Industry Voices

PRODUCT CERTIFICATION

Reducing Carbon in Concrete Erosion Protection Structures

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In collaboration with

CONCRETE CANVAS® Concrete on a Roll

Reducing Carbon in Concrete Erosion Protection Structures

With global carbon emissions reaching an all-time high, there are calls from scientists and environmental activists for governments, corporations and companies to act to prevent the further acceleration of climate change.

The Current Situation

The concrete industry is a leading producer of carbon dioxide (CO^2), generating up to 8% of worldwide man-made CO^2 emissions[1]. One of the main contributors to carbon emissions in the process of cement production is due to the high temperatures required to heat alite to the point of forming clinker.[2]

As a result, both the concrete industry and its clients must find ways to reduce carbon production in both the manufacturing process and end-use.

In 2013, the UK Government published 'Construction 2025', detailing their vision for the construction industry. They have set a target of lowering greenhouse gas emissions in the built environment by 50%. The British Board of Agrément (BBA) has supported the innovative ideas that aim to achieve this target.

The mission of the BBA is to support and facilitate quality and innovation in the construction industry, providing a catalyst for the development and application of safe, technically excellent and innovative solutions for a better-built environment.

Concrete Canvas used for channel lining on a major rail scheme

[1] Chatham House Report "Making Concrete Change: Innovation in Low-carbon Cement and Concrete" : https://reader.chathamhouse.org/making-concrete-change-innovation-low-carbon-cement-and-concrete#

[2] Green cement: Concrete solutions article: https://www.nature.com/news/green-cement-concrete-solutions-1.12460

Concrete Canvas Slope Protection
Installation in Spain

"As climate change continues, the potential for more frequent extreme weather events and melting of ice caps means..."

Concrete Use in Erosion Protection

One of the many uses of cement is in concrete erosion control structures.

They can be fabricated from poured, precast or sprayed concretes and are typically used to create irrigation channels, crest drainage ditches, outfalls and spillways. Concrete lined erosion control structures prevent water from eroding soils, which could cause potential ground instability and failure, or allow water migration and flooding of sensitive areas. As climate change continues, the potential for more frequent extreme weather events and melting of ice caps means that the necessity to control water and prevent erosion becomes even more important.

Concrete lined erosion control structures can provide long term (in excess of 60 years) erosion control and can be designed to withstand sustained high-velocity water flows.

Replacing Concrete in Erosion Protection Structures

The simplest way to reduce the carbon used in erosion control structures is to

eliminate the use of concrete for protection. Some irrigation structures and ditches may perform for their required design life if vegetation cover provides sufficient erosion protection. A good, consistent cover with a well-developed root zone can 'bind' the substrate and help prevent the erosion of the soil particles.

However, the erosion protection provided by vegetation cover reduces over time (based on CIRIA Report No 116, Design of reinforced grass spillways).

There are several Geosynthetic Turf Reinforcement Mats (TRMs) available on the market which can be temporary (biodegradable) or permanent (non-biodegradable) which improve limiting velocity and duration of the resistance of vegetation to erosion.

Vegetated and Turf reinforced structures can often provide a suitable engineered solution for many erosion-controlled structures. However, there are still erosion control applications that may require more robust, armoured solutions. Conventional concrete, such as poured, precast and sprayed solutions are used when higher levels of erosion protection are required than TRMs can offer, or when vegetation

Concrete Canvas used for remediation of existing channel on a hydroelectric scheme

'Aged' Concrete Canvas Material - installation for Natural Resources Wales

needs to be prevented from establishing to avoid long term maintenance issues.

Some drainage channels can become 'disestablished' over time due to silt deposition or significant vegetation growth, which has the potential to reduce the capacity of the channel and cause potential problems including drainage management issues. This is particularly important when drainage channels prevent water from causing damage to critical infrastructures, such as crest drainage channels that prevent surface runoff water from saturating a slope, which would otherwise cause potential instability and soil slippage onto buildings, highways or rail tracks.

Highways, rail and asset owners may often choose to line these channels in concrete to reduce the need for regular maintenance, protecting critical assets.

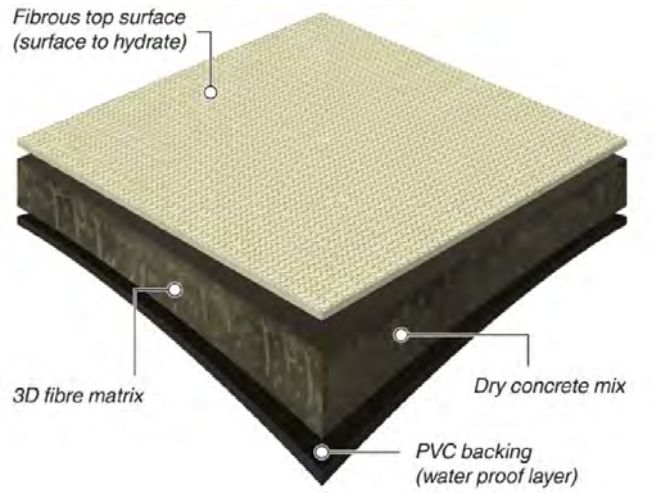
A Lower Carbon Alternative – the GCCM

Over the past decade, a new construction product has been developed to provide an alternative to the use of conventional concrete for erosion control – the Geosynthetic Cementitious Composite Mat (GCCM). GCCMs have been defined in ASTM standard D4439-20[3] as 'a factory-assembled geosyn-

[3] ASTM D4439-20 'Standard Terminology for Geosynthetics'

thetic composite consisting of a cementitious layer contained within a layer or layers of geosynthetic materials that becomes hardened when hydrated'. (see Figure 1)

Figure 1. Section of a GCCM



GCCMs consist of a three-dimensional fibre structure filled with a dry cement/concrete mix, overlain by a hydrophilic filter layer and underlain by a watertight polymeric film. The material is delivered in its dry format and unrolled into place using similar installation techniques to traditional geosynthetics. Once in place, it is hydrated by spraying with water and the cement/concrete mix hardens.

