An Introduction to Geosynthetic Cementitous Composite Mats (GCCM), (Concrete Cloth)

Michael Close, PE
Senior Sales & Technical Service Engineer
Milliken Infrastructure Solutions, LLC

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Agenda

Brief Introduction to Milliken & Company

Introduction to Concrete Cloth™

Civil Applications

Concrete Cloth Properties & Milliken Testing Program

Milliken & Company

Milliken | Milliken Infrastructure Solutions, LLC

Founded in 1865

Privately held

Over 48,000 products

~7,000 associates

Manufacturing in 5 countries

Operations throughout Americas, Europe and Asia

Key Markets

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Specialty Chemicals

Floor Coverings & Interiors

Protective & Performance Textiles

Industrial Products






CONCRETE CANVAS SHELTERS

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CC Shelter in Afghanistan

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CONCRETE CANVAS LTD - History

First Application for Concrete Cloth™

- Sandbag reinforcement in Afghanistan – British Military

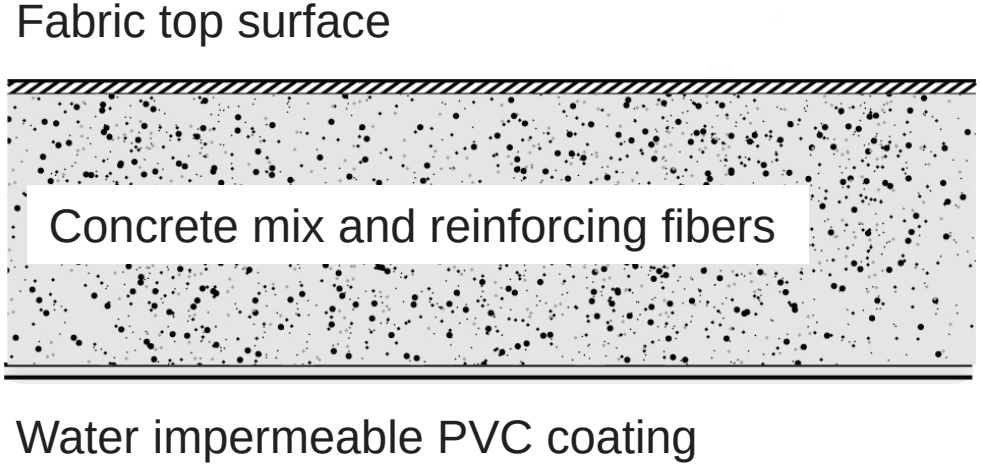
What is Concrete Cloth™?

A flexible cement-impregnated fabric that hardens when hydrated to form a thin, durable concrete layer.

Concrete Cloth™ ("CC") consists of:

-Dry concrete mix
-Reinforcing fiber matrix
-Fabric top surface
-PVC bottom coating

CC Section View



Concrete Cloth™ comes in two roll varieties:

Portable Batched Rolls

Bulk Roll

Concrete Cloth™ Roll Characteristics

CC	Thickness (in)	Batch Roll Size (ft^2)	Bulk Roll Size (ft^2)	Roll Width (ft)
CC5	0.20	108	2150	3.3
CC8	0.31	54	1345	3.6
CC13	0.51	N/A	860	3.6

CC	Mass (unset) (lb/ft^2)	Density (unset) (lb/ft^3)	Density (set) (lb/ft^3)
CC5	1.4	93.6	+30-35%
CC8	2.5	93.6	+30-35%
CC13	3.9	93.6	+30-35%

Key benefits of Concrete Cloth™

- *Quick:* Unroll, place and wet
- *Simple:* Cannot be over-hydrated
- *Versatile:* One material, many uses
- *Durable:* Wear-resistant concrete
- *Robust:* Fiber matrix reinforcement

Portable: Easily transported and deployed without specialized equipment

Concrete Cloth™ Civil Applications

Ditch lining

Erosion and scour protection

Slope protection, weathered rock protection

External pipe protection & ballast

Internal culvert repair

Secondary containment

Weed control

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Butler County, AL
CMP Rehabilitation

Date: February 14, 2013

Owner: Butler County, Alabama

Application: CMP Invert Rehabilitation

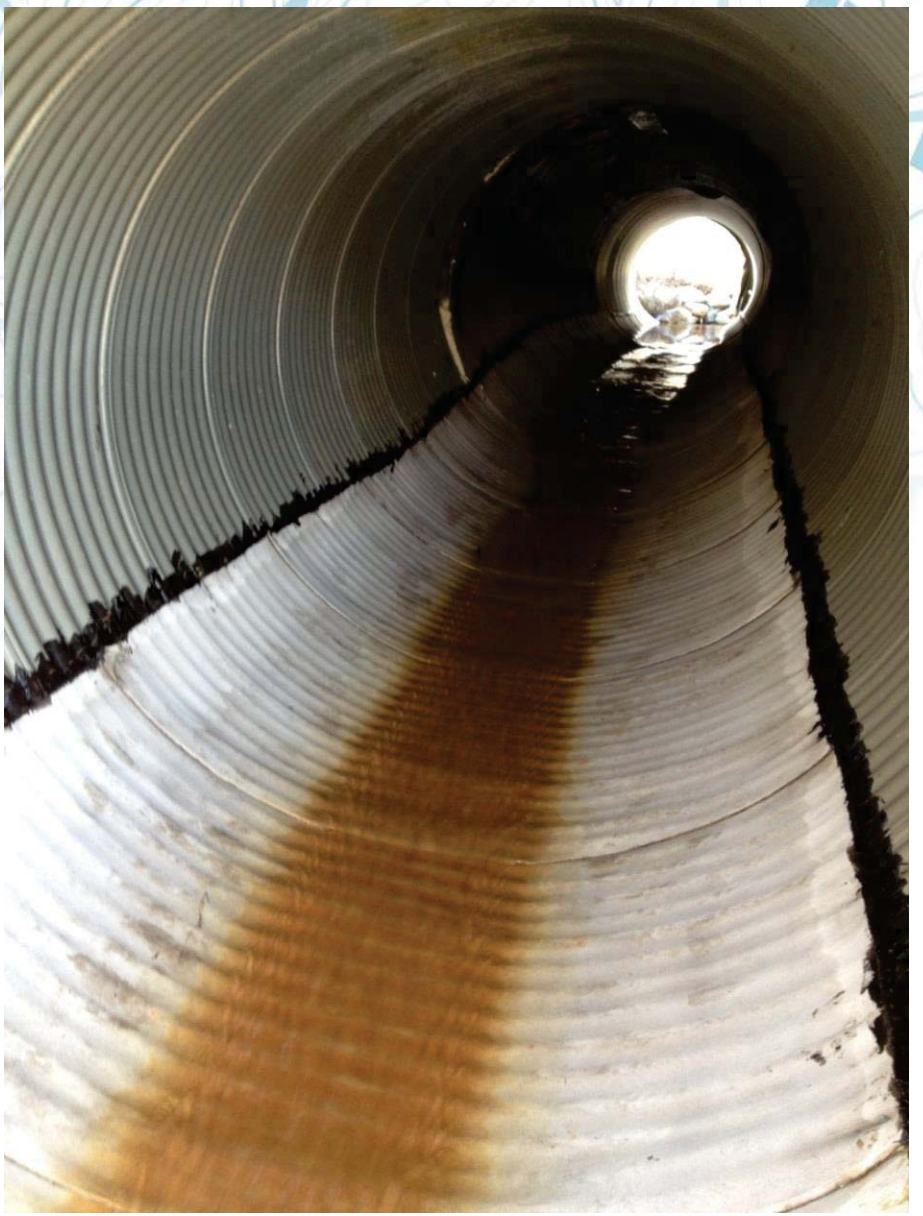
The invert of dual 72 inch diameter galvanized corrugated metal pipe (CMP) culverts had rusted through in some sections and the county decided to use Concrete Cloth CC8 to repair the areas of concern to add years of service to the existing culverts instead of replacing the culverts.

