

INTRODUCTION



# An introduction to Geosynthetic Cementitious Composite Mats – an innovative approach to lining canals

*“Will is Director and co-founder of Concrete Canvas Ltd, which together with Peter Brewin, he has led from a university start-up to a multinational manufacturing business selling into over 80 countries around the world.*

*Will originally studied Engineering at the University of Bristol in the UK and Berkeley in the US and also has degrees from the RCA and Imperial College in London.”*

**Will Crawford** (MEng MA DIC)  
Director  
Concrete Canvas Ltd



**IGS TECHNICAL COMMITTEE ON HYDRAULICS**  
**Improving the Performance of Canals with Geosynthetics**

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THE PROBLEM



***‘50% of the world’s population will face water shortages by 2025..... if we do nothing’***

UK Government, Trade Commissioner for Africa  
(2021)

***‘1/3 water is lost during transportation in canals’***

International Committee of Irrigation & Drainage  
(2006 census)



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## THE PROBLEM

### Conventional concrete solutions are problematic

- In-service
  - Ground-heave / settlement causes cracking
  - Cracking leads to water seepage
  - Seepage can cause
    - Salination of soils
    - Waterlogging
    - Undermining leading to total collapse



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    - Salination of soils
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    - Undermining leading to total collapse
- Installation
  - Time consuming
  - On-site quality control
  - Side slope angle limitation (<1:1.5 without formwork)



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THE PROBLEM

Concrete also has its advantages...

So why is concrete still used?

*“concrete linings remain the preferred method of lining canals, because engineers and agencies are familiar with concrete linings”*

Giroud & Plusquellec 2017

- Hard-wearing
- Durable
- UV Resistant



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THE PROBLEM

Geomembrane Canal Lining: Benefit/Cost Comparison

In 2002 the US Department of Reclamation completed a 10 year trial on 34 canal lining test sections across 11 irrigation districts. The 34 sections are divided into 4 generic categories.

Type of Lining	Durability	Maintenance Cost	Effectiveness at Seepage Reduction	Benefit/Cost Ratio
	years	\$/ft <sup>2</sup> -yr	%	B/C
Fluid Applied Membrane	10-15	0.01	90	0.2-1.5
Concrete Alone (Shotcrete)	40-60	0.005	70	3.0-3.5
Exposed Geomembrane	10-25	0.01	90	1.9-3.2
Geomembrane with Concrete Cover	40-60	0.005	95	3.5-3.7



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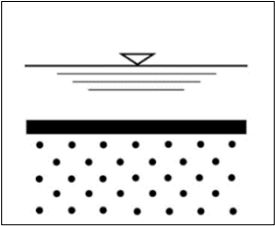


THE PROBLEM

Dual Challenges of:

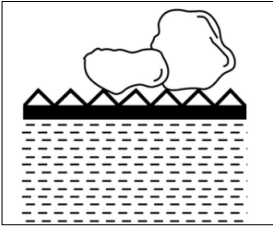
FUNCTION:

Waterproofing



+

Protection / Erosion Control




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THE PROBLEM

Dual Challenges of:

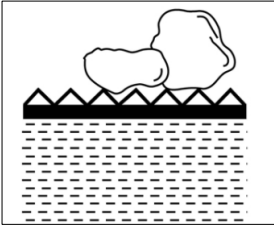
FUNCTION:

Waterproofing



+

Protection / Erosion Control



PROPERTIES:

*Impermeable*

*Durable & Hard-wearing*

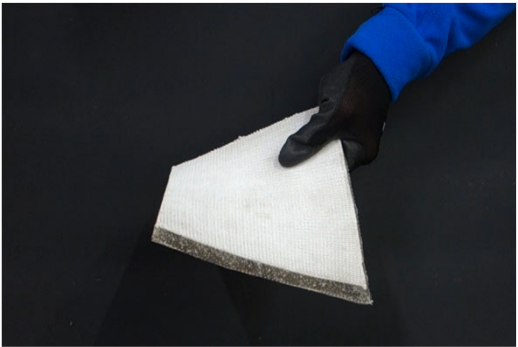
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Improving the Performance of Canals with  
Geosynthetics

