EUROPEAN ASSESSMENT DOCUMENT

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GEOSYNTHETIC CEMENTITIOUS COMPOSITE MATS AND BARRIERS

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This European Assessment Document (EAD) has been developed taking into account up-to-date technical and scientific knowledge at the time of issue and is published in accordance with the relevant provisions of Regulation (EU) No 305/2011 as a basis for the preparation and issuing of European Technical Assessments (ETA).

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1 SCOPE OF THE EAD

1.1 Description of the construction product

Geosynthetic Cementitious Composite Mats and Barriers (GCC-Ms/GCC-Bs) (see Figure 1.1.1) are flexible concrete filled fabrics for use in a range of geotechnical applications.

These construction products consist of a three-dimensional fibre matrix containing a concrete mix that hardens when hydrated to form a thin and durable concrete layer.

GCC-Ms/GCC-Bs consist of top and bottom geotextile layers that constrain a concrete mix. A polymeric coating may be applied to the bottom layer of some GCC-Ms/GCCs-Bs to improve the waterproof capability. The connecting yarns/fibres of the fibre matrix sets the thickness of the GCC-Ms/GCC-Bs by securing the top and bottom geotextile layers together.

GCC-Bs consist of the following:

- Geotextile top layer (synthetic or biodegradable)
- Concrete mix: a specially formulated dry concrete mix
- Internal polymeric fibre matrix consisting of connecting yarns/fibres
- Geotextile bottom layer with or without a polymeric coating

For GCC-Bs a geosynthetic barrier (e.g., PVC, LLDPE, HDPE) is laminated or extruded onto the rear surface of the GCC-M to provide improved impermeability.

For the water permeability it is the geosynthetic barrier (geomembrane) which defines the performance and which is representative for the whole product.

The product is not covered by a harmonised European standard (hEN).