Concrete Cloth placed perpendicular to the direction of flow.

Concrete Cloth was attached with screws to the pipe

Water flowing through the pipe was also used to hydrate the Concrete Cloth

An asphalt tar was used to seal the edges to prevent water from getting between the Concrete Cloth and the pipe.



Hunter Army Airfield, Savannah, GA

Date: April 2013

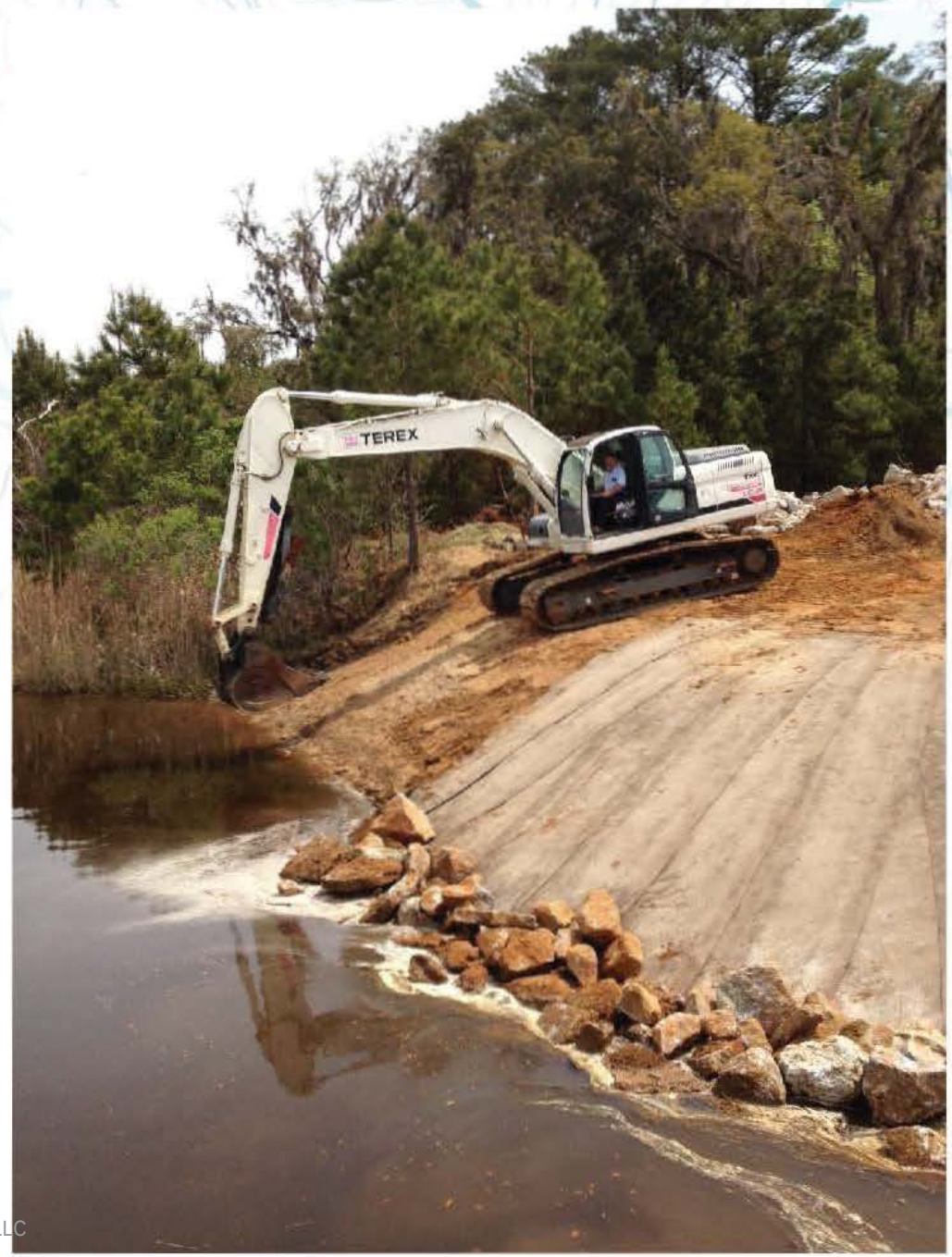
Owner: US Army, Fort Stewart Public Works

Application: Stream Bank/Slope Protection

Many years ago a sea wall was placed at Hunter to control salt water intrusion in a freshwater estuary. Over time the bank has eroded on the fresh water side, and older sea walls were removed to bring to safe standards.

Fresh Water

Brackish Water



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I-95/Highway 87 NCDOT Bridge Maintenance

Date: May 2013

Location: Harnett County, North Carolina

Application: Slope Foundation Protection

Faced with a leaking bridge joint, the NCDOT either had to replace the bridge joint which would have required closing lanes of traffic on I-95 or provide slope protection on the slope below the bridge joint.

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Intrepid Potash Mine, Carlsbad, NM

Date: April, 2013

Owner: Intrepid Potash

Application: Ditch Lining - Erosion Control

A ditch along a rail line was susceptible to erosion and the Potash mine did not want to compromise this location further. The contractor, Constructors, Inc., installed 2 bulk rolls of CC8 in less than half a day including the hydration of the Concrete Cloth.

