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

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Milliken Infrastructure Solutions, LLC
Agenda

Brief Introduction to Milliken & Company
Introduction to Concrete Cloth™
Civil Applications
Concrete Cloth Properties & Milliken Testing Program
Milliken & Company

Founded in 1865
Privately held
Over 48,000 products
~7,000 associates
Manufacturing in 5 countries
Operations throughout Americas, Europe and Asia
Key Markets

Specialty Chemicals
Floor Coverings & Interiors
Protective & Performance Textiles
Industrial Products
CONCRETE CANVAS SHELTERS
CONCRETE CANVAS SHELTERS
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
Fabric top surface
Concrete mix and reinforcing fibers
Water impermeable PVC coating
Concrete Cloth™ comes in two roll varieties:

- Portable Batched Rolls
- Bulk Roll
# Concrete Cloth™ Roll Characteristics

<table>
<thead>
<tr>
<th>CC</th>
<th>Thickness (in)</th>
<th>Batch Roll Size (ft²)</th>
<th>Bulk Roll Size (ft²)</th>
<th>Roll Width (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CC5</td>
<td>0.20</td>
<td>108</td>
<td>2150</td>
<td>3.3</td>
</tr>
<tr>
<td>CC8</td>
<td>0.31</td>
<td>54</td>
<td>1345</td>
<td>3.6</td>
</tr>
<tr>
<td>CC13</td>
<td>0.51</td>
<td>N/A</td>
<td>860</td>
<td>3.6</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CC</th>
<th>Mass (unset) (lb/ft²)</th>
<th>Density (unset) (lb/ft³)</th>
<th>Density (set) (lb/ft³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CC5</td>
<td>1.4</td>
<td>93.6</td>
<td>+30-35%</td>
</tr>
<tr>
<td>CC8</td>
<td>2.5</td>
<td>93.6</td>
<td>+30-35%</td>
</tr>
<tr>
<td>CC13</td>
<td>3.9</td>
<td>93.6</td>
<td>+30-35%</td>
</tr>
</tbody>
</table>
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
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
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.
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.
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?
Freeze Thaw

<table>
<thead>
<tr>
<th>Freeze/Thaw Cycles</th>
<th>Average Primary Flexural Strength (psi)</th>
<th>Average Secondary Flexural Strength (psi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>586</td>
<td>632</td>
</tr>
<tr>
<td>100</td>
<td>567</td>
<td>651</td>
</tr>
<tr>
<td>200</td>
<td>578</td>
<td>641</td>
</tr>
</tbody>
</table>

- 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

Cross Machine Direction Tensile
Abrasion Resistance
Abrasion Test #1

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
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