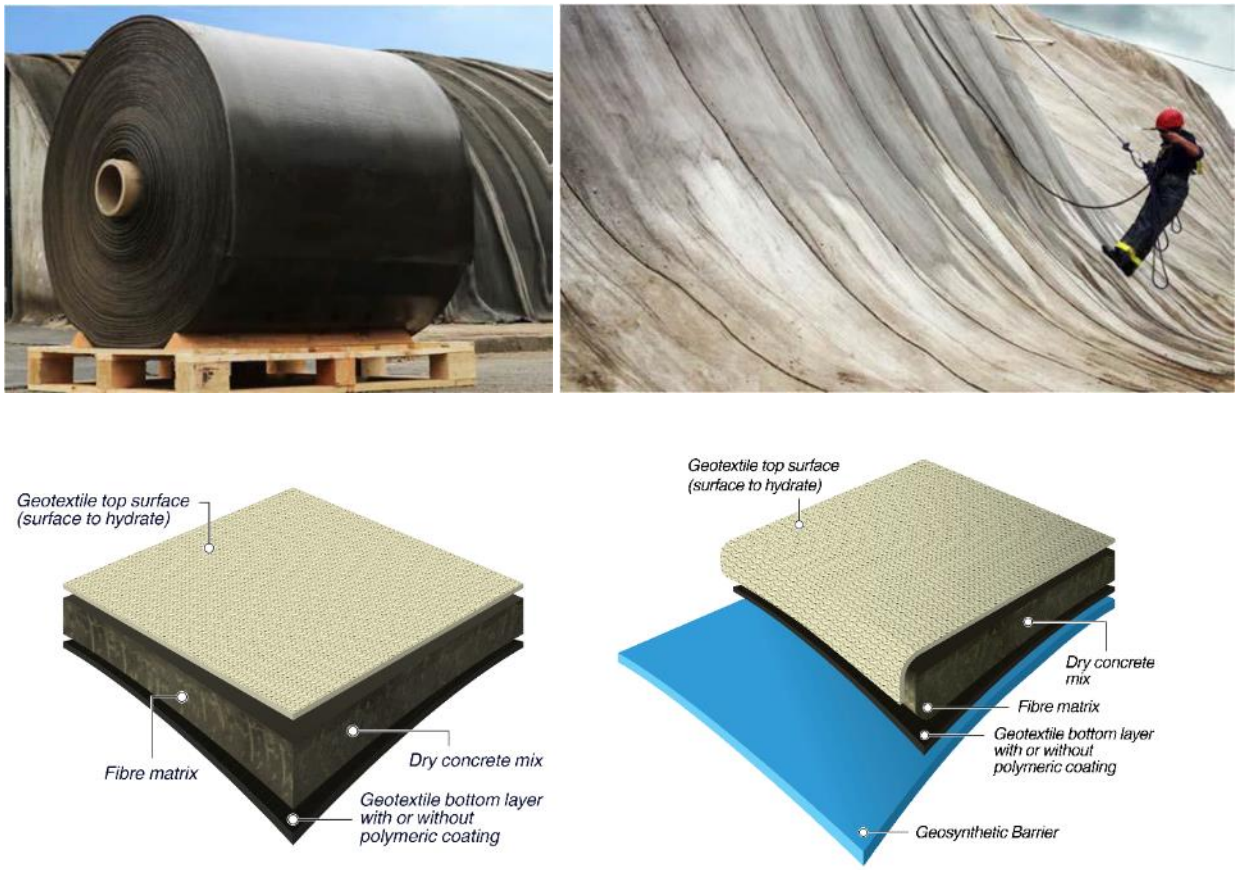

Figure 1.1.1. Geosynthetic Cementitious Composite Mats and Barriers

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Concerning product packaging, transport, storage, maintenance, replacement and repair it is the responsibility of the manufacturer to undertake the appropriate measures and to advise their clients on the transport, storage, maintenance, replacement and repair of the product as they consider necessary.

It is assumed that the product will be installed according to the manufacturer's instructions or (in absence of such instructions) according to the usual practice of the building professionals.

Relevant manufacturer's stipulations having influence on the performance of the product covered by this European Assessment Document shall be considered for the determination of the performance and detailed in the ETA.

1.2 Information on the intended use(s) of the construction product

1.2.1 Intended use(s)

The products covered by this EAD are for use as erosion control and containment linings for water channels, for drainage or irrigation and as facings for slopes as a replacement for non-structural concrete on slopes up to defined limitations. The intended uses can be outlined as:

- **Channel Lining**
- **Slope Protection**
- **Bund Lining**
- **Remediation**
- **Culvert Lining**

1.2.2 Working life/Durability

The assessment methods included or referred to in this EAD have been written based on the manufacturer's request to take into account a working life of the GCC-Ms/GCC-Bs for the intended use of up to 50 years when installed in the works (provided that the material is subject to appropriate installation). These provisions are based upon the current state of the art and the available knowledge and experience.

When assessing the product the intended use as foreseen by the manufacturer shall be taken into account. The real working life may be, in normal use conditions, considerably longer without major degradation affecting the basic requirements for works[1].

The indications given as to the working life of the construction product cannot be interpreted as a guarantee neither given by the product manufacturer or his representative nor by EOTA when drafting this EAD nor by the Technical Assessment Body issuing an ETA based on this EAD, but are regarded only as a means for expressing the expected economically reasonable working life of the product.

[1] The real working life of a product incorporated in a specific works depends on the environmental conditions to which that works is subject, as well as on the particular conditions of the design, execution, use and maintenance of that works. Therefore, it cannot be excluded that in certain cases the real working life of the product may also be shorter than referred to above.

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2 ESSENTIAL CHARACTERISTICS AND RELEVANT ASSESSMENT METHODS AND CRITERIA

Note: All undated references to standards or to EAD's in this EAD are to be understood as references to the dated versions listed in clause 4.

2.1 Essential characteristics of the product

Table 2.1.1 shows how the performance of the GCCs-M/GCC-Bs is assessed in relation to the essential characteristics.

Table 2.1.1 Essential characteristics of the product and methods and criteria for assessing the performance of the product in relation to those essential characteristics

No	Essential characteristic	Assessment method	Type of expression of product performance
Basic Works Requirement 1: Mechanical resistance and stability			
1	Flexural strength	2.2.1	*Level*
2	Static Puncture resistance	2.2.2	*Level*
3	Dynamic Puncture resistance	2.2.3	*Level*
4	Pyramid puncture resistance	2.2.4	*Level*
5	Strength of internal linking fibres	2.2.5	*Level*
Basic Works Requirement 4: Safety and accessibility in use			
6	Resistance to chemicals	2.2.6	*Level*
7	Resistance to environmental effects	2.2.7	*Level*
Basic Works Requirement 7: Sustainable use of natural resources			
8	Abrasion resistance	2.2.8	*Level*
9	Freeze – Thaw	2.2.9	*Level*
10	Water Permeability	2.2.10	*Level*
11	Gas Permeability	2.2.11	*Level*

2.2 Methods and criteria for assessing the performance of the product in relation to essential characteristics of the product

This chapter is intended to provide instructions for TABs. Therefore, the use of wordings such as "shall be stated in the ETA" or "it has to be given in the ETA" shall be understood only as such instructions for TABs on how results of assessments shall be presented in the ETA. Such wordings do not impose any obligations for the manufacturer and the TAB shall not carry out the assessment of the performance in relation to a given essential characteristic when the manufacturer does not wish to declare this performance in the Declaration of Performance.

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2.2.1 Flexural strength

The flexural strength of the GCC-M/GCC-B must be measured as described in Annex A, in the cross-machine and machine direction with the topside, uppermost in the flexural testing machine.

