Milliken®

Concrete Cloth™

Technical Note

Concrete Cloth Abrasion Resistance Phase 1

Introduction

Concrete Cloth is frequently installed where the potential for abrasion can occur. This may be as simple as a small channel or ditch lining subject to storm runoff and soil loading, all the way to a large diameter culvert invert repair application, or a large channel collecting and controlling storm water where velocities and bed loads are significantly more severe. In these applications Concrete Cloth may be exposed to a range of velocities of running water and a range of bed loads of silt or sand particles (sometimes cobbles) during storm events. Quantification of the abrasion resistance in these applications and where possible, comparison of Concrete Cloth performance to other erosion materials is the focus of this technical note.

This technical note includes a literature search of the abrasion resistance of concrete to provide background to this topic, testing performed to date, and finally potential additional testing under consideration.

Literature Search

A literature search of the abrasion resistance of concrete was performed. Reference 1 is a concrete pipe industry technical note that correlates abrasion with either water cement ratio or compressive strength, as shown in figures 1 & 2. As shown, abrasion resistance increases as water/cement ratio decreases, and as compressive strength increases.

Figure 1

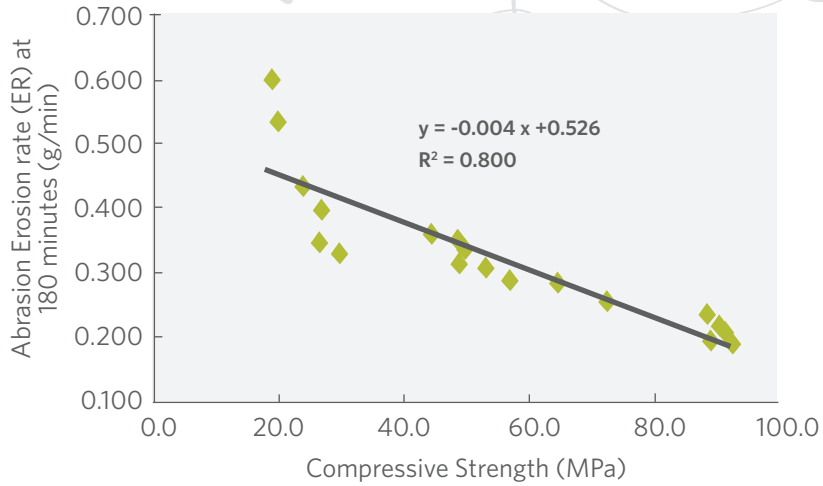
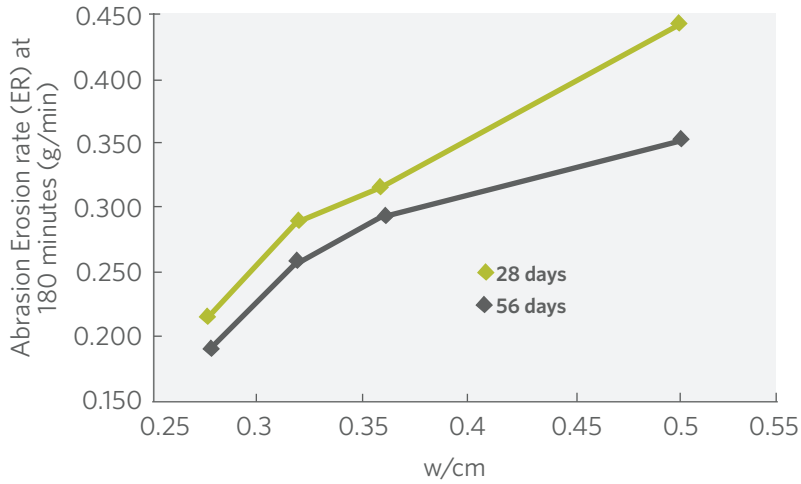