Cell Phone Tower Access Road Swale

Date: Spring 2012

Location: Eastern Tennessee

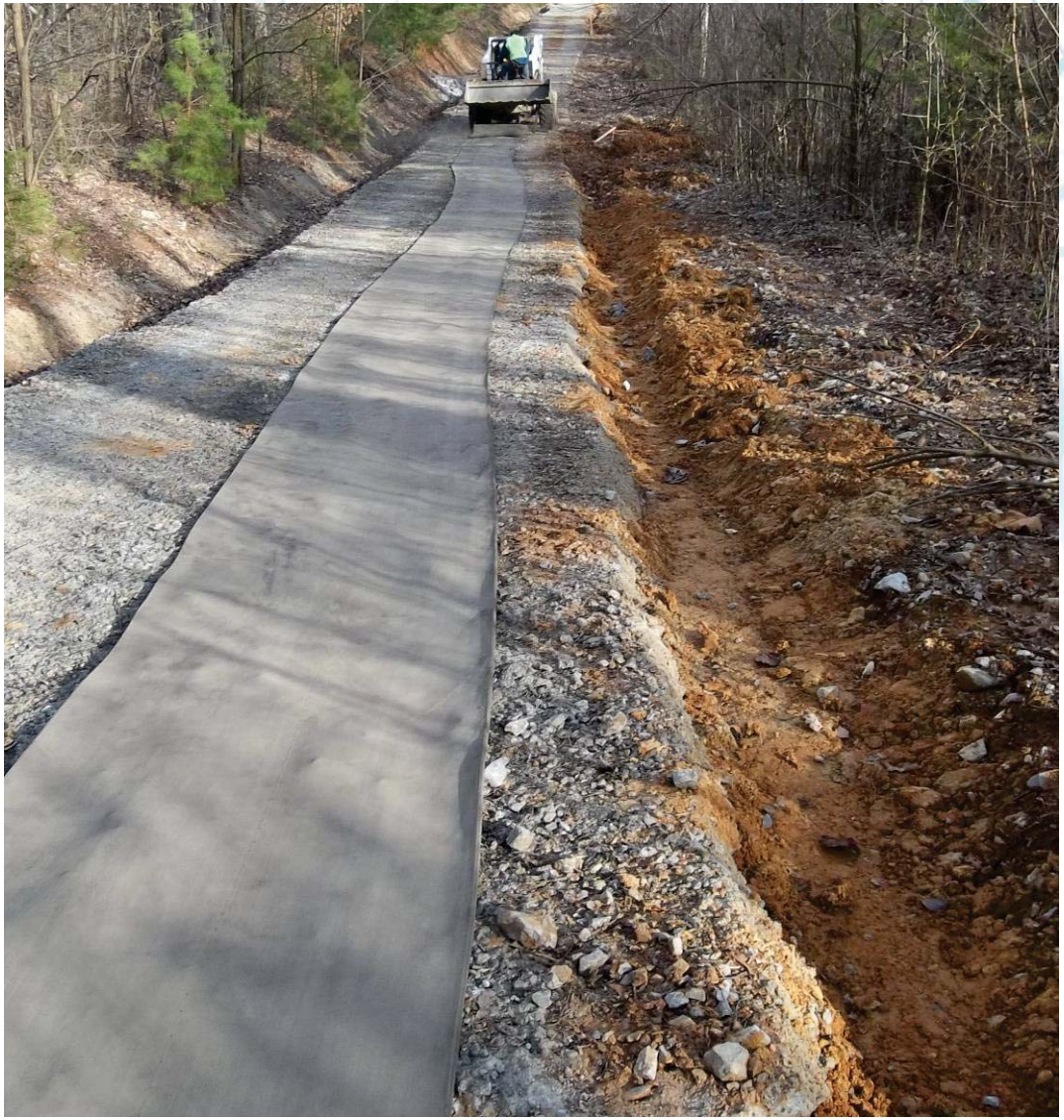
Application: Swale Construction

Erosion had caused a drop off at the edge of the roughened concrete access road that could strand a vehicle and erosion was beginning to undermine the concrete. The decision was made to create a swale along the access road with Concrete Cloth (CC8).

The Site

Construction

Construction



Finished Installation

I-65 Right-of-Way Line Stream

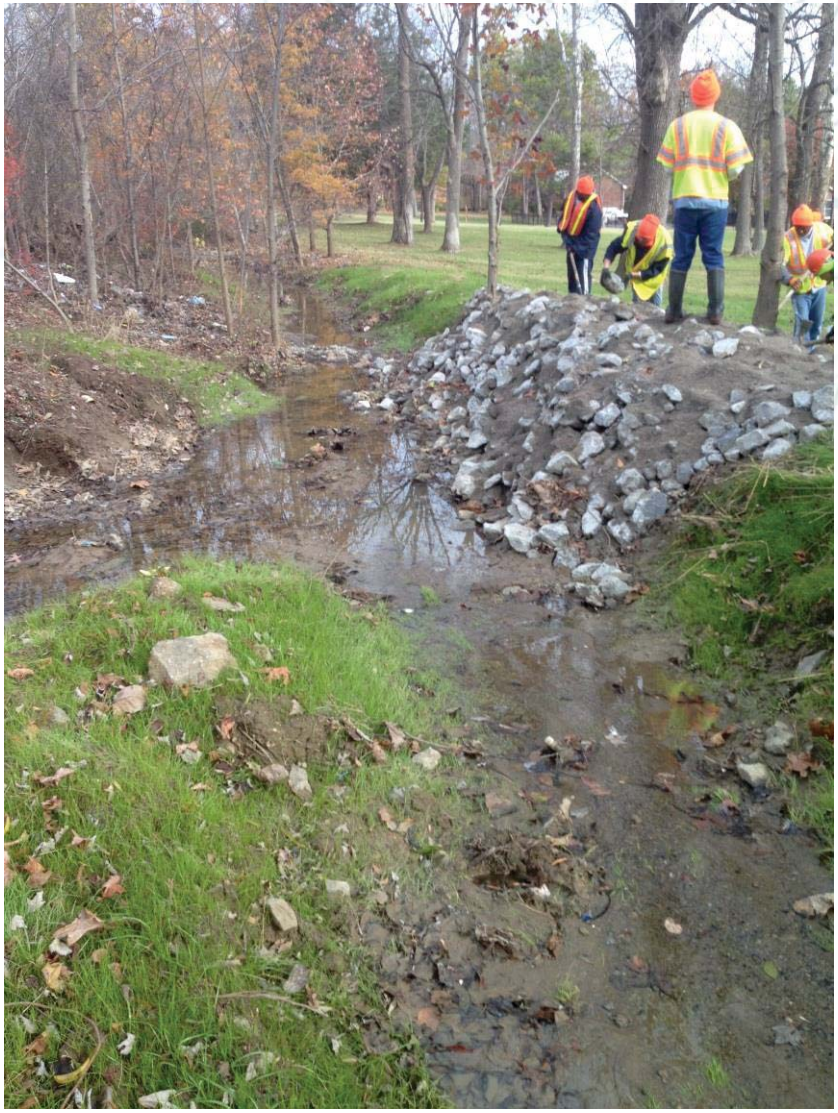
Date: November 19, 2013

Location: Falcon Drive, Nashville, Tennessee

Application: Streambank Protection

High velocity water after recent storms carried riprap from the stream that parallels the freeway far out into the adjacent residents yard. Repeat maintenance was becoming costly. Heavy trucks crossing the residents yard would get stuck in the soft wet soil. CC5 was used.