Samples shall be prepared in accordance with Annex B, padded dry with a paper towel or allowed to drip dry for up to 2 hours and tested at 24-26 hours from initial hydration.

2.2.2 Static Puncture resistance

The static puncture of hardened (cured) GCC-M/GCC-B must be determined in accordance with EN ISO 12236. Samples shall be prepared in accordance with Annex B and tested not earlier than 1 day of hydration (Annex B) + 27 days storage in 21+/- 2°C and 65+/-5% relative humidity.

2.2.3 Dynamic Puncture resistance

The dynamic puncture resistance of hardened (cured) GCC-M/GCC-B must be determined in accordance with EN ISO 13433. Samples shall be prepared in accordance with Annex B and tested no earlier than 1 day of hydration (Annex B) + 27 days storage in 21+/- 2°C and 65+/-5% relative humidity

2.2.4 Pyramid puncture resistance

The protection of hardened (cured) GCC-M/GCC-B against pyramid puncture resistance of supported sample must be determined in accordance with EN 14574. Samples shall be prepared in accordance with Annex B and tested no earlier than 1 day of hydration (Annex B) + 27 days storage in 21+/- 2°C and 65+/-5% relative humidity.

2.2.5 Strength of internal linking fibres

The strength of the internal linking fibres of the dry (uncured) GCC-M/GCC-B must be determined in accordance with Test B of EN ISO 13426-2. The top and bottom layers shall be separated by severing the lining fibres with a knife or razor for the first 100mm in accordance with Figure 4 of the standard.

2.2.6 Resistance to chemicals

The Chemical resistance of the hardened (cured) GCC-B must be determined in accordance with EN 14414 (Methods A-D) with one exception. The flexural strength as per Section 2.2.1 of this EAD must replace the tensile strength test determined in accordance with EN ISO 527-1. The initial flexural strength of specimens after treatment to EN 14414 must be divided by the initial flexural strength of reference specimens to report in the ETA the retained initial flexural strength as a percentage value.

Samples shall be prepared in accordance with Annex B and tested no earlier than 1 day of hydration (Annex B) + 27 days storage in 21+/- 2°C and 65+/-5% relative humidity.

2.2.7 Resistance to environmental effects

The resistance of the product to environmental effects for the hardened (cured) GCC-M/GCC-B shall be determined in accordance with the requirements of the required characteristics stated in the standards for geotextiles and related products and geosynthetic barriers as appropriate. For example, EN 13361 Annex A for geosynthetic barriers and EN 13254 Annex B for geotextiles and related products. For each specific characteristic tested the evaluation shall be by change in flexural strength as per Section 2.2.1 of this EAD instead of by change in tensile strength stipulated in those Annexes. Specimen number shall be taken from EN 12226 where referenced in the test methods below. However, samples shall be prepared in accordance with Annex B and tested no earlier than 1 day of hydration (Annex B) + 27 days storage in 21+/- 2°C and 65+/-5% relative humidity.

Resistance to environmental effects characteristics to be tested shall be:

Weathering (UV):	EN 12224
Microbiological resistance:	EN 12225
Leaching:	EN 14415
Thermal ageing:	EN 14575

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2.2.8 Abrasion resistance

The abrasion resistance of the fibrous top surface of the hardened (cured) GCC-M/GCC-B must be measured as per Annex C. Samples shall be prepared in accordance with Annex B and tested no earlier than 1 day of hydration (Annex B) + 27 days storage in 21+/- 2°C and 65+/-5% relative humidity.

2.2.9 Freeze – Thaw

The freeze-thaw resistance of the hardened (cured) GCC-M/GCC-B must be determined in accordance with EN 12467 with one exception. The evaluation shall be by change in flexural strength as per Section 2.2.1 of this EAD.

2.2.10 Water Permeability

The water permeability of the GCC-B must be determined in accordance with EN 14150. Testing is to be performed on the geosynthetic barrier (geomembrane) component only.

2.2.11 Gas Permeability

The Gas Permeability of the hardened (cured) GCC-B must be measured as per Annex D. (Test to be performed on the geosynthetic barrier (geomembrane) component only)

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3 ASSESSMENT AND VERIFICATION OF CONSTANCY OF PERFORMANCE

3.1 System(s) of assessment and verification of constancy of performance to be applied

For the products covered by this EAD the applicable European legal act is: Commission Delegated Decision (EU) 2015/1958.

The system is: 2+

3.2 Tasks of the manufacturer

The cornerstones of the actions to be undertaken by the manufacturer of the product in the procedure of assessment and verification of constancy of performance are laid down in Table 3.2.1.

