Panel discussion: Sedimentation of tailings

Débat de spécialistes: Sédimentation des stériles miniers

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ABSTRACT: Tailings are sedimented in water. Their density after sedimentation determines many of their properties. Both the colloidal content of the water in which they are sedimented and the noise level in it at the time of deposition affect this density, as discussed here.

RESUMÉ: Cet article présente la façon dont la teneur en colloïde de l'eau dans laquelle ils sont sédimentés et le niveau sonore présent dans l'eau au moment de leur déposition affectent cette densité.

INTRODUCTION

The properties of non-cohesive sediments are controlled by the mechanism of hydraulic deposition. In nature this produces a wide range of densities, including very loose packing. In the laboratory, with clean water and sand, it produces a near consistent relative density of around 0.3 - 0.4. Factors involved in the field are the nature of the water into which sedimentation occurs, and the energy of the depositional environment.

THE EFFECT OF WATER CHEMISTRY

This was considered by Mantz (1977). He measured the angle of repose of different sizes of quartz particles in water of different salt concentrations, from pure water to sea water. A level sedimented surface in a measuring cylinder was tilted, and the angle of repose determined as the angle to which the surface moved. Figure 1 shows the results obtained. The angle for 0.015mm particles changes from 27° to 36° as salt concentration changes from soft to hard water. The change disappears for particles larger than 0.066mm diameter. The results indicate that particles smaller than 0.05mm (medium silt) are affected by the chemistry of the water. The effect increases with decreasing size.

THE EFFECT OF COLLOIDS IN THE WATER

Washed sand and clean water are usually used in laboratory sedimentation. Neither is likely in the field. Water is usually dirty and contains colloidal clay particles. Natural deposits of clean sand are rare. Some years ago some simple laboratory tests were run at Imperial College, London, as undergraduate projects. A quartz sand was deposited in water with a varying colloidal clay content. A 0.03 - 0.15mm sand was used, so that packing was unaffected by water chemistry. The results are relevant to deposition of tailings in ponds, rather than on a beach.

1000ml measuring cylinders were used in the main experiments, filled with water in which clay had been dispersed. London tap-water was used, and the clay suspension was flocculated. Sand (initially dry) was poured over about thirty seconds to fill the bottom of the cylinder to about 200ml.

Various clay contents, types of clay and clay-silt mixtures were used. Figure 2 shows typical results using base-exchanged UK Sodium Bentonite and London clay in the water. About half the London clay is of colloidal particle size. The void ratio is for the sand alone, and does not include the clay trapped within the sand. Maximum and minimum void ratios, determined in the standard way, are shown for comparison. The effect of a small amount of clay is significant. 10g/l of bentonite in the water is sufficient to give a void ratio greater than the normal maximum. The dry density is decreased by 20%. The clay trapped in the sand increases its dry density by about 0.4%. The clay fraction measured in a grading test on the deposited sand would be 0.4%. The clay suspensions used were little more than dirty water. The results shown were measured shortly after deposition. About 90% of the change was retained after 24 hours.

Deposition by vertical sedimentation is rather artificial, and a second approach was adopted. A small laboratory flume was filled with a clay/water suspension. A platform was placed just above water level, leading to a 33.7° underwater slope. Sand was

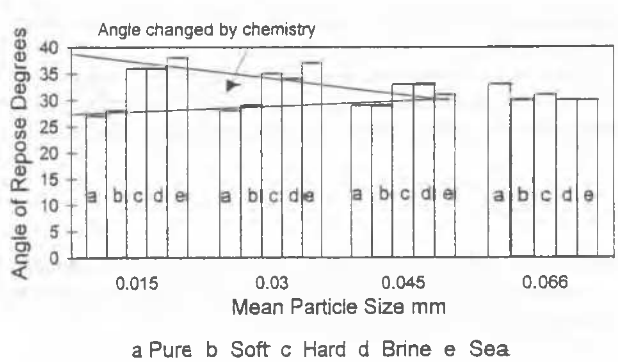

Figure 1 The effect of salt concentration on the under-water angle of repose of silica sands and silts (after Mantz, 1977)

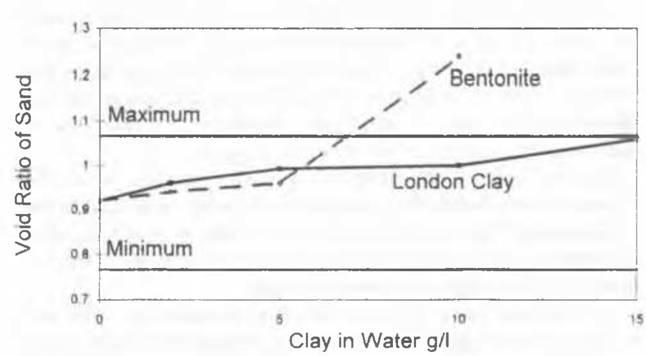

Figure 2 The increase in void ratio of quartz sand deposited in clay/water suspensions.

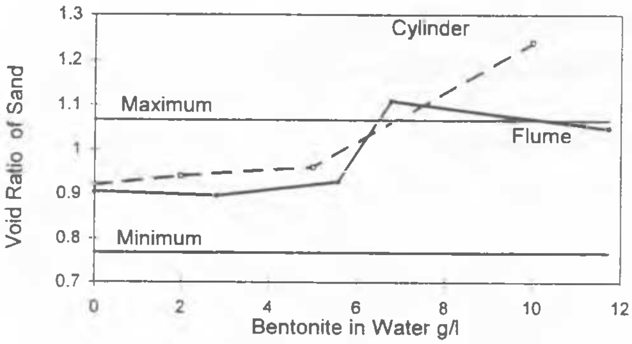

Figure 3 The void ratio of sand deposited on an underwater slope in clay/water suspensions.