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THE SOLUTION

New Class of Geosynthetic material



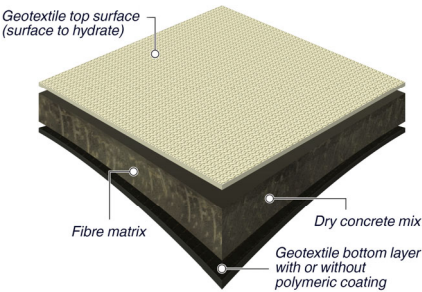
GCCMs change from flexible to rigid on hydration

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WHAT ARE GCCMS?

GCCMs (Geosynthetic Cementitious Composite Mats)

Flexible concrete filled geosynthetic that hardens when hydrated to form a thin, durable waterproof concrete layer. Used for **erosion control** and **containment** applications.



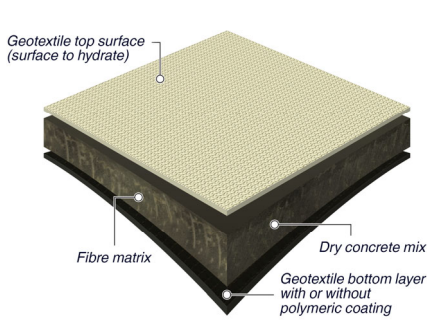
GCCMs: **Erosion Control**

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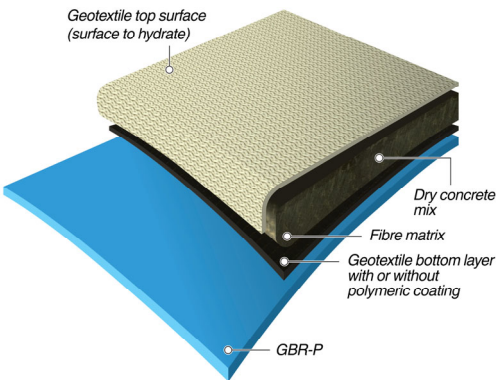
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GCCMs: **Erosion Control**



GCCBs: **Containment**

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GCCM DELIVERY FORMATS

**TYPICAL DELIVERY FORMATS**



**CC Bulk Rolls**  
Up to 200sqm of concrete on a single pallet



**CC Batched Rolls**  
Man portable batched rolls of 5 or 10sqm



**CC Wide Rolls**  
Available in 2.2m and 3.3m widths


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PROPERTIES				
GCCM Properties				
ASTM D8364 Spec Standard for GCCMs		TYPE I	TYPE II	TYPE III
Thickness (mm) - <i>typical</i>	ASTM D5199	~5mm	~8mm	~13mm
Mass (kg/sqm) - <i>typical</i>	ASTM D5993	7kg	12kg	19kg
Flex Strength (N/m) – Initial (24hrs)	ASTM D8058	>625	>1500	>3750
Flex Strength (MPa) – Initial (24hrs)	ASTM D8058	>3.5MPa		
Flex Strength (MPa) – Final (24hrs)	ASTM D8058	>4.0MPa		
Compressive Strength (MPa) (28 days)	ASTM D8329	>40MPa	>50MPa	>60MPa
Abrasion Resistance (mm/1000c) 28 days	ASTM C1353	<0.3mm/ 1000 cycles		

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Typical Type I GCCM slope protection application  
CC5™, Brunei, 2019




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Compressive Strength (MPa) (28 days)	ASTM D8329	>40MPa	>50MPa	>60MPa
Abrasion Resistance (mm/1000c) 28 days	ASTM C1353		<0.3mm/ 1000 cycles	