Table 3.2.1 Control plan for the manufacturer; cornerstones

No	Subject/type of control	Test or control method	Criteria,if any	Minimum number of samples	Minimum frequency of control
Factory production control (FPC) [including testing of samples taken at the factory in accordance with a prescribed test plan					
1	Thickness	3.4.1	According to control plan	1	Per week
2	Mass per unit area & Density	3.4.2	According to control plan	1	Per week
3	Flexural strength	2.2.1	According to control plan	3	Per year
4	Static Puncture	2.2.2	According to control plan	3	Per year
5	Abrasion resistance	2.2.8	According to control plan	3	Per year

3.3 Tasks of the notified body

The cornerstones of the actions to be undertaken by the notified body in the procedure of assessment and verification of constancy of performance for GCC-Ms/GCC-Bs are laid down in Table 3.3.1.

Table 3.3.1 Cornerstones for Notified Body

No	Subject/type of control	Test or control method	Criteria, if any	Minimum number of samples	Minimum frequency of control
Initial inspection of the manufacturing plant and of factory production control					
1	Notified Body will ascertain that the factory production control with the staff and equipment are suitable to ensure a continuous and orderly manufacturing of the "Product".	Verification of the complete FPC as described in the control plan agreed between the TAB and the manufacturer	According to Control plan	According to Control plan	When starting the production or a new line
Continuous surveillance, assessment and evaluation of factory production control (for systems 1+, 1 and 2+ only)					
2	The Notified Body will ascertain that the system of factory production control and the specified manufacturing process are maintained taking account of the control plan.	Verification of the controls carried out by the manufacturer as described in the control plan agreed between the TAB and the manufacturer with reference to the raw materials, to the process and to the product as indicated in Table 3.2.1	According to Control plan	According to Control plan	1/year

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3.4 Special methods of control and testing used for the assessment and verification of constancy of performance

3.4.1 Thickness

Thickness of the whole structure must be determined as per EN 1849-2 on dry (uncured) samples. Three test samples of the dry (uncured) GCC-M/GCC-B shall be taken as per section 5.3 in EN 1849-2.

3.4.2 Mass per unit area and Density

The mass per unit area of dry (uncured) GCC-M/GCC-B shall be determined in accordance with EN 1849-2. The density of the dry (uncured) samples can then be calculated by dividing the mass per unit area of the product by the thickness.

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4 REFERENCE DOCUMENTS

[1] EN 1849-2 : 2009 Flexible sheets for waterproofing. Determination of thickness and mass per unit area. Bitumen sheets for roof waterproofing

[2] EN 12224 : 2000 Geotextiles and geotextile-related products. Determination of the resistance to weathering

[3] EN 12225 : 2000 Geotextiles and geotextile related products – Methods for determining the microbiological resistance by a soil burial test

[4] EN 12226 : 2012. Geosynthetics. General tests for evaluation following durability testing

[5] EN 12467 : 2012 + A1 : 2016 Fibre-cement flat sheets. Product specification and test methods

[6] EN 13254 : 2016 Geotextiles and geotextile-related products. Characteristics required for the use in the construction of reservoirs and dams

[7] EN 13361 : 2018 Geosynthetic barriers. Characteristics required for use in the construction of reservoirs and dams

[8] EN 14150 : 2006 Geosynthetic barriers. Determination of permeability to liquids

[9] EN 14414 : 2004 Geosynthetics. Screening test method for determining chemical resistance for landfill applications

[10] EN 14415 : 2004 Geosynthetic Barriers – Test method for determining the resistance to leaching

[11] EN 14574 : 2015 Geosynthetics. Determination of the pyramid puncture resistance of supported geosynthetics

[12] EN 14575 : 2005 Geosynthetic barriers – Screening test method for determining the resistance to oxidation

[13] EN ISO 527-1 : 2012 Plastics. Determination of tensile properties. General principles

[14] EN ISO 12236 : 2006 Geosynthetics. Static puncture test (CBR test)

[15] EN ISO 13433 : 2006 Geosynthetics. Dynamic perforation test (cone drop test)

[16] EN ISO 13426-2 : 2005 Geotextiles and geotextile-related products. Strength of internal structural junctions. Geocomposites

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Annex A – Test Method to Determine the Flexural Strength of Geosynthetic Cementitious Composite Mats and Barriers (GCC-Ms/GCC-Bs)

A.1 Scope

A.1.1 This test method covers the evaluation of flexural strength by determination of the initial flexural strength, the deflection at initial break, the final flexural strength and the initial modulus of elasticity of GCC-Ms/GCC-Bs in both the machine and cross machine directions.

A.1.2 This method uses a three-point bending test apparatus setup with the load applied at the centre. The load and displacement are recorded simultaneously to determine the initial and final flexural strengths, the deflection at those loads and the initial modulus.

A.2 Auxiliary Apparatus

A.2.1 Flexural Testing machine, a constant rate of extension (CRE)-type of testing machine with displacement measurement shall be used.

