RockBlok™ – Use in Barrier Layer for Containment Facilities

TEST REPORT #1 ROCKBLOK™ BARRIER LAYER

Technology Overview

RockBlok™ comprises a blend of AquaBlok 2080FW9 particles with a fines (sand, silt or aggregate fines) and gravel fill material (Figure 1). Typical formulations are 6% to 8% bentonite by weight that can be used to construct a low perm/high strength barrier layer using primarily indigenous materials.

AquaBlok® is a patented, composite-aggregate technology resembling small stones and typically comprised of a dense aggregate core, clay or clay sized materials, and polymers. For typical formulations, AquaBlok's clay (sealant) component consists largely of bentonite clay. However, other clay minerals can be incorporated to meet specific needs. Other technology parameters (particle size, relative clay content, etc.) can also be modified, as appropriate.

AquaBlok particles expand when hydrated, with the degree of net expansion determined largely by the formulation, application thickness, and the hardness and salinity of the hydrating water. Once hydrated, AquaBlok will infill voids creating an effective physical, hydraulic, and chemical barrier by virtue of its relatively cohesive and homogeneous character, and low permeability to water.

Problem Statement

A low-permeability, hydraulic barrier layer is required during construction of landfills, lagoons, tailing pile ponds and other waste containment facilities to minimize the potential for uncontrolled transport of contaminants to groundwater or surface water.

Current practice for creating a hydraulic barrier layer for a waste containment facility generally involves a soil and/or synthetic liner system.

Soil liners traditionally require the compaction of a clayey fine-grained soil to achieve the desired permeability. This process can be difficult and expensive, particularly in locations without suitable fine-grained material and logistical and cost challenges to import material to the project site.

Synthetic liner systems are susceptible to failure if not paired with a suitable soil liner as a result of settlement induced shear stresses. When the waste contains angular or subangular aggregate material, these shear stresses may result in the puncturing or tearing of the synthetic liner. These punctures and tears will act as preferential pathways for the movement of contaminants beyond the hydraulic barrier layer.

Why RockBlok™ Works

The blend of AquaBlok with a sand and gravel fill material results in a product with the low hydraulic conductivity of AquaBlok and the bearing capacity and stability properties of sand and gravel. RockBlok provides the option of using locally available material (including mining process waste materials of sand and gravel size) to construct a barrier reducing the logistical and cost challenges associated with typical soil liners. Only the AquaBlok component of the blended material would need to be manufactured on-site (or transported from off-site manufacturing).

Purpose and Methods of Testing

Most applications as a hydraulic barrier layer for waste containment facilities will require that RockBlok provide a suitably low hydraulic conductivity (<1x10^{-7} cm/s) in combination with high shear strength.

Figure 1. RockBlok™

To this end, the particle size distribution (ASTM Method D 422), hydraulic conductivity (ASTM Method D 5084), Consolidated Undrained shear strength (ASTM Method D 4767), unconfined compressive (UC) strength (ASTM Method D 2166), Standard Proctor (ASTM Method D 698), and California Bearing Ratio (CBR) tests were performed on representative blends of different formulations as examples of the relative performance.

Figure 2. Particle Size Distribution for Sample Blends

Sieve Size (inches)	RockBlok 6% Bentonite	RockBlok 7% Bentonite	RockBlok 8% Bentonite
	Percent Finer	Percent Finer	Percent Finer
0.50	100.0	100.0	100.0
0.375	96.4	97.5	98.5
#4 – 0.187	56.5	60.9	57.6
#10 – 0.078	35.9	35.1	33.5
#20 – 0.033	26.9	26.1	26.1
#40 – 0.0165	18.7	18.3	18.7
#60 – 0.0098	10.7	11.3	12.1
#140 – 0.0041	7.6	8.3	9.3
#200 – 0.0029	7.3	8.0	9.0

Results

Testing results for the selected sample formulations are presented in Figures 2 through 7.