Typical Type II GCCM channel lining application  
CC8™, Myra Falls, Canada, 2016



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GCCM Properties				
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Thickness (mm) - <i>typical</i>	ASTM D5199	~5mm	~8mm	~13mm
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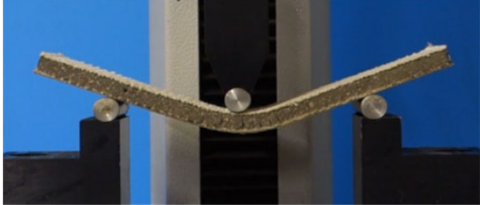
Typical Type III GCCM application over loose subgrade with high velocity flow.  
CC13™, Willow Creek, Canada, 2012



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PROPERTIES				
GCCM Properties				
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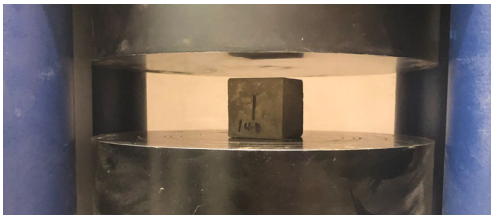
Flexural Strength testing



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Compressive Strength of Cementitious Mix



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PROPERTIES

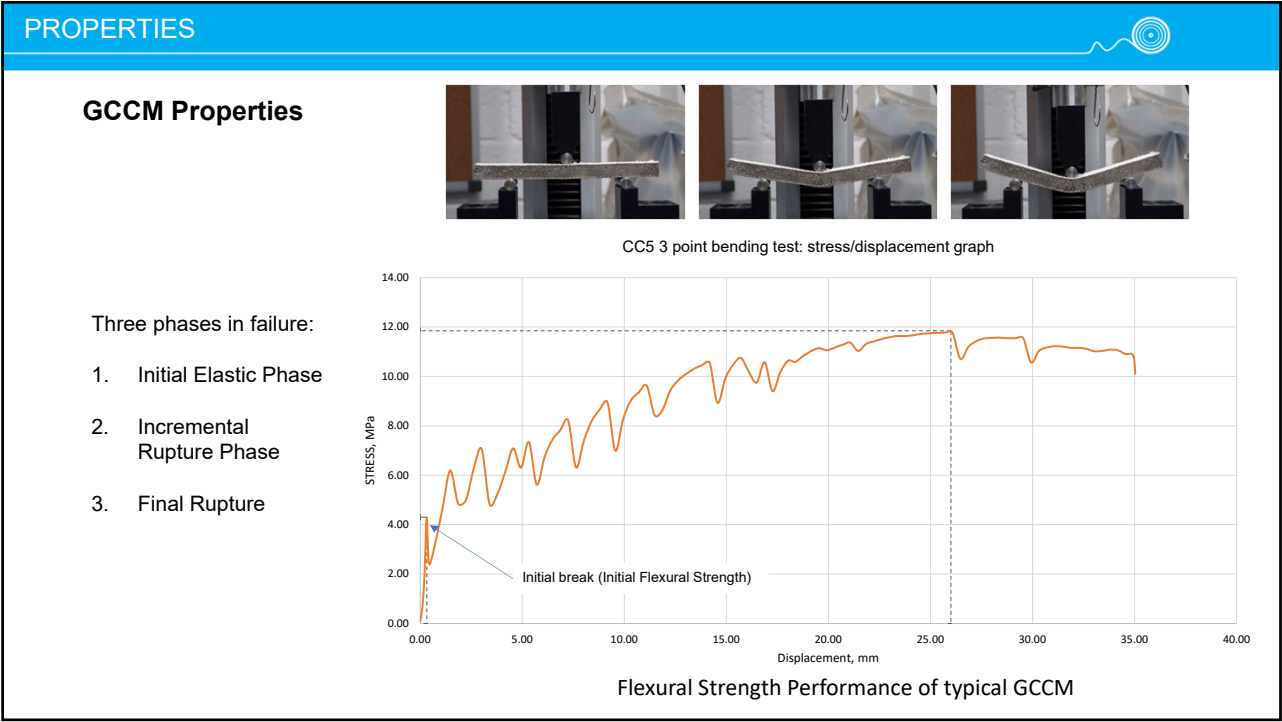
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### BBA Certification