A.2.2 Three-Point Flexural Fixture, a fixture designed for use with the flexural testing machine with two bottom supports and a third edge which is used to load the specimen from the top at mid span. The fixture is designed so that the specimen is loaded and can be analysed as a simple beam. The supports are cylindrical on the specimen contact surface with a 10 +/-2mm radius. These support points shall revolve and shall be designed so that they cannot exert longitudinal or vertical constraints. The loading surface must have a similar edge bearing.

A.2.3 Micrometer, mounted to the loading member with a reading to 0.25 mm, to determine the deflection of the specimen at the centre of the test span as the load is measured.

A.2.4 Thickness Gage, a measurement device for characterising the thickness of the specimens in the vicinity of the breaks which occur during the flexural test. The thickness gage shall have an accuracy of +/-0.05 mm.

A.3 Sampling

A.3.1 All sampling and specimen preparation shall be in accordance with the method set out in Annex B.

A.3.2 The specimens must be tested at 24 hours from initial hydration +/- 4hours.

A.3.3 Prepare specimens to 40 +/-1.6mm wide by 160 +/-1.6mm long. Each specimen must have a flatness tolerance of 5mm. Prepare 10 specimens in the machine direction and 10 specimens in the cross-machine direction.

A.4 Procedure

A.4.1 Using the thickness gage, measure the total thickness of the specimen at a minimum of 2 points along the mid span of the specimen where the loading fixture will be positioned. For specimens manufactured with a textured top surface that has clearly variable thickness, measure 2 crest thicknesses and 2 trough thicknesses. Record the average total GCC-M/GCC-B thickness. Measuring at direct cut edges must be avoided. When measuring the thickness of GCC-B or GCC-M where the backing membrane is thicker than 0.75mm, measure the average membrane thickness at a minimum of 2 points and calculate the average membrane thickness. Deduct the average membrane thickness from the total GCC-M/GCC-B thickness for flexural strength test result calculations.

A.4.2 Set up a uniform deflection rate on the flexural testing machine so the initial break will occur in the specimen between 5 and 30s from the start of the test.

A.4.3 The error in load reading shall not exceed 1% of the maximum load.

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A.4.4 The test span shall be 100 +/-1.6mm and the load line and support shall be parallel.

A.4.5 Position the specimen on the three-point flexural fixture with the topside uppermost, making sure to centre the specimen on the central supports.

A.4.6 Move the loading fixture so that it is just making contact with the topside of the specimen.

A.4.7 Measure and record the load and deflection when the initial breaking load (the first drop in load) and final breaking load (the maximum load) are reached.

A.5 Calculation

A.5.1 Calculate the flexural strength of each specimen by using the following equation:

$$R = \frac{3PL}{2bd^2}$$

where:

R	=	flexural strength, MPa
P	=	breaking load, N
L	=	length of span, mm
b	=	width of specimen, mm
d	=	average thickness, mm.

A.5.2 Calculate the average value for the initial flexural strength and standard deviation for the machine direction and cross-machine direction respectively.

A.5.3 Calculate the average value for the final flexural strength and standard deviation for the machine direction and cross-machine direction respectively.

A.5.4 Calculate the initial modulus of elasticity of each specimen by using the following equation:

$$E = (P_2 - P_1) \times L^3 \,/\, 4b\, d^3 (y_2 - y_1)$$

where:

E	=	modulus of elasticity, N/mm^2
P_2 and P_1	=	loads, N, taken from two points within the linear section of the plot before the initial breaking load
y_1 and y_2	=	deflections, mm corresponding to the loads selected
L	=	length of span, mm
b	=	width of specimen, mm
d	=	average thickness, mm.

A.5.5 Calculate the average value for the initial modulus of elasticity and the standard deviation for the machine direction and cross-machine direction respectively.

A.6 Report

A.6.1 Report the type of GCC-M or GCC-B tested (for example the manufacturer description or product number) and sample identification (for example the sample number) and the curing time of the specimens.

A.6.2 Report the average value for initial flexural strength for both machine and cross-machine directions.

A.6.3 Report the average value for the deflection at initial breaking load.

A.6.4 Report the average value for final flexural strength for both machine and cross-machine directions.

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A.6.5 Report the average value for initial modulus of elasticity for both machine and cross-machine directions.

A.6.6 Report the standard deviation for A.6.2 to A.6.5.

A.6.7 Any deviation from the procedure described in this paragraph.

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Annex B –Method to Prepare Cured Samples of Geosynthetic Cementitious Composite Mats and Barriers (GCC-Ms/GCC-Bs)

B.1 Scope

B.1.1 This method covers the instructions for preparing samples of cured GCC-Ms/GCC-Bs for essential characteristic testing.

B.1.2 This method is useful for providing a basis for consistent and repeatable essential characteristic testing.

B.2 Auxiliary Apparatus

B.2.1 Hydration tank, a watertight container capable of holding GCC-M/GCC-B samples.

