Settling Characteristics

TEST REPORT #2: Typical Settling Characteristics of Individual and Bulk Masses of AquaBlok™ Particles Through Water

Background and Purpose of Testing

Variable quantities or types of clay minerals can be used to manufacture different AquaBlok™ formulations to accommodate site-specific needs and overall project objectives. The physical characteristics of dry, bulk (mixed) AquaBlok masses as well as discrete grain size classes vary as a function of product formulation (see Test Report #1). Nevertheless, despite differences in physical parameters like bulk density or percent clay content between formulations, bulk samples of AquaBlok consistently display a broad range of particle sizes as well as predictably variable particle densities amongst the size fractions (Test Report #1).

The settling velocity of any single particle through a standing (non-flowing) water column depends on a particle's size, density, and shape, and on water density and viscosity. In general, the settling velocity of a larger particle is higher than that of a smaller particle of the same density and shape. Quantitatively, Stoke's law states that, under such conditions, a particle's settling velocity is proportional to the square of its radius (Day, 1965). Unpublished laboratory research conducted in the University of Toledo's Civil Engineering Department (UT) also indicates that constant (terminal) settling velocities for individual AquaBlok particles of different sizes typically occur within one foot of vertical descent through a standing water column.

In contrast to the relatively predictable settling behavior of individual particles, the settling behavior of bulk (mixed composite) material masses through water is typically much more complex. Bulk material tends to settle as a single entity rather than as individual particles (Dortch, 1990). As a mass settles, shear stresses and drag forces develop at the mass/water interface, resulting in the formation of turbulent eddies within and around the settling mass. According to Dortch (1990), a settling mass tends to reach terminal velocity after falling only a short distance.

The purpose of this laboratory testing was two-fold: (1) to quantitatively demonstrate average settling velocities of individual AquaBlok particles of different sizes through small, standing water columns, and (2) to qualitatively demonstrate settling characteristics of different bulk AquaBlok masses through field-scale water columns. Data related to the settling characteristics of individual AquaBlok particles provide a useful theoretical basis for characterizing the settling behavior of bulk AquaBlok masses through standing water columns, which is more relevant to field applications.

In turn, laboratory observations of settling characteristics of bulk AquaBlok masses through non-flowing water columns provides baseline information that can be used when modeling applications to flowing-water environments.

Methods

Settling Velocity of Individual Particles

Ten representative AquaBlok particles were chosen from selected particle-size fractions of a sieved, air-dry sample of a 5050 FW formulation (see Test Report #1). Each particle was dropped through a 31 inch-tall standing column of municipal tap water at room temperature (~70° F) from just above the water surface and the fall time for each particle was measured with a stop watch to the nearest 0.01 second.

Settling Characteristics of Bulk AquaBlok Masses

The general settling characteristics of bulk masses of 5050 FW AquaBlok were observed as part of several large-scale settling column studies. The studies were conducted using a large (23-inch x 23-inch x 12 foot-tall), steel-reinforced plexiglas settling column. Each AquaBlok mass was applied from just above the water surface by "pouring" the material from a bucket. Relative settling velocities of different sized particles comprising the bulk mass were qualitatively observed, as was the general nature of dispersion and movement of the mass during descent.

To more closely mimic AquaBlok applications as they occur in the field (e.g. applied gradually from barged stockpiles or shore based conveyors), the application of AquaBlok masses to standing water columns was continuous and rapid, but not instantaneous. Product application on a less than-instantaneous basis – although more representative of field practice - precludes precise quantification of settling velocities for bulk settling AquaBlok masses, or a detailed evaluation of how variable mass or water-column thickness may quantitatively affect settling behavior.
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Typical behavior of a settling AquaBlok mass.

Results

Table 1 summarizes results of average settling velocities of individual AquaBlok particles through the small standing water column, while Photograph 1 qualitatively illustrates typical particle-settling and dispersive behavior of bulk AquaBlok masses during descent through large water columns (in this case, approximately 31 pounds of dry AquaBlok descending through a 8.8 foot water column).

AquaBlok Particle Size Fraction (inches)	Average Setting Velocity (ft/sec)
1.00 – 0.75	1.94
0.75 – 0.38	1.55
0.38 – 0.19	1.03
0.19 – 0.08	0.72

Table 1.
Settling Behavior of Individual Particles (5050 FW Formulation).

Observations and Conclusions

Individual AquaBlok Particles

Smaller AquaBlok particles tend to settle slower than larger particles (Table 1). This is because smaller particles have lower densities and higher surface-area-to-mass ratios than larger particles. Differences in average settling velocities as a function of particle size probably also occur for other AquaBlok formulations, although actual values may differ.

Based on results of research at UT, average settling velocities reported above should approximate terminal settling velocities for most individual AquaBlok particles.

AquaBlok Particle Masses

Visual observations of typical settling masses (Photograph 1) indicate that, as expected, little to no difference in settling velocities appear to occur as a function of particle size when the product is applied as a bulk mass. Instead, the mass tends to behave more-or-less as a single, turbulent and complex entity as it descends through the water column.

When applied as a bulk mass, AquaBlok tends to disperse during descent (Photograph 1). Results of several different column studies indicate that a relatively greater degree of lateral dispersion tends to occur with greater water column thickness, and that such dispersion may be constrained somewhat (during laboratory testing) when applying large masses of AquaBlok through laboratory columns. Empirical observations also indicate that a greater degree of lateral dispersion of the AquaBlok mass typically results in a more spatially uniform distribution of AquaBlok across the targeted sediment surface.

Due to the virtual lack of vertical segregation of AquaBlok particle sizes during bulk-mass descent through a field-scale water column, product segregation is not typically observed within the applied AquaBlok layer as it settles across the targeted sediment area.

References

Day, P.R. 1965. Particle fractionation and particle-size analysis, pp. 545567 in “Methods of Soil Analysis”, Vol. 1, by C.A. Black (Ed.), American Society of Agronomy.

Dortch, M.S., tech. Ed. 1990. “Methods of Determining the Long-Term Fate of Dredged Material for Aquatic Disposal Sites,” Technical Report D-90-1, U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, Miss

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AquaBlok® Composite Particle System

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