Durability (GCCB / GCCM)	BBA	50yrs / 120yrs
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CASE STUDY



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CASE STUDY



24



CASE STUDY



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CASE STUDY



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CASE STUDY



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SUMMARY

**GCCMs** : for **Erosion Control**  
**GCCBs** : for **Seepage Control**

- Speed of Installation
- Ease of Installation
- Durable
- Lower Carbon



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Presented by:

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Director  
will.crawford@concretecanvas.com



Thank You

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ASTM D8364 TABLE 1

GCCM Property	Test Method	State of GCCM	Unit	Minimum Values Unless Specified		
				Type I	Type II	Type III
Thickness	ASTM D5199	uncured	mm	4.5	7.0	7.0
Thickness	ASTM D5199	cured - 24 hrs	mm	4.5	7.0	7.0
Mass per Unit Area	ASTM D5993	uncured	kg/m <sup>2</sup>	6.5	10.5	10.5
Density	ASTM D5993/D5199	uncured	kg/m <sup>3</sup>	1250	1250	1250
Flexural Strength - Initial Breaking Load	ASTM D8058	cured - 24 hrs	N/m	625	1500	3750
Flexural Strength- Initial Flexural Strength	ASTM D8058	cured - 24 hrs	MPa	3.5	3.5	3.5
Flexural Strength- Final Flexural Strength	ASTM D8058	cured - 24 hrs	MPa	4	4	4
Compressive Strength of Cementitious Mix	ASTM D8329	cured - 28 days	MPa	40	50	60
Pyramid Puncture Resistance	ASTM D5494 Type B	cured - 28 days	kN	2.0	3.5	4.5
Abrasion Resistance (maximum value)	ASTM C1353	cured - 28 days	mm/1000 Cycles	0.3	0.3	0.3
Tensile Strength - Final	ASTM D6768	uncured	kN/m	8	8	8
Tensile Strength - Initial	ASTM D4885	cured - 28 days	kN/m	3.5	6.5	9
Tensile Strength - Final	ASTM D4885	cured - 28 days	kN/m	10	19	19
Freeze - Thaw (residual Initial Flexural Strength after 200 cycles)	ASTM C1185	cured - 28 days	%	80	80	80

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ASTM D8364 SECTION 13 - REVIEW OF MANUFACTURERS CERTIFICATIONS



## CC SPEC SHEET TO ASTM D8364

### Concrete Canvas® (CC) Classification Properties to ASTM D8364 "Standard Specification for GCCM Materials"

2103.01.EN

GCCM Property	Test Method	State of GCCM	Unit	Minimum Values Unless Specified				
				Type I Specification	CC5™	Type II Specification	CC8™	Type III Specification
Thickness	ASTM D5199	uncured	mm	4.5	>5.0	7.0	>7.5	7.0
Thickness	ASTM D5199	cured - 24 hrs	mm	4.5	>5.0	7.0	>7.5	7.0
Mass per Unit Area	ASTM D5993	uncured	kg/m <sup>2</sup>	6.5	>6.5	10.5	>10.5	10.5
Density	ASTM D5993/D5199	uncured	kg/m <sup>3</sup>	1250	>1250	1250	>1250	1250
Flexural Strength - Initial Breaking Load * (1st crack in cementitious material)	ASTM D8058	cured - 24 hrs	N/m	625	>625	1500	>1500	3750
Flexural Strength- Initial Flexural Strength * (1st crack in cementitious material)	ASTM D8058	cured - 24 hrs	MPa	3.5	>3.5	3.5	>3.5	3.5
Flexural Strength- Final Flexural Strength *	ASTM D8058	cured - 24 hrs	MPa	4	>4	4	>4	4
Compressive Strength of Cementitious Mix (water/cementitious materials ratio to ASTM D8329)	ASTM D8329	cured - 28 days	MPa	40	>40	50	>50	60
Pyramid Puncture Resistance	ASTM D5494 Type B	cured - 28 days	kN	2.0	>2.0	3.5	>3.5	4.5
Abrasion Resistance (cementitious barrier depth of wear - maximum value)	ASTM C1353	cured - 28 days	mm/1000 Cycles	0.3	<0.25	0.3	<0.25	0.3
Tensile Strength - Final *	ASTM D6768	uncured	kN/m	8	>8	8	>8	8
Tensile Strength - Initial ** (1st crack in cementitious material)	ASTM D4885	cured - 28 days	kN/m	3.5	>3.5	6.5	>6.5	9
Tensile Strength - Final **	ASTM D4885	cured - 28 days	kN/m	10	>10	19	>19	19
Freeze - Thaw (residual Initial Flexural Strength to ASTM D8058 after 200 cycles)	ASTM C1185	cured - 28 days	%	80	>80	80	>80	80
GCCM Classification	ASTM D8364	Type		CC5™ = Type I GCCM		CC8™ = Type II GCCM		CC13™ = Type III GCCM