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

**Concrete Cloth (CC8)-Fabric Surface Wearing**
- $y = 3 \times 10^{-5}x + 0.0218$
- $R^2 = 0.9315$

**Concrete Cloth (CC8)-Reinforced Cement Surface Wearing**
- $y = 4 \times 10^{-6}x + 0.0374$
- $R^2 = 0.97$

**Galvanized Steel**
- $y = 6 \times 10^{-7}x + 6 \times 10^{-5}$
- $R^2 = 0.9846$

**Quikrete disc (2400 psi)**
- $y = 6 \times 10^{-07}x - 0.0002$
- $R^2 = 0.9575$

**HDPE**
- $y = 6 \times 10^{-06}x + 0.0039$
- $R^2 = 0.9628$

**SCC Portland (9300 psi)**
- $y = 6 \times 10^{-07}x - 0.0011$
- $R^2 = 0.9913$

**Linear**
- **Concrete Cloth (CC8)-Fabric Surface Wearing**
- **Concrete Cloth (CC8)-Reinforced Cement Surface Wearing**
- **Galvanized Steel**
- **Quikrete disc (2400 psi)**
- **HDPE**
- **SCC Portland (9300 psi)**
Concrete Cloth has abrasion resistance similar to high compressive strength concrete, but will not fall apart (fiber reinforced) as wears.
<table>
<thead>
<tr>
<th>Sample</th>
<th>Rate of Thickness Loss due to Abrasion (inch/cycle)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fabric Surface of Concrete Cloth (CC8)</td>
<td>20 x 10(^{-6})</td>
<td>Mostly fibrous, but some concrete mix</td>
</tr>
<tr>
<td>Fiber-reinforced Interior of Concrete Cloth (CC8)</td>
<td>4 x 10(^{-6})</td>
<td>Compressive strength ~5-6 ksi</td>
</tr>
<tr>
<td>Quickcrete Cylinder cured in lab</td>
<td>30 x 10(^{-6})</td>
<td>Compressive Strength ~2.4 ksi</td>
</tr>
<tr>
<td>SCC Cylinder cured in lab</td>
<td>6 x 10(^{-6})</td>
<td>Compressive Strength ~9.3 ksi</td>
</tr>
<tr>
<td>Galvanized Steel</td>
<td>0.6 x 10(^{-6})</td>
<td>3 mils abraded in 5000 cycles</td>
</tr>
<tr>
<td>HDPE</td>
<td>0.6 x 10(^{-6})</td>
<td></td>
</tr>
</tbody>
</table>

- 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
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

<table>
<thead>
<tr>
<th>Sample</th>
<th>Avg Water Depth (ft)</th>
<th>Manning Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Longitudinal</td>
<td>0.12</td>
<td>0.010</td>
</tr>
<tr>
<td>Longitudinal</td>
<td>0.17</td>
<td>0.011</td>
</tr>
<tr>
<td>Longitudinal</td>
<td>0.25</td>
<td>0.012</td>
</tr>
<tr>
<td>Longitudinal</td>
<td>0.31</td>
<td>0.012</td>
</tr>
<tr>
<td>Transverse</td>
<td>0.12</td>
<td>0.010</td>
</tr>
<tr>
<td>Transverse</td>
<td>0.17</td>
<td>0.011</td>
</tr>
<tr>
<td>Transverse</td>
<td>0.22</td>
<td>0.011</td>
</tr>
<tr>
<td>Transverse</td>
<td>0.29</td>
<td>0.012</td>
</tr>
</tbody>
</table>
TRI Environmental - Concrete Cloth High Flow Testing
TRI Environmental - Concrete Cloth High Flow Testing
Environmental Impact
Environmental Impact  
EPA TCLP Testing

**Procedure**

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

**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
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.
Environmental Impact
TRI Test Installation

**Procedure**
- 1000 ft² test drainage ditch
- CC8 Product
- Installed at TRI Environmental
- <200 ft³ 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 ft³ collection basin
- Large 300 ft³ collection basin

1000 ft² test Concrete Cloth Installation at TRI

Source: MIS Technical Note 1.30
## Environmental Impact
### TRI Test Installation

<table>
<thead>
<tr>
<th>Test Sample</th>
<th>Area of Concrete Cloth (ft²)</th>
<th>Volume of Hydration water (ft³)</th>
<th>Volume of Basin (ft³)</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>On Site Water</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>8.2</td>
</tr>
<tr>
<td>First Pint of Excess Hydration Water</td>
<td>~1000</td>
<td>0.2</td>
<td>0</td>
<td>11.6</td>
</tr>
<tr>
<td>First Small Basin After Hydration</td>
<td>~1000</td>
<td>40-60</td>
<td>&lt;5</td>
<td>11.1</td>
</tr>
<tr>
<td>Second Large Basin After All Hydration</td>
<td>~1000</td>
<td>40-60</td>
<td>&lt;300</td>
<td>8.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

If 0.3 ft³ per 1.0 ft² 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

**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
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.
Weed Control

Original Problem
The Solution
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.
Concrete Cloth Installation
Concrete Cloth Installation
Concrete Cloth Installation
Culvert Headwall (LA DOTD)
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

Right side anchoring of the Concrete Cloth

Spray marking for the right side anchor trench
Day 2

Note that the lighter colored zone was hydrated on day 1.
Finished Installation
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.
CITY OF CALGARY - Mowing Strips Trial
Mowing Strips Trial - Cutting the CC in Half
Preparing the Area for Installation
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?