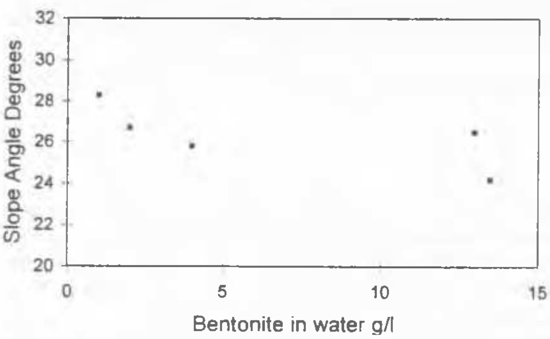

Figure 4 Slope formed by sand underwater as a function of the amount of clay in the water.

placed on the platform and pushed forward to slide down the slope. A length of flume was filled, the volume and weightt of sand being measured. Figure 3 shows some results compared with those from cylinder tests. The flume tests were not as accurate, but a similar trend was found.

Figure 4 shows the eventual slope angles formed by the sand. The slope angle decreased with an increasing amount of clay in the water.

THE EFFECT OF NOISE DURING DEPOSITION

The bottom of a stream during a flood may be a noisy place. Tests were performed to examine the effect of noise level during deposition. Cylinder deposition tests were repeated, but with the cylinder standing on a loudspeaker from an old steam radio. A single frequency noise was generated by an oscillator and played through the loudspeaker, at different frequencies and energising voltages. The loudest noise used was comfortable to listen to. It had no effect on the density of sand after it had been sedimented.

The effect of noise during sedimentation of sand in clean water is shown on figure 5. Void ratio decreased as voltage and noise increased. As shown on figure 6, frequency, changed over the range 25 - 200 Hz at constant voltage and electric power, had no apparent effect on the void ratio obtained. It seems that a sedimenting particle has no natural frequency.

Figure 7 shows the effect of noise on void ratio when the water into which the sand is sedimented contains small amounts of bentonite. The noise prevents the increase in void ratio with increasing clay concentration which happens without noise. It seems to be effective in quite dirty water.

Under-water noise during deposition decreases the void ratio of the deposited sand. The deliberate application of under-water noise during deposition may be a useful way increasing density,

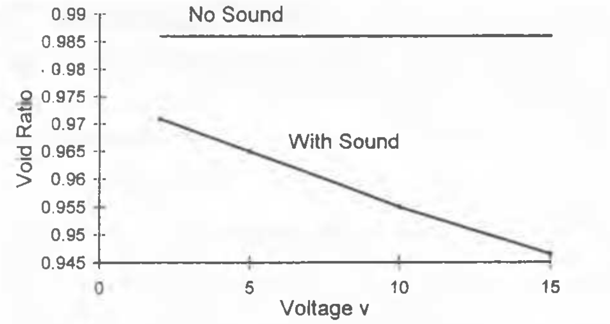

Figure 5 Influence of underwater noise during the sedimentation of quartz sand in clean water on the void ratio after sedimentation.

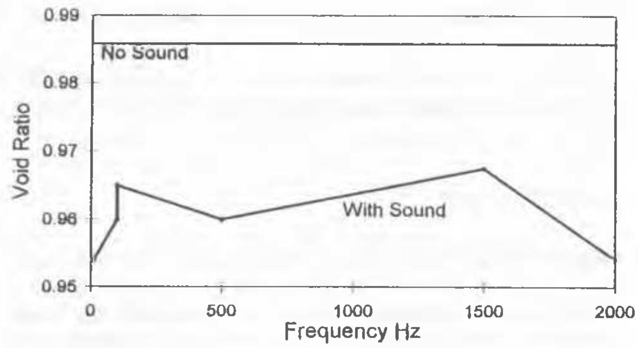

Figure 6 Influence of frequency of underwater noise during sedimentation of clean sand on the void ratio obtained.

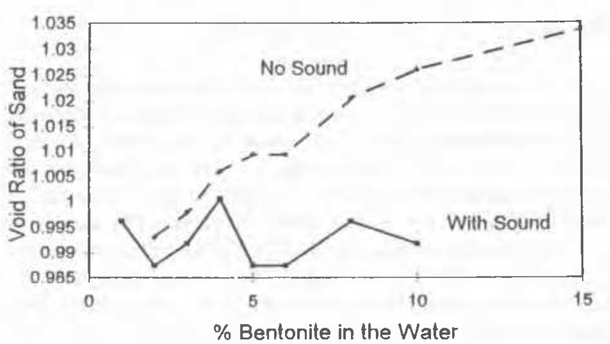

Figure 7 Void ratio of quartz sand after deposition in clay/water suspensions, with and without under-water noise.

although there may be environmental problems with deaf fish. Since the effect depends on energy rather than frequency, it may be more aesthetically pleasing to play music rather than a single frequency noise. Some modern performers produce the equivalent of high-energy white noise. Sadly, earlier and more melodious works might not be as effective.

The simple experiments described show that a given amount of energy is much more effective when applied as noise during deposition than when applied as compaction after deposition.

REFERENCE

Mantz P A (1977) Packing and angle of repose of naturally sedimented fine silica solids immersed in natural aqueous electrolytes. Sedimentology Vol 24.