The Site



Construction

Finished Installation

Durability – How long does it last?

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Freeze Thaw

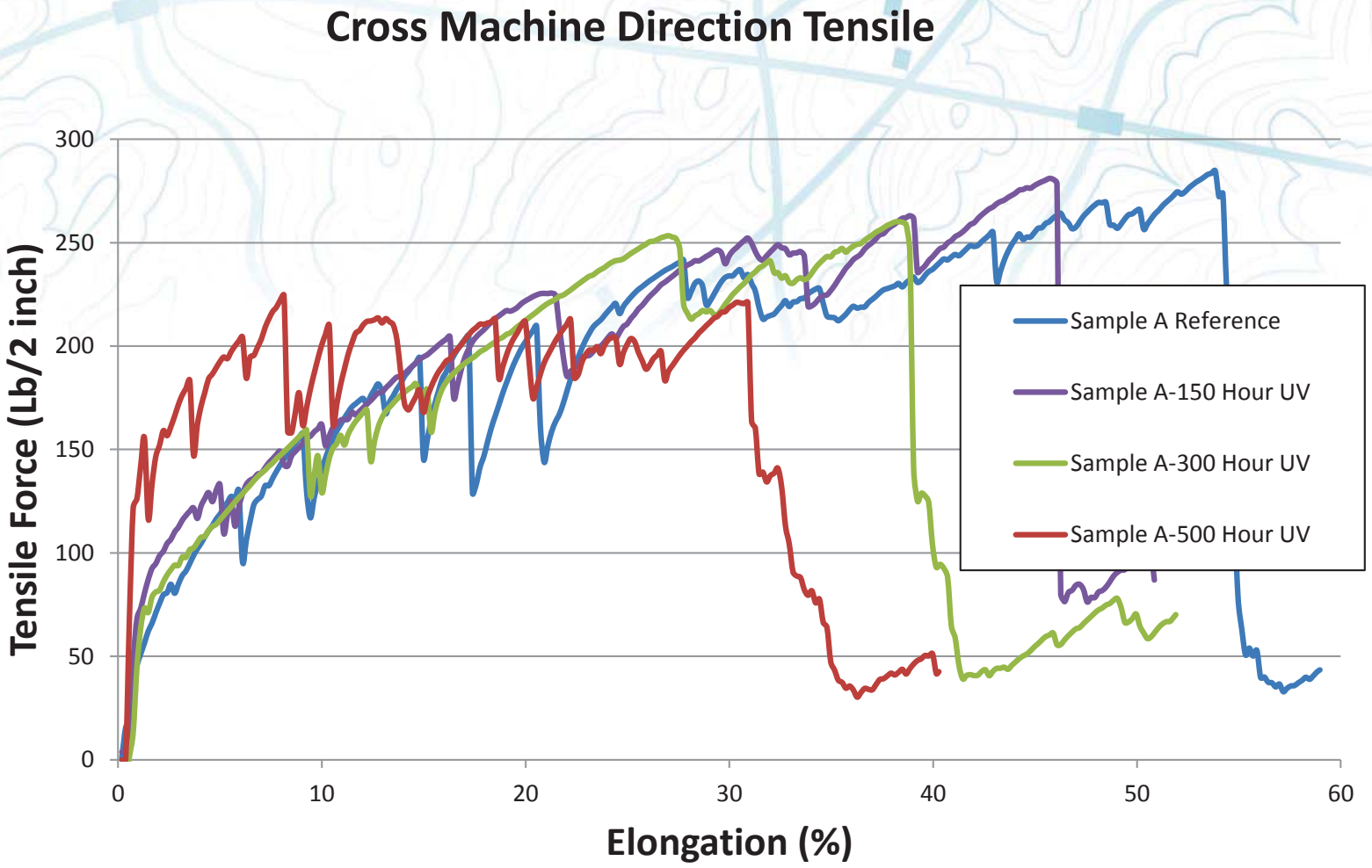
Freeze/Thaw Cycles	Average Primary Flexural Strength (psi)	Average Secondary Flexural Strength (psi)
50	586	632
100	567	651
200	578	641

- Testing according to ASTM C1185 by CTL Group
- CTL Group's Conclusion:

Average flexural strength values of freeze-thaw specimens are greater than the values published on the Milliken Concrete Cloth data sheet.

UV Exposure

Exposed according to ASTM D4355
Tested according to ASTM D5035



Abrasion Resistance

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Abrasion Test #1

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ASTM C1138M Underwater Abrasion

75 steel balls (0.5”-1.0” diameter): ~4 lbs

72 hours of agitation to roll over surface of fabric underwater at 1200 rpm

Fabric surface not appreciably abraded

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Taber Abrasion

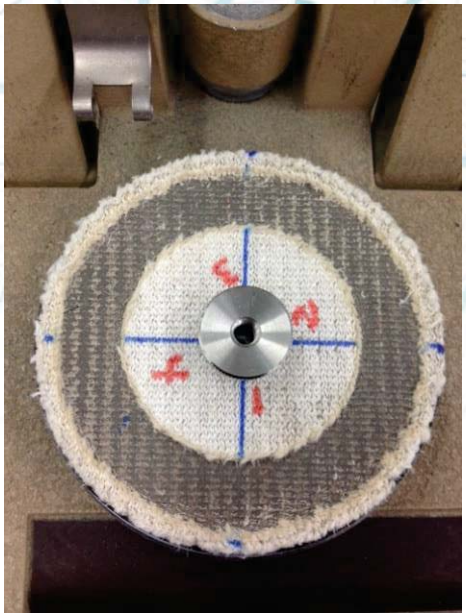
Overview of Taber Abrasion

- Taber 5150 Abraser
- Two H22 Abrasive wheels
- 1000 g weights on each wheel
  - Estimate ~18 psi pressure
- Resurface abrasive wheel with diamond tip every 500 cycles
- Measure change in mass and change in thickness versus number of cycles
- Testing similar to ASTM C1353 “Test Method Using the Taber Abraser for Abrasion Resistance of Dimension Stone Subjected to Foot Traffic”