B.2.2 Tile Saw, with diamond tipped blades for cutting cured samples

B.2.3 Porous forms, positioned either side of the GCC-M in the hydration tank, such as porous stones or perforated steel plates. Forms must be flat, stiff and allow water through and into the GCC-M, the porous forms must have a density greater than 1g/cm3 and a mass of more than 2kg.

B.2.4 Aluminium Bars with a square cross section of approximately 12 x 12mm. Four bars of length 250mm are required.

B.3 Sampling

B.3.1 Obtain a sufficient quantity of GCC-M or GCC-B that is representative of the bulk product.

B.3.2 The number of test specimens and dimensions of the specimens shall be specified in each essential characteristic test method.

B.3.3 Using a knife or die, cut a coupon of the GCC-M/GCC-B for hydration that is sufficient to cut the required number of specimens once cured, typically 300x300mm. The coupon must be oversized by at least 25mm so that no specimens are cut from the edge of the coupon. This may require cutting multiple coupons to fit in the hydration tank without the coupon touching the sides of the tank. Mark the machine direction on the coupon.

B.4 Procedure

B.4.1 Prepare the hydration tank with water equilibrated to 21 +/-2°C of a sufficient depth to fully submerge the coupons.

B.4.2 Insert a porous form in the bottom of the hydration tank.

B.4.3 Place the coupon in the tank, with topside uppermost, Ensure the coupon is flat and place the four aluminium bars resting on the four sides of the coupon. Each bar shall be no further than 25mm from the edges of the coupon and equidistant from the corners. Cover with another porous form that is supported on the four bars, it is important that the upper porous form does not contact the topside of the coupon. Make sure the coupons are fully submerged and that water can enter the coupon from the edges. Multiple coupons may be hydrated by forming a stack of porous forms, bars and coupons as in B4.1 to B4.3 provided that the topside of each coupon is not contacted anywhere other than around it’s perimeter by a set of aluminium bars.

B.4.4 Allow the coupon to cure for 24 hours in the hydration tank, then remove and cut out the specimens to the orientation and dimensions as specified by the essential characteristic test method, the 25mm perimeter shall be cut off and discarded. The specimen reference number shall be written onto the top surface of the specimens.

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B.4.5 The specimens are placed in an atmosphere of 21+/-2°C and 65+/-5% relative humidity and remain in this environment for the remainder of the curing time as specified by the essential characteristic method listed in section 2.2 of this EAD.

B.5 Calculation

B.5.1 The cured GCC-M/GCC-B specimens shall be tested in accordance with the particular essential characteristic methodology specified in section 2.2 of this EAD.

B.6 Report

B.6.1 The duration from initial hydration to the time of testing the GCC-M/GCC/B shall be reported.

B.6.2. All other requirements for reporting shall be in accordance with the particular essential characteristic requirements specified in section 2.2 of this EAD.

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Annex C - Test Method to Determine the Depth of Wear and Mass Loss of Geosynthetic Cementitious Composite Mats and Barriers (GCC-Ms/GCC-Bs)

C.1 Scope

C.1.1 This test method covers the evaluation of abrasion resistance by determination of depth of wear and mass loss of GCC-Ms/GCC-Bs.

C.1.2 This test method makes use of a Taber abraser machine to determine the weight loss under controlled conditions.

C.1.3 This test method is useful in indicating the differences in abrasion resistance between the various GCC-Ms/GCC-Bs. This test method provides one element in comparing GCC-Ms/GCC-Bs of the same type.

C.2 Auxiliary Apparatus

C.2.1 Abrasive wheel refacing machine, with a removable specimen turntable platform, a motor to rotate the turntable at a speed of 72+/-2r/min or 60+/-2r/min, a pair of pivoted arms which the abrasive wheels and accessory weights are attached, an adjustable vacuum and orifice to remove debris and a counter to record the number of cycles made by the turntable. The abrasive wheels shall be H22 Calibrade, 12.7mm thick and 51.9mm diameter. Accessory weights shall provide 1000g of force per arm when the wheel is pressed against the specimen, exclusive of the mass of the wheel.

C.2.2 Balance, to weigh specimens, with accuracy to 0.01g

C.2.3 Micrometre, to measure specimen thickness, graduated to 0.01 mm or better.

C.2.4 A ventilated drying oven.

C.3 Sampling

Three specimens 100 mm square shall constitute a sample and shall be chosen from material to be tested.

C.4 Procedure

C.4.1 Determine the bulk density (p) in accordance with Section 3.4.2 of this EAD. Dry in an oven at a temperature of 60 $\pm$ 2°C for 48 h. Cool in a desiccator and weigh (w_0). The test specimens shall remain in desiccator until tested. Tests shall not begin unless the relativehumidity is 45 to 55 % and the temperature is at 22 $\pm$ 3°C.