Figure 2



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Laboratory Testing

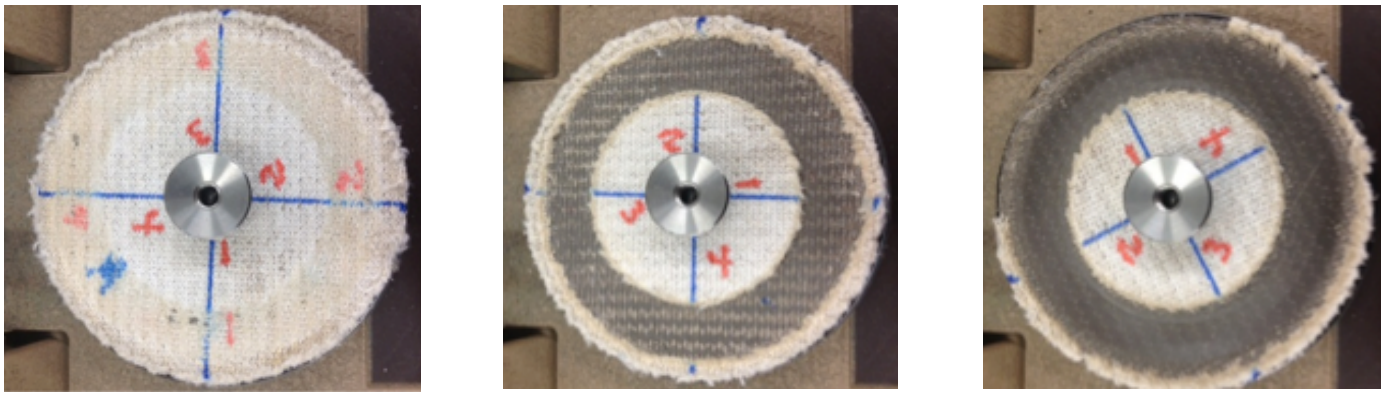
Several test methods exist that quantify abrasion resistance. Reference 2 describes early work performed on fiber reinforced concrete that resulted in the development of ASTM C1138M-05(2010)e1 "Standard Test Method for Abrasion Resistance of Concrete (Underwater Method)". This method involves a water filled chamber into which the specimen is inserted, then steel balls are spun utilizing a blade arrangement.

Milliken built a test apparatus according to the standard and the results of this lab test showed little to no damage to the Concrete Cloth after the required 10000 revolutions. While this testing compares favorably with the reference 1 results, it may not answer questions of engineers and potential specifiers in understanding the abrasion resistance of Concrete Cloth compared to building materials they are familiar with. Consideration was given to subjecting Concrete Cloth to ASTM A926-03 (reapproved 2008) "Standard Test Method for Comparing the Abrasion Resistance of Coating Materials for Corrugated Metal Pipe" but we were unable to find a lab with the equipment currently in use. Other test methods were considered including ASTM C779 "Test Method for Abrasion Resistance of Horizontal Concrete Surfaces" mostly used for concrete pavement, ASTM C418 Test Method for Abrasion Resistance of Concrete by Sandblasting" mostly used for pavers, and ASTM C241/C241M-09 "Standard Test Method for Abrasion Resistance of Stone Subjected to Foot Traffic".

We finally decided to use ASTM C1353 "Test Method Using the Taber Abraser (Abrader) for Abrasion Resistance of Dimension Stone Subjected to Foot Traffic" because it would be easy to run multiple samples so that we could easily compare Concrete Cloth to typical building materials like concrete, steel and asphalt that everyone in construction was familiar with. The Taber Abraser (Abrader) is similar to a rotating stone allowing for the easy measurement of abrasion resistance. Concrete plates are placed under an abrasive rotating wheel and wear versus number of revolutions is measured. It should be noted that both the Concrete Cloth CC8 and the Quikcrete samples were cured for 28 days before they were subjected to this abrasion test.

	Number of Cycles	Abrasion Rate (inches/cycle) (or Rate of Thickness Loss)	Compressive Strength
Concrete Cloth CC8 Surface	0-2000	0.00002 or 2 $x10^{-5}$	
Concrete Cloth CC8 Interior	2000-10000	0.000004 or 4 $x10^{-6}$	5800 psi
Quikcrete	4000	0.00003 or 3 $x10^{-5}$	2400 psi
Self-consolidating Portland Cement Concrete	5000	0.0000006 or 6 $x10^{-6}$	9300 psi
Galvanized Steel	5000	0.0000006 or 6 $x10^{-7}$	
HDPE	5000	0.0000006 or 6 $x10^{-7}$	
Asphalt Coating	<500	0.005 or 5 $x10^{-3}$	

The surface of the Concrete Cloth is a combination of mostly polyester fibers and some concrete and as the table above shows it took about 2000 cycles for the textile component to wear off. The rate of thickness loss in inches per cycle was about 0.00002. For instance the thickness of the surface of CC8 is about 0.04 inches which equals 2000 times 0.00002. The interior of the Concrete Cloth is mostly concrete with some fibers.