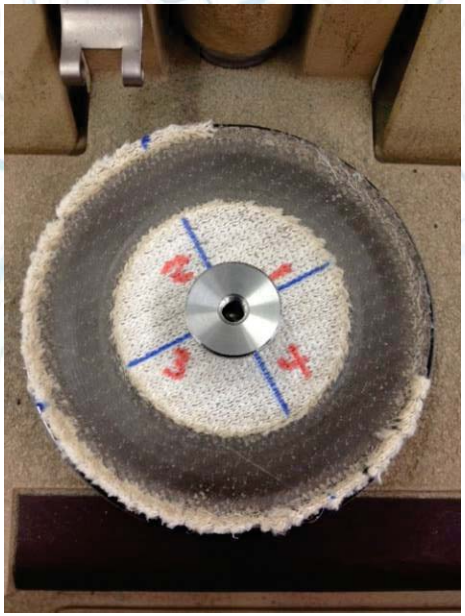
Images of Abraded CC8

500 Cycles

1500 Cycles



2000 Cycles



6500 Cycles

Taber Abrasion of CC8

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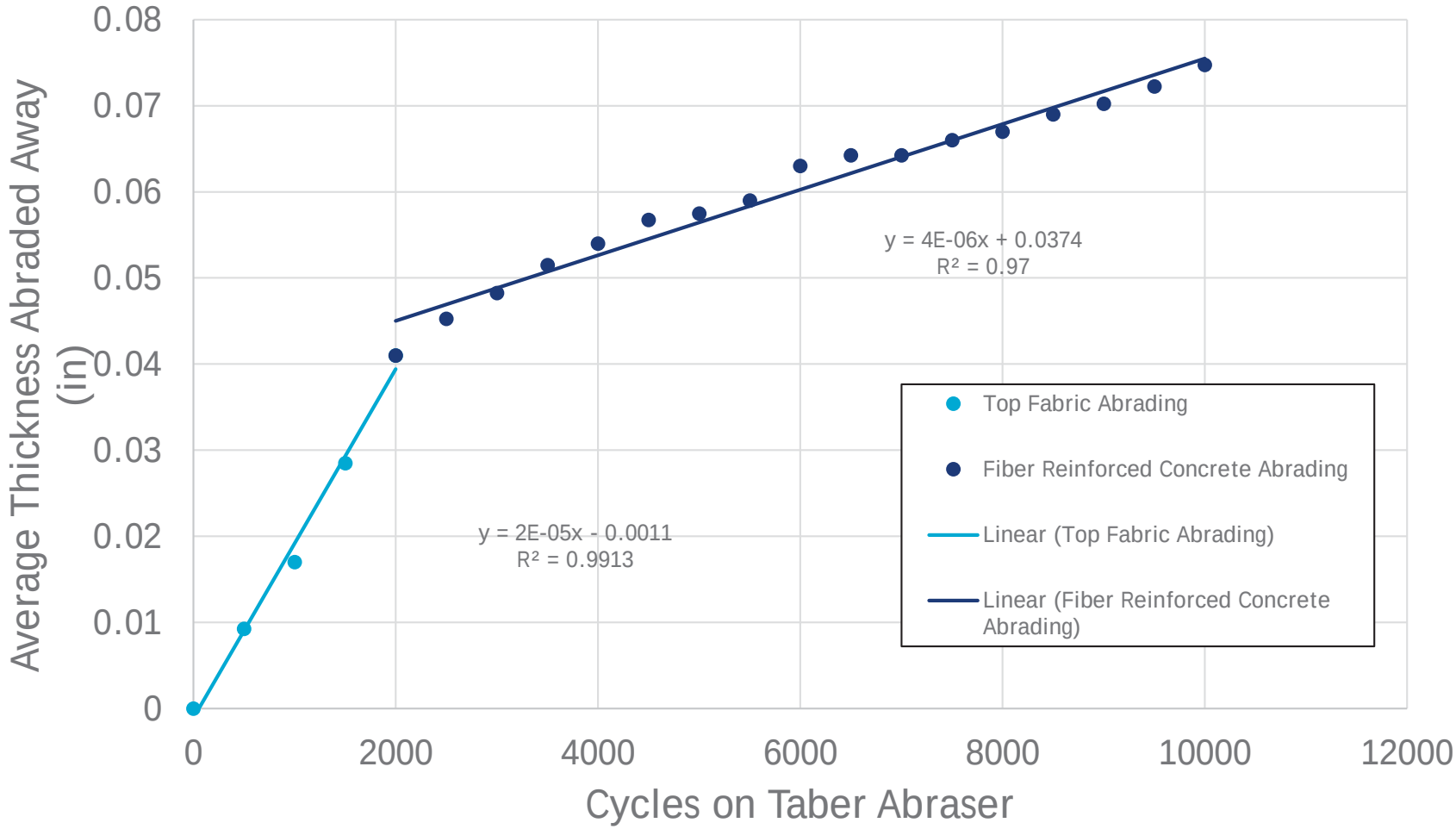

- Faster rate of abrasion until top fabric surface removed (~2000 cycles)
- Estimate ~70000 cycles to abrade away thickness