\* GCCM materials are non-isotropic and the values for flexural strength, tensile strength, and initial breaking load are reported as the lower of the material machine production direction (length of roll) or material cross-machine production direction (width of roll).

\*\* When using CC tensile strength properties for design purposes, please contact Concrete Canvas Ltd for advice on the appropriate data to use.

For independent laboratory test results please consult the CC5™ ASTM D8364 Type I, CC8™ ASTM D8364 Type II and CC13™ ASTM Type III reports by BICS Laboratories Ltd



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		<b>BICS Laboratories Ltd</b>		120 Oliver Road, Brighton, West Sussex, BN1 1ST T +44 (0) 1293 727776 E info@bics-labs.co.uk W www.bics-labs.co.uk	
Contract Ref: 185		Material: Concrete Canvas		Report Ref No: BS-00024 Date: 10/05/2024	
TEST METHOD: CC5		TEST SPECIMEN NUMBER		MEAN	
Sample ID: CC5		1 2 3 4 5 6 7 8 9 10		BICS Sample Ref: 1	
Thickness (ASTM D5199)		0.36 0.44 0.46 0.48 0.50 0.52 0.54 0.56 0.58 0.60		0.50	
Mass Per Unit Area (ASTM D5993)		1.07 1.10 1.13 1.16 1.19 1.22 1.25 1.28 1.31 1.34		1.20	
Density (ASTM D5993/D5199)		1250 1250 1250 1250 1250 1250 1250 1250 1250 1250		1250	
Flexural Strength (ASTM D8058)		625 625 625 625 625 625 625 625 625 625		625	
Initial Flexural Strength (N/m)		1500 1500 1500 1500 1500 1500 1500 1500 1500 1500		1500	
Initial Flexural Strength (MPa)		3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5		3.5	
Final Flexural Strength (N/m)		3750 3750 3750 3750 3750 3750 3750 3750 3750 3750		3750	
Final Flexural Strength (MPa)		4 4 4 4 4 4 4 4 4 4		4	
Compressive Strength (MPa)		40 40 40 40 40 40 40 40 40 40		40	
Pyramid Puncture Resistance (kN)		2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0		2.0	
Abrasion Resistance (mm/1000 Cycles)		0.3 0.3 0.3 0.3 0.3 0.3 0.3 0.3 0.3 0.3		0.3	
Tensile Strength - Final (kN/m)		8 8 8 8 8 8 8 8 8 8		8	
Tensile Strength - Initial (kN/m)		3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5		3.5	
Tensile Strength - Final (kN/m)		10 10 10 10 10 10 10 10 10 10		10	
Freeze - Thaw (%)		80 80 80 80 80 80 80 80 80 80		80	
GCCM Classification		CC5™ = Type I GCCM		CC8™ = Type II GCCM	

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