Technical Memorandum

Subject: Capillary Suction Time Test
Date: April 26, 2012
Project: Spirit Lake Sediment Site

CST Tests

The Capillary Suction Time (CST) Test has been used since the 1970's as a fast, yet reliable method for characterizing fluid filterability, the water retention capacity, and the coefficient of consolidation can be deduced (Hoff, et al., 2004). It has been applied to determine the state of flocculation of clay-bearing fluids.

The capillary suction of the filter paper sucks out the filtrate while a cake is formed inside the cylinder. The filtrate moves outward from the center of the filter. The time it takes for the wet front to travel between two concentric circular rings is referred to as the capillary suction time. The force generated by capillary suction is much greater that the hydrostatic head within the cylinder, so the test is relatively independent of the amount of material as long as there is enough to generate a CST measurement. Fluids with very long CST values cannot be very clearly differentiated and artifacts such as evaporation of water from the blotting paper control the rate of advance of the filtrate. To reduce the effects of evaporation, the tests were conducted inside a "glove-box" where a higher relative humidity was maintained.

In a capillary suction timer, the filterability of the suspension is determined by measuring the filtration rate of water through a standard filter paper using two electrodes. A low CST implies good filterability. For a flocculated sample, the CST should be low since water flows quickly through the bed of particles while for a well dispersed sample, the CST should be high. This gives a quick and reliable method of determining dispersability of colloidal suspensions. The higher the value of CST, the higher the dispersability of the material.

The relative floc strength can be determined by measuring the CST after stirring. The slope of the CST vs. stirring time plot is used as a measure of floc breakdown. A small (or negative which means better filterability after turbulence) slope means strong flocs. Filtration velocity (the slope of CST vs. stirring

time) reveals the flocculation mechanism because it is a measure of the bulk properties of the primary flocs. An increase in the number of small particles causes a decrease in the dewaterability.

Studies have shown that the CST values correlated well with the Methylene Blue Adsorption (MBA) test values and may be used as a complementary technique for the evaluation of a material. An inverse relationship was found between CST values and MBA values.

Procedure

The CST test was performed using a OFI Testing Equipment, Inc. Model 294-00 CST instrument with #294-01, chromatography grade filter paper (comparable to Whatman 17 chromatography paper). A 1.8 cm funnel opening was used during testing. Manufacturer's SOP was followed for testing. An approximate 5 mL subsample collected from a homogenized bulk sample was used for testing. The entire CST apparatus was placed into a "glove box" to reduce the effects of water evaporation during testing.

Results

The CST testing yielded times (average of three tests) ranging from a high of 846.5 seconds for Sample UC-502-1 and a low of 101.0 seconds for Sample WM-517-1. It was noted that the samples that had a higher CST values also had a higher standard deviation. This could be the effect of the non-homogeneous nature of the material or evaporation of water during the test.

Discussion

Additional CST testing results from future samples would provide a more reliable (larger) data set. Further analysis of the data will be performed during the Feasibility Study.

Table 1
Capillary Suction Tests
Spirit Lake (Former U. S. Steel Duluth Works) Sediment Site
Saint Louis River, Duluth, Minnesota

11/25/2011

UC-501-1					
Trial	Size (cm)	Paper	Time (s)		
1	1.8	294-01	253.6		
2	1.8	294-01	415.1	Average Time:	Standard Deviation
3	1.8	294-01	457.1	375.3	107.4

11/25/2011

UC-502-1					
Trial	Size (cm)	Paper	Time (s)		
1	1.8	294-01	669.9		
2	1.8	294-01	1308.1	Average Time:	Standard Deviation
3	1.8	294-01	561.6	846.5	403.4

11/28/2011

UC-504-1					
Trial	Size (cm)	Paper	Time (s)		
1	1.8	294-01	646.5		
2	1.8	294-01	464.1	Average Time:	Standard Deviation
3	1.8	294-01	445.0	518.5	111.2

11/28/2011

WM-509-1					
Trial	Size (cm)	Paper	Time (s)		
1	1.8	294-01	432.1		
2	1.8	294-01	104.5	Average Time:	Standard Deviation
3	1.8	294-01	322.9	286.5	166.8

11/29/2011

WM-510-1					
Trial	Size (cm)	Paper	Time (s)		
1	1.8	294-01	288.3		
2	1.8	294-01	323.3	Average Time:	Standard Deviation
3	1.8	294-01	379.1	330.2	45.8

11/29/2011

WM-512-1					
Trial	Size (cm)	Paper	Time (s)		
1	1.8	294-01	167.0		
2	1.8	294-01	139.0	Average Time:	Standard Deviation
3	1.8	294-01	167.7	157.9	16.4

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11/29/2011

WM-515-1					
Trial	Size (cm)	Paper	Time (s)		
1	1.8	294-01	269.7		
2	1.8	294-01	427.5	Average Time:	Standard Deviation
3	1.8	294-01	103.0	266.7	162.3

11/30/2011

WM-516-1					
Trial	Size (cm)	Paper	Time (s)		
1	1.8	294-01	77.8		
2	1.8	294-01	103.1	Average Time:	Standard Deviation
3	1.8	294-01	125.3	102.1	23.8

11/30/2011

WM-517-1					
Trial	Size (cm)	Paper	Time (s)		
1	1.8	294-01	83.4		
2	1.8	294-01	108.1	Average Time:	Standard Deviation
3	1.8	294-01	111.6	101.0	15.4