Comparison with Other Materials

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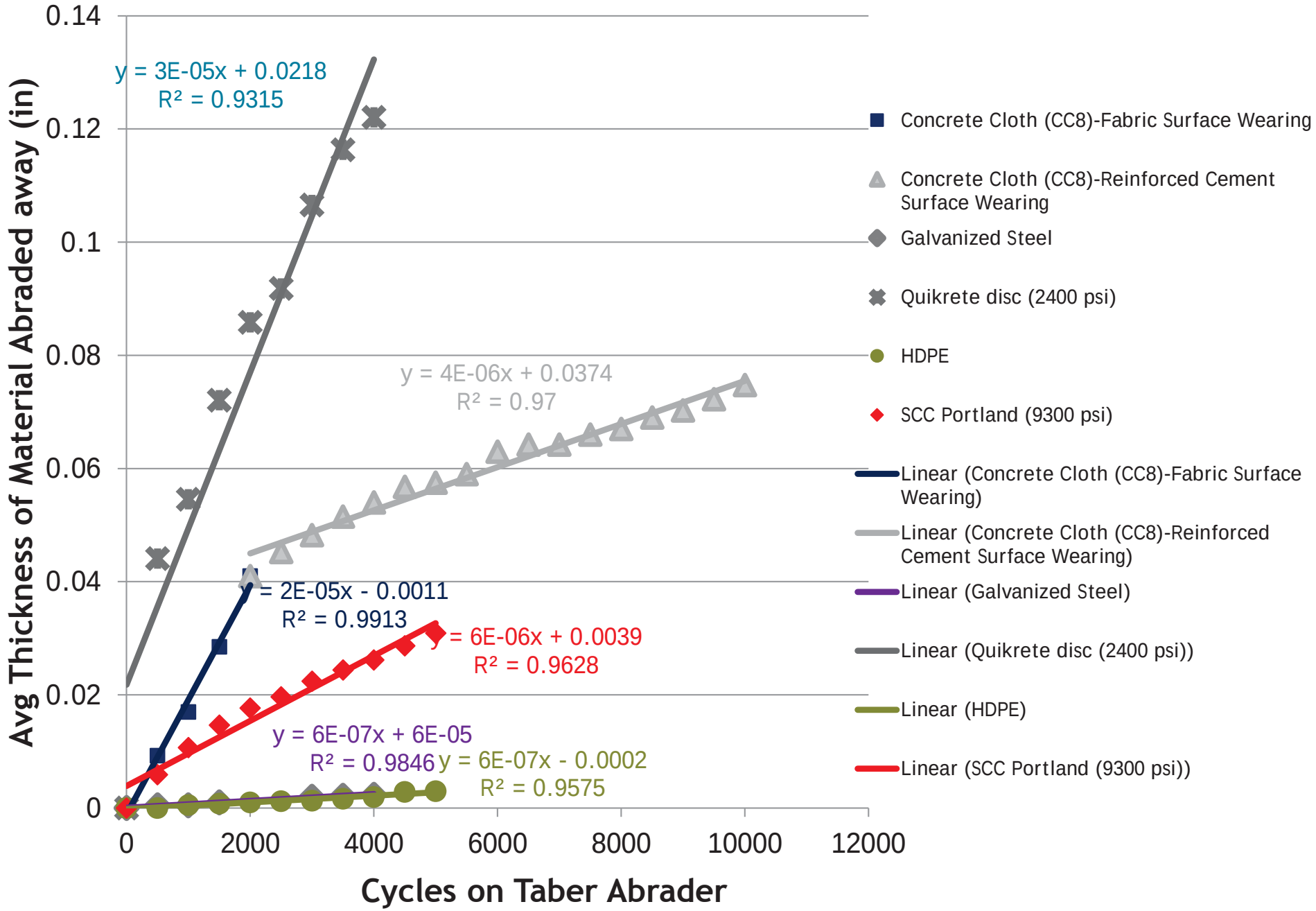
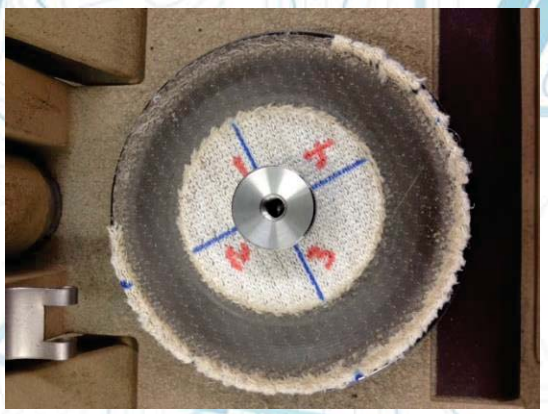
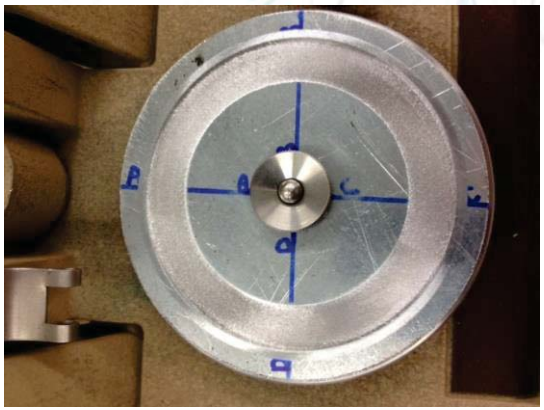


2400 psi Concrete, 4700 cycles

9300 psi Concrete, 5000 cycles



Concrete Cloth CC8, 6500 cycles



Galvanized Steel, 4500 cycles

Asphalt Coated Galvanized Steel, 100 cycles

HDPE, 4500 cycles

Concrete Cloth has abrasion resistance similar to high compressive strength concrete, but will not fall apart (fiber reinforced) as wears

Sample	Rate of Thickness Loss due to Abrasion (inch/cycle)	Notes
Fabric Surface of Concrete Cloth (CC8)	20×10^{-6}	Mostly fibrous, but some concrete mix
Fiber-reinforced Interior of Concrete Cloth (CC8)	4×10^{-6}	Compressive strength ~5-6 ksi
Quickcrete Cylinder cured in lab	30×10^{-6}	Compressive Strength ~2.4 ksi
SCC Cylinder cured in lab	6×10^{-6}	Compressive Strength ~9.3 ksi
Galvanized Steel	0.6×10^{-6}	3 mils abraded in 5000 cycles
HDPE	0.6×10^{-6}	

- Galvanized steel abrasion rate can be expected to accelerate once galvanic coating is removed and rusting sets in
- HDPE abrasion rate can be expected to accelerate with continued UV exposure

Hydraulic Performance

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Manning Number Testing at TRI Environmental

- $Manning\ Eqn: V = 1.486\, R^{2/3} S^{1/2} / n$
- V= Average flow velocity
- R = hydraulic radius
- S = Slope
- N = Manning number

Sample	Avg Water Depth (ft)	Manning Number
Longitudinal	0.12	0.010
Longitudinal	0.17	0.011
Longitudinal	0.25	0.012
Longitudinal	0.31	0.012
Transverse	0.12	0.010
Transverse	0.17	0.011
Transverse	0.22	0.011
Transverse	0.29	0.012

TRI Environmental – Concrete Cloth High Flow Testing

TRI Environmental – Concrete Cloth High Flow Testing

TRI Environmental – Concrete Cloth High Flow Testing

Environmental Impact

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Environmental Impact
EPA TCLP Testing

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Procedure

- 12” x 12” samples
- CC8 product
- Sampling according to ASTM C-1185

CTL GROUP

Samples

- Unhydrated powder

  Material was removed from product to measure unhydrated virgin powder
- Unhydrated samples (A&B)

  1.25 gallons of hydrate water collected per sample
- Hardened samples (A&B)

  1.25 gallons of water collected after contact with hardened product

Hydration of initial samples with 1.25 gallons of water

Environmental Impact
EPA TCLP Testing

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Toxicity Characteristic Leaching Procedure (TCLP)