Concrete Cloth after 500 Cycles, 2000 Cycles, and 6500 Cycles of the Taber Abrader

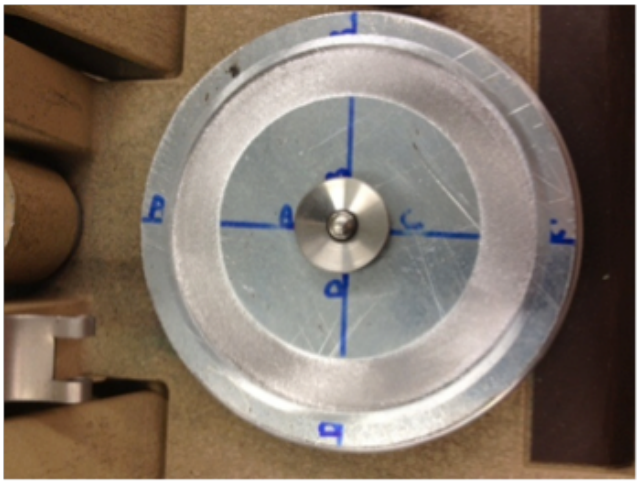
The Quikcrete, as expected for a 2400 psi compressive strength Portland cement concrete lost thickness much faster than the interior of the Concrete Cloth when abraded. At the other end of the spectrum galvanized steel used for corrugated metal pipe and HDPE lost thickness at a slower rate than Concrete Cloth when abraded. It should be noted that galvanized steel abrades much more rapidly after the corrosion process begins and HDPE abrades more rapidly after it has been exposed to UV light. The asphalt coating was about 40 mils thick and it abraded at a rate of 0.005 inches per cycle, very rapidly. In Phase 2 we will test the abrasion resistance of several other concrete mixes with different strengths to aid in the comparison to the abrasion resistance of Concrete Cloth.

The Taber Abrader

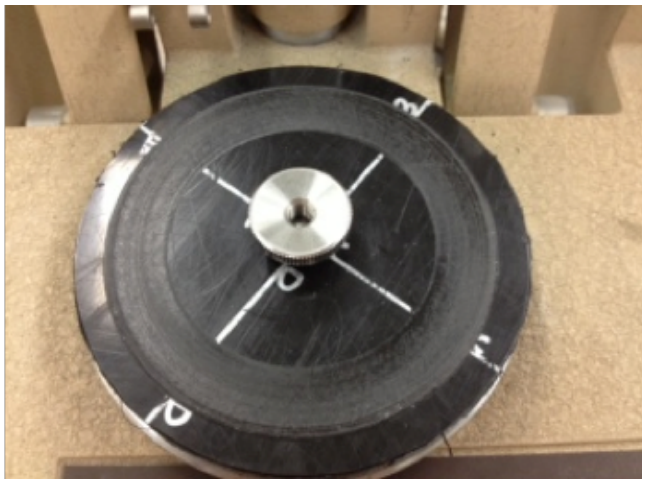
Quikcrete after 4700 Cycles

Self-Consolidating Portland Cement Concrete after 5000 Cycles

Note the fact that the Quikrete disc (~2400 psi compressive strength) cracked and fell apart. The fiber reinforcement of the Concrete Cloth would not allow this to happen.



Galvanized Steel after 4000 Cycles



HDPE after 4500 Cycles

Conclusions

Every installation of erosion control materials is unique, with unique stresses, abrasion history and field challenges. This technical note describes the abrasion or erosion resistance of Concrete Cloth in several testing regimes and compares those results with concrete. Of special note, the abrasion resistance of Concrete Cloth was about the same as 9300 psi compressive strength self-consolidating Portland Cement concrete (SCC) as the Concrete Cloth's abrasion resistance in our tests was slightly higher than the SCC. Concrete Cloth has demonstrated excellent abrasion resistance, and has equivalent or comparable abrasion resistance to several materials commonly used in erosion control applications.

References

1. "Abrasion Resistance of Concrete Pipe", Paul IMM. P. Eng. OCPA Technical Resources Engineer, Ontario Concrete Pipe Association (OCPA) Published November 22, 2013
2. "Abrasion-Erosion Resistance of Fiber-Reinforced Concrete", Liu, T.C. & McDonald, J.E. Published ASTM 1982.R
3. ASTM C1138M-05(2010)e1 "Standard Test Method for Abrasion Resistance of Concrete (Underwater Method)"
4. ASTM C1353 "Test Method Using the Taber Abraser for Abrasion Resistance of Dimension Stone Subjected to Foot Traffic"

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