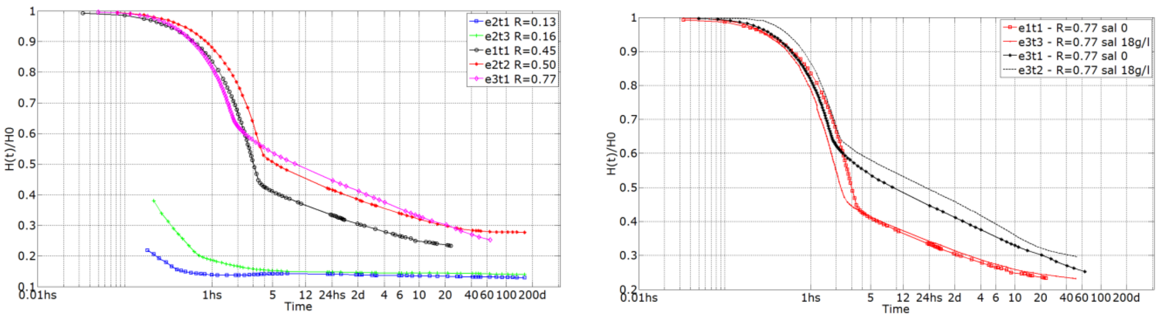

Fig. 2. Temporal variation of front position, during the sedimentation test.

Conclusions

We presented several self-weight consolidation tests performed with Río de la Plata sediments. The main results are in good agreement with exiting results available in the bibliography (Migniot, 1989; Samadi-Boroujeni, 2005). Samples with higher silt/clay proportion showed faster settling and consolidation stages with a stable height during the first day of the experiment. A different behaviour is observed for cohesive sediment with a balanced proportion between silt and clay, here a slow initial settling stage and a continuous consolidation process during several days with a decreasing rate. The data collected during these tests allowed for a better understanding of the consolidation process for the different regions of the Río de la Plata, and the future incorporation of the consolidation process into existing numerical models.

References

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