Analyte	RCRA TCLP Max. conc. (mg/L)	Original Cementitious Material (not exposed to water) (mg/L)	Stage 1 (water sprayed on 1 Sq. ft. of cloth)		Stage 2 (water sprayed on 1 Sq. ft. of hardened cloth)		Base run with DI water (mg/L)	ICP detection limit
			Sample A (mg/L)	Sample B (mg/L)	Sample C (mg/L)	Sample D (mg/L)		
Antimony (Sb)	1	0.04	0.06	0.06	BDL	BDL	BDL	<0.01
Arsenic (As)	5	0.36	0.06	0.06	BDL	BDL	BDL	<0.04
Barium (Ba)	100	0.089	0.22	0.20	0.12	0.14	0.24	---
Beryllium (Be)	0.007	0.003	BDL	BDL	BDL	BDL	BDL	<0.0007
Cadmium (Cd)	1	0.007	BDL	BDL	BDL	BDL	BDL	<0.001
Chromium (Cr)	5	0.028	0.006	0.005	BDL	BDL	BDL	<0.001
Lead (Pb)	5	BDL	BDL	BDL	BDL	BDL	BDL	<0.01
Mercury (Hg)	0.2	BDL	BDL	BDL	BDL	BDL	BDL	<0.001
Nickel (Ni)	70	0.033	BDL	BDL	BDL	BDL	BDL	<0.002
Selenium (Se)	1	BDL	BDL	BDL	BDL	BDL	BDL	<0.06
Silver (Ag)	5	BDL	BDL	BDL	BDL	BDL	BDL	<0.0003
Thallium (Tl)	7	BDL	BDL	BDL	BDL	BDL	BDL	<0.02

Concrete Cloth powder, hydration water and exposed water all have extractable heavy metals well below EPA's Resource Conservation and Recovery Act (RCRA) permissible limits.

Source: CTL Group Project No. 052635

Environmental Impact
TRI Test Installation

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Procedure

- 1000 ft^2 test drainage ditch
- CC8 Product
- Installed at TRI Environmental
- <200 ft^3 of water used to hydrate

Samples

The Concrete Cloth was hydrated and the following samples were measured for pH:

- On-Site Water Reservoir
- First pint of excess hydration water
- Small 5 ft^3 collection basin
- Large 300 ft^3 collection basin

1000 ft^2 test Concrete Cloth Installation at TRI

Source: MIS Technical Note 1.30

Environmental Impact
TRI Test Installation

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Test Sample	Area of Concrete Cloth (ft^2)	Volume of Hydration water (ft^3)	Volume of Basin (ft^3)	pH
On Site Water	N/A	N/A	N/A	8.2
First Pint of Excess Hydration Water	~1000	0.2	0	11.6
First Small Basin After Hydration	~1000	40-60	<5	11.1
Second Large Basin After All Hydration and Addition of First Basin	~1000	40-60	<300	8.5

If 0.3 ft^3 per 1.0 ft^2 of Concrete Cloth is used to dilute any hydration water, the rise in pH will be negligible. The high initial pH of the on-site water (8.2) shows a worst case field condition.

Source: MIS Technical Note 1.30

Environmental Impact
CMP Culvert Rehabilitation

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Procedure

- 150 ft^2 of Concrete Cloth
- CC5 Product
- Installed in corroded 40 ft CMP culvert
- Installation occurred in a light rain
- Flow through the culvert was ~0.1 cfs

Samples

pH and Turbidity measurement were taken both upstream and downstream of the culvert at various times before and after the installation.

Concrete Cloth lining of a corroded culvert in Seymour, TN with an active stream

Environmental Impact
CMP Culvert Rehabilitation

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Time (min)	Location	pH	Turbidity (NTU)
0	60 ft upstream of culvert	6.6	5
155	60 ft upstream of culvert	7.2	6
25	At outfall of culvert	7.5	32
45	At outfall of culvert	7.7	85
155	At outfall of culvert	7.6	6
45	20 ft downstream of culvert	7.3	40

Data collected on both pH and turbidity show only small rises in both quantities during and immediately after the Concrete Cloth installation.

The effects are consistent with those of a heavy rain, and could be additionally limited with simple BMPs.

Source: MIS Technical Note 1.31

Weed Control

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Original Problem

The Solution

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SCDOT RMC Interchange
Business I-85 and 176