C.4.2 Weigh the test specimen to the nearest 0.01 g and measure the specimen thickness on four points along the path to be abraded, approximately 38mm from the centre of the specimen and 90° apart. Calculate the average of the readings, record as T_1.

C.4.3 Place the test specimen on the table of the abraser with the surface to be tested uppermost.

C.4.4 Perform test work in a controlled environment, space, or room.

C.4.5 Set the vacuum cleaner-extractor to 90 to 100 % capacity. Lower and adjust the orifice arm so the orifice is a distance of 1 to 2 mm above the test surface.

C.4.6 Load each holder with a 1 kg weight above the abrasive wheel and gently lower the wheels onto the surface of the test specimen.

C.4.7 Switch on the vacuum cleaner-extractor.

C.4.8 Rotate the table for 1000 revolutions. Gently brush the abrasive wheels while the test specimen is rotating to assist in the removal of loose dust and prevent clogging the abrasive wheels.

C.4.9 Remove the specimen carefully from the table, brush clean the dust and abrasive grains, and record the thickness ($T1$) and weight (w_1).

C.4.10 Repeat C.4.8 -C.4.9 until minimum of 8000 cycles is completed. Record weight (w_2) and average thickness T_2. Record the nearest 1000 cycles after the surface fabric has worn.

C.5 Calculation

C.5.1 Calculate the depth of wear per 1000 cycles:

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$$T = \frac{(T_1 - T_2) * 1000}{n_2 - n_1}$$

where:

T_1 = initial thickness of test specimen (or the thickness at nearest 1000 cycles after the surface fabric was worn),mm

T_2 = thickness of test specimen after maximum number of revolutions, mm

n_1 = number of revolutions at nearest 1000 cycles after the surface fabric was worn.

n_2 = total number of revolutions.

A negative thickness change represents a thickness loss

C.5.2 Calculate the mass loss per 1000 cycles as follows:

$$w = \frac{(w_2 - w_1) * 1000}{n_2 - n_1}$$

where:

w_1 = initial weight of test specimen (or weight at nearest 1000cycles after the surface fabric was worn, g

w_2 = weight of test specimen after maximum number of revolutions, g

n_1 = number of revolutions at nearest 1000 cycles after the surface fabric was worn.

n_2 = total number of revolutions.

A negative mass change represents a mass loss

C.6 Report

Report the following additional information for each test specimen:

C.6.1 Value of depth of wear per 1000 cycles,

C.6.2 Value of mass loss per 1000 cycles,

C.6.3 Presence of any defect or surface feature likely to have influenced the result,

C.6.4 The actual number of revolutions run.

C.6.5 Any deviation from the procedure described in this paragraph.

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Annex D – Test Method to Determine the Gas Permeability of the Geosynthetic Barrier (Geomembrane) Component of Geosynthetic Cementitious Composite Barriers (GCC-Bs)

D.1 Scope of

D.1.1 This test method covers the evaluation of gas transmission through the geosynthetic barrier component of a GCC-B, using a gas transmission cell to determine the permeation of gas from one chamber through the geosynthetic barrier to the other chamber.

D.2 Auxiliary Apparatus

D.2.1 Volumetric gas transmission cell

D.2.2 Precision glass capillaries, or manometers of various diameters (0.25, 0.5, 1mm) with a suitable U-bend to trap the manometer liquid and a standard-taper joint to fit into the cell.

D.2.3 Cathetometer, or suitable scale for measuring changes in meniscus position to the nearest 0.5mm

D.2.4 Temperature control liquid bath, for controlling the temperature of the cell body to +/- 0.1°C.

D.2.5 Micrometer, to measure the geosynthetic barrier thickness to the nearest 2.5µm.

D.2.6 Barometer, suitable for measuring the pressure of the atmosphere to the nearest 133Pa.

D.2.7 Pressure gage, measuring absolute pressure over the range from 0 to 333kPa.

D.2.8 Cylinder of compressed gas, typically oxygen, of high purity equipped with pressure reducing valves.

D.2.9 Capillary liquid, 4-methyl-2-pentanone (methyl isobutyl ketone) or other appropriate liquid coloured with a suitable dye.

D.2.10 Filter paper, high grade, medium-retention, non-ashing cellulosic filter paper.

D.3 Sampling

The test specimen shall be representative of the bulk geosynthetic barrier, free of wrinkles, creases, pinholes or other imperfections. The specimen shall be cut to the appropriate size to fit the test cell.

D.4 Calibration

D.4.1 Calibrations shall be made at 23°C.

D.4.2 Place a column of clean mercury, approximately 70mm long, in the capillary and measure the length with a cathetometer.

D.4.3 Transfer all of the mercury to a tared beaker and obtain the weight of the mercury on an analytical balance.