Observations and Conclusions

Particle Size Distribution

The particle size distribution for the three example formulations of RockBlok are very similar. The increases in bentonite content do correspond to a higher percentage of fines, as expected (Figure 2). Based on the Unified Soil Classification System (ASTM Method D 2487), RockBlok may be classified as a non-plastic granular material, comprised of poorly-graded sand with silt and gravel (SP-SM), poorly-graded sand with gravel (SP), and well-graded sand with silt and gravel (SW-SM).

Hydraulic Conductivity

Due to the angular gravel present in the product, a bentonite paste material was applied to the outer surface of the test cylinder ranges to address voids in replicate hydraulic conductivity tests. This addressed edge effects resulting from sample preparation and compaction in a Proctor Mold. Samples were prepared with 5% additional moisture added during compaction. The ranges of permeabilities reported are subject to varying confining pressures ranging from 50 psi to 100 psi. From these tests, it is apparent that RockBlok blends can meet the criteria for a low permeability, hydraulic barrier layer with a hydraulic conductivity in the range of 1x10^{-7} to 1x10^{-9} cm/s (Figure 3).

Figure 3. Hydraulic Conductivity of Sample Blends

RockBlok™ Formulation	Hydraulic Conductivity Values (cm/sec)		
	50 psi	90 psi	100 psi
6% Bentonite	$3.5x10^{-7}$	$6.9x10^{-9}$	$2.5x10^{-8}$
7% Bentonite	$4.1x10^{-7}$	$3.4x10^{-9}$	$4.1x10^{-6}$
8% Bentonite	$2.7x10^{-7}$	$1.6x10^{-9}$	$8.7x10^{-10}$

Figure 4. Consolidated Undrained Shear Strength of Sample Blends

RockBlok™ Formulation	6% Bentonite	7% Bentonite	8% Bentonite
Total			
Cohesion (psf)	1700	1290	1760
Ø (degrees)	26.7	31.3	27.1
Effective			
Cohesion (psf)	0	0	0
Ø (degrees)	40.4	43.2	41.1

Figure 5. Unconfined Compressive Strength of Sample Blends

RockBlok™ Formulation	Unconfined Compressive Strength (psf)
6% Bentonite	506
7% Bentonite	732
8% Bentonite	861

Figure 6. Standard Proctor of Sample Blends

RockBlok™ Formulation	Maximum Dry Density (pcf)	Optimum Moisture Content (%)
6% Bentonite	114.4	15.0
7% Bentonite	114.3	15.3
8% Bentonite	114.7	15.2

Figure 7. California Bearing Ratio of Sample Blends

RockBlok™ Formulation	CBR at 0.1 inch penetration	CBR at 0.2 inch penetration
6% Bentonite	10.1	15.7
7% Bentonite	6.6	11.9
8% Bentonite	5.5	8.7

Consolidated Undrained (CU) Shear Strength

Samples were sheared at pressures of 15, 45 and 75 psi. The results indicate that RockBlok has a high angle of internal friction, and also a relatively high cohesion (Figure 4), a characteristic rarely found in natural soil or gravel fills.

Unconfined Compressive (UC) Strength

While UC tests are commonly performed on fine-grained homogenous materials, and RockBlok is a mixture of fine grained material and aggregate, the results may not be representative of the actual strength. Nonetheless, this test does show that the bentonite component of RockBlok does provide some internal cohesion though, and the UC strength correspondingly increases with increasing bentonite content (Figure 5).

Standard Proctor and California Bearing Ratio (CBR)

The samples used in the CBR test were compacted to the maximum dry density at the optimum moisture content as determined in the Standard Proctor test for each RockBlok formulation (Figure 6). The CBR values reported for the RockBlok formulations decrease with increasing bentonite content and the values correspond to those expected of a fine-grained material (Figure 7).

Custom Blends

AquaBlok can assist in designing specific RockBlok formulations to achieve specific hydraulic barrier and geotechnical stability requirements using indigenous materials (including off-spec aggregates and rock waste fill) to provide an economic solution to large scale, remote construction projects, including performing engineering and laboratory testing using customer-supplied information and materials.

The test reports are also available on our web site at: www.aquablok.com.

Contact AquaBlok Today

For more information, contact AquaBlok, Ltd. at (419) 825-1325, or via email at services@aquablok.com.

AquaBlok® Composite Particle System