Date: May, 2013

Owner: RMC Interchange

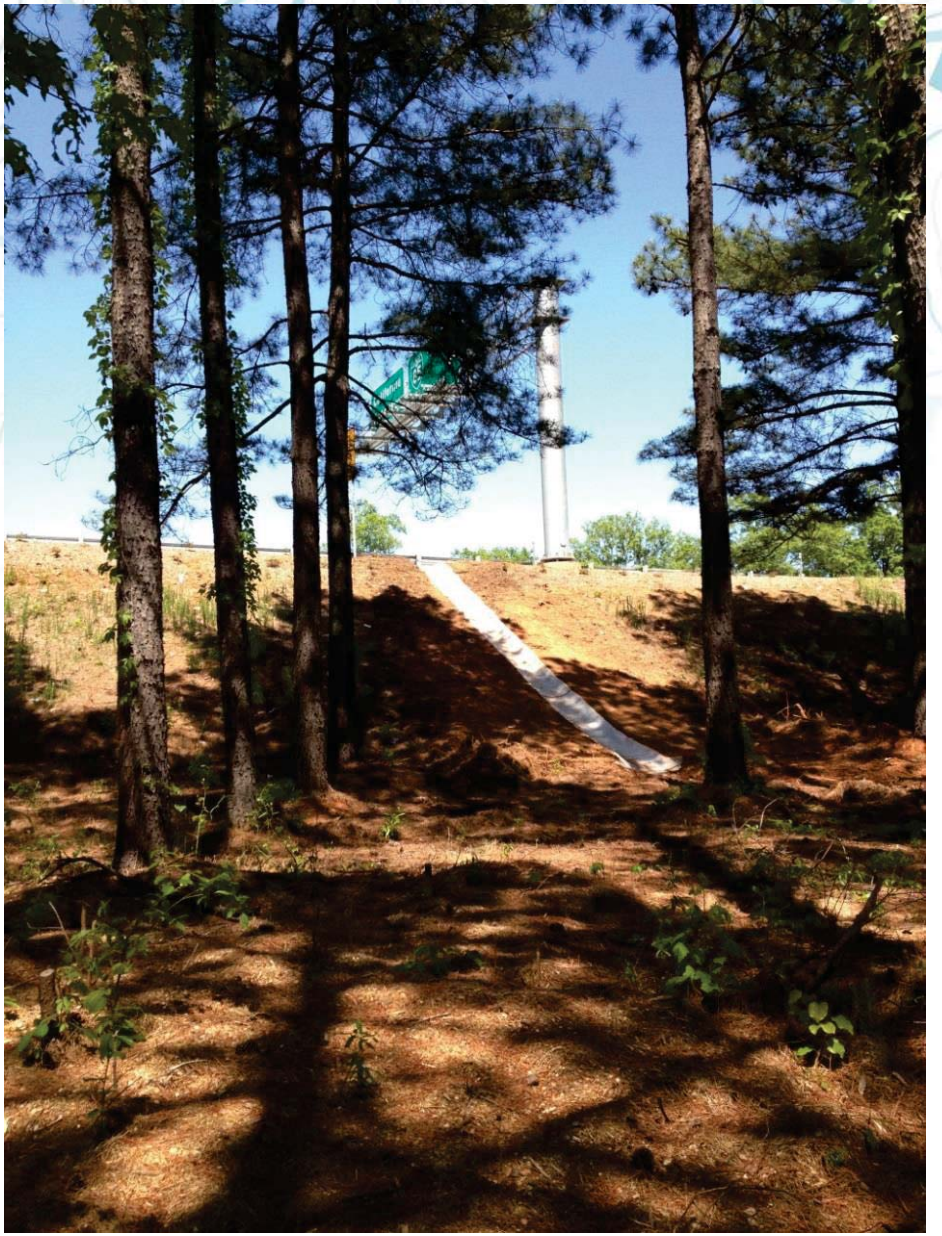
Application: Flume and Drainage Ditches

Reduced installation cost avoiding forms, concrete trucks, lane closure, traffic control, specialty labor and worker exposure.

Original Problem

Concrete Cloth Installation

Concrete Cloth Installation



Concrete Cloth Installation

Culvert Headwall (LA DOTD)

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Southeast US
Landfill Slope Protection

Date: May 2012

Engineer: CH2M Hill

Application: Slope Protection

A geotextile wraparound reinforced soil slope had been constructed. Attempts to vegetate the slope face were not completely successful, so the decision was made to cover and protect this slope face. Concrete Cloth (CC8) was selected as the protection medium.

Before

Note the RSS facing wraparound

Day 1

Day 2

Spray marking for the right side anchor trench

Right side anchoring of the Concrete Cloth

Day 2

Note that the lighter colored zone was hydrated on day 1

Finished Installation

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Academy Road Pipe Repair
Georgetown County, SC

Date: September 13, 2012

Owner: Georgetown County Public Works

Application: Concrete Pipe Repair

A depression formed in the roadway and shoulder above a 24" diameter Reinforced Concrete Pipe (RCP) underneath Academy Road. The exposed pipe revealed a 2" gap caused by roots and 2 RCP pipe that didn't fit. CC8 was used to wrap and repair the joint, eliminating the infiltration of fill material.

Roadway Damage at Academy Road

Fill entering the pipe created unsafe and dangerous shoulder.

The pipe joint was exposed, and the bed was re-graded.

The undisturbed pipe was exposed and cleaned off, and wrapped in Concrete Cloth.

The end piece was replaced and the joint was wrapped in CC8. Straps were used to hold the CC8 in place.

The Concrete Cloth was hydrated using a 5 gallon bucket and water from the nearby creek.

The point repair was finished in less than 2 hours, and provides a more permanent, structural solution when compared with filter fabric and fill.

The repair was backfilled that afternoon, and the road was safely back in service. Root infiltration is no longer a concern at this location.

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CITY OF CALGARY - Mowing Strips Trial

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Mowing Strips Trial - Cutting the CC in Half

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Preparing the Area for Installation

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Fast Layout

Installation of CC Completed

Installation of CC Completed

City Of Calgary - Savings Cost for Using CC

City of Calgary's current maintenance costs for Mowing Strips - 100 Km's fencing X $7,500 per / km / year = $750,000/year

Cost of CC Installation -100Km's X $25 per Linear metre @ 500mm width = $2,500,000

After 40 months the initial expense of retrofitting would be covered in maintenance cost savings

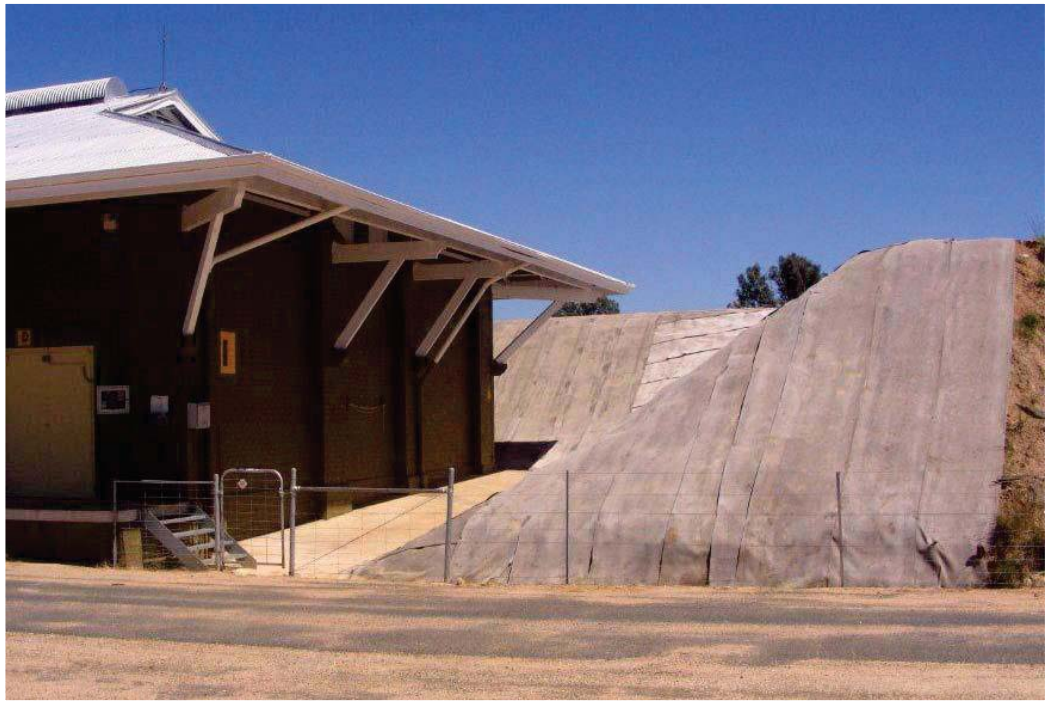
Assuming a lifespan of 10 years Calgary would save $750,000 X 7 years = $5,250,000

Pipe Protection & Pipe Ballast

- 2000sqm CC13

- Joint protection

Secondary Containment (South America)



Other Applications?

Any Questions?

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