The result is a fibre-reinforced concrete layer with a thickness typically between 5mm and 13mm.

The ability to transport, store and deploy concrete surfacing in a rolled format offers significant logistical advantages over conventional concrete solutions. A single bulk roll of 8mm thick GCCM can be transported on a single pallet and will surface 125sqm; this will cover the equivalent area as two 17T ready-mix trucks using poured concrete.

GCCMs have erosion control[4] and weed suppression characteristics[5] similar to conventional concrete and have been used to replace up to 150mm of poured concrete for use in erosion-controlled structures,[6] some of which have been designed to accommodate highly erosive water flows up to 20m/s. An 8mm thick GCCM uses 95% less material than the poured concrete alternative which not only provides logistical benefits but also reduces the carbon footprint.

A recent study (Mironov V. 2017 Embodied Carbon Report, Concrete Canvas Ltd) to assess the carbon footprint of a leading GCCM product using ISO 14040 full Life Cycle Assessment method, found that when considering raw materials alone, an 8mm thick GCCM lined channel contained less than 45% (≈16.13/36.00) of the embodied carbon of a conventional 150mm thick unreinforced concrete channel. (See Table 1)

Table 1. Raw material assessment of concrete channel lining systems to ISO 14040

Lining Material	**Kg CO_2-Eq/sqm**
ST4 Insitu Concrete (C20/24MPa) 150mm)	36.00
GCCM (8mm)	16.13

When transportation was taken into consideration and based on the GCCM being transported 5 times further to a site than locally sourced concrete, the GCCM still provided more than a 50% (=(0.44-0.21)/0.44) reduction in transportation carbon costs. (See Table 2)

Table 2. Transportation assessment of concrete channel lining systems to ISO 14040

Transport to Site Compaction	**Tonnes**	**Miles**	**Kg CO_2-Eq/sqm**
ST4 Concrete (C20/24MPa) (150mm)	17	20	0.44
GCCM (8mm)	1.6	100	0.21

GCCMs are typically installed at ten times the rate of poured concrete so significant carbon savings are expected when considering Construction Installation Process carbon costs but will vary from project to project.

Recently, leading GCCM manufacturer, Concrete Canvas Ltd, received BBA Certification for their product which provided them with a recognised symbol of quality and reassurance for a plethora of stakeholders in the construction industry.

For such an innovative product that ultimately lends itself to the reduction of the carbon footprint, the certification of the system was challenging as Concrete Canvas Ltds products are used in a wide variety of applications that were not fully covered in the scope of any Standards. Therefore, to provide certification the BBA had to identify appropriate test methods and assessment criteria.

This included GCCM climatic performance, which was evaluated through testing of the material's freeze/thaw resistance.

On conclusion of the assessment, the BBA awarded Certificate 19/5685 covering use of the Concrete Canvas Geosynthetic Cementitious Composite Mat and Barrier product for erosion control and weed suppression applications with a life expectancy in

[4] Concrete Canvas Technical Report; "Abrasion resistance", 2019

[5] Concrete Canvas Technical Report; "Weed suppression: Japanese knotweed", 2016

[6] Concrete Canvas Case Study; "Channel lining", 2017

excess of 120 years under normal UK conditions.

What this means for the market is that a GCCM such as Concrete Canvas® can be used to replace poured concrete for erosion protection applications, leading to a considerable reduction in the carbon cost over a comparable design life when designed, installed and maintained in accordance with this BBA Certificate.

Conclusion

It is possible to reduce carbon emissions associated with the concrete industry by using alternative solutions to concrete for erosion control applications. For low risk, low erosion situations a vegetated or turf reinforced lining can be considered.

For higher flow/erosion applications, or where reduced maintenance or prevention of vegetation growth is required, concrete can now be replaced with GCCMs, providing over 50% carbon footprint reductions, in line with the Governments Construction 2025 vision.

Attaining a BBA Certificate facilitates the use of these and other innovative products while ensuring that they meet the required standards, providing reassurance to specifiers, contractors and architects that the products are fit-for-purpose.

Meet the authors

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A qualified engineer with a Post-Doc Research Fellowship from the University of Greenwich London, a BSc 1st Class Honours, an MSc Distinction and a PhD in Civil Engineering (Structures) at the School of Engineering, Shiraz University in Iran. Morteza is a Fellow member of Institute of Materials, Minerals and Mining (IOMMM) and a Graduate member of the Institute of Civil Engineering (ICE). He began his career as a lecturer at the universities of Shiraz and East London, becoming a senior lecturer at the university of Greenwich for Structures and Construction Materials. Following this he worked as a Principal Engineer at Chelmer Consultancy Services before joining the BBA. He is the Principal Structural Engineer in the BBA's Technical Excellence department.

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Lee Church is an Engineering Technician with the Institute of Civil Engineering (ICE) with a Bachelor's degree in Geology from Durham University. Lee has over 14 years' experience in Geotechnical Engineering, primarily in slope stability design and the specification of erosion control solutions. Lee has worked with Concrete Canvas Ltd for 5 years and as Technical Manager is responsible for design, research and development of GCCM material applications.

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