D.4.4 The volume of the mercury, V_M, in microlitres is given by the equation:

$$V_m = 10^3 \times W \; / \; 13.54$$

where:

W	=	weight of the mercury, g, and
13.54g/mL	=	density of mercury at 23°C.

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Since for a cylinder:

$$V_M = a_c l$$

where:

a_c = cross sectional area, mm², and

l = length of mercury column, mm, then:

$$a_c = V_M / l$$

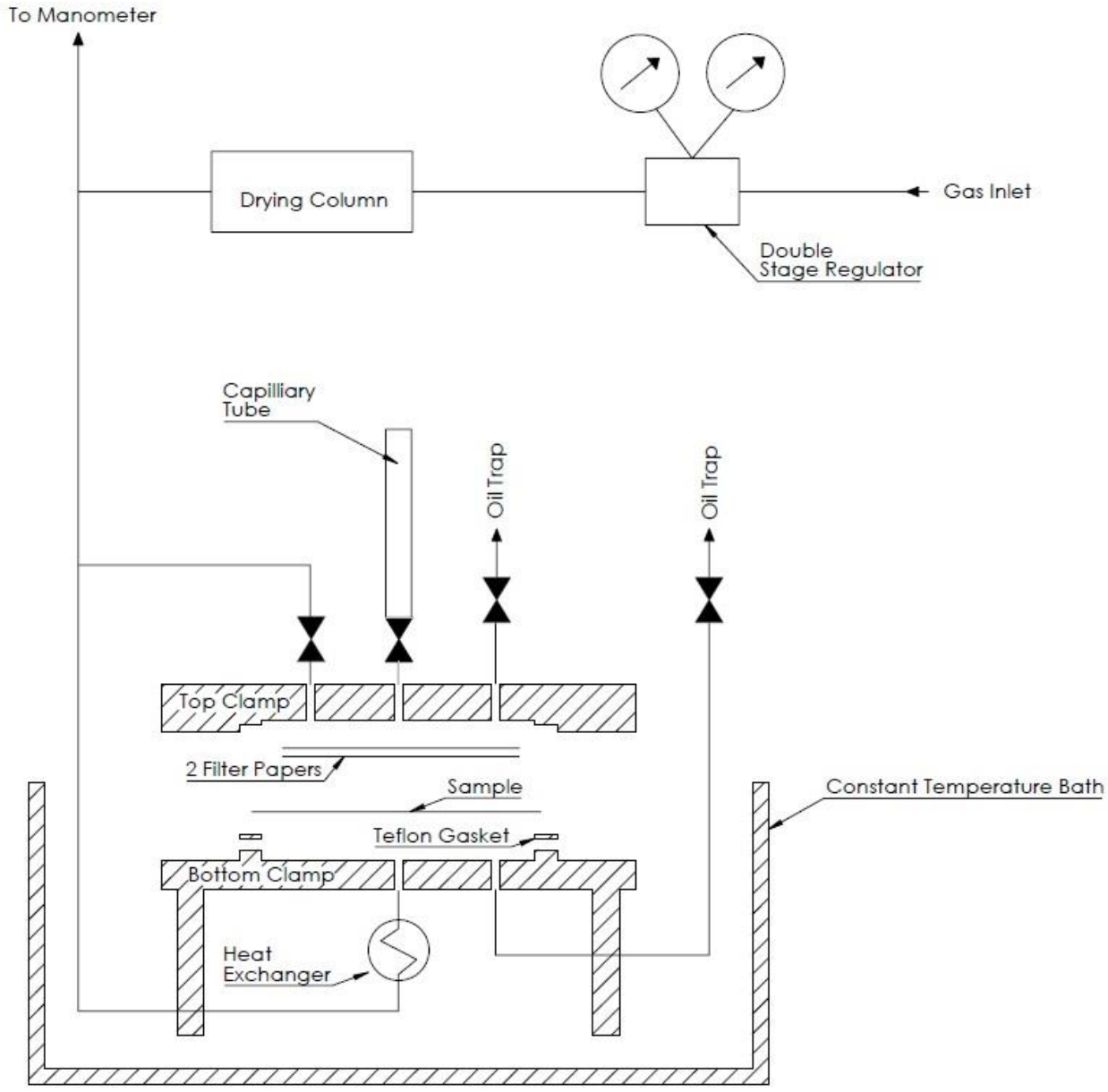

Figure [D.4.1] Volumetric Gas Transmission Cell Diagram

D.5 Procedure

D.5.1 Condition all test specimens at 23 +/-2°C in a desiccator over calcium chloride or other

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suitable desiccant for not less than 48h prior to testing.

D.5.2 Centre a piece of filter paper in the upper portion of the test cell.

D.5.3 Place the conditioned specimen smoothly on the upper portion of the test cell.

D.5.4 Lightly grease the rubber gasket, O-ring, or flat metal that the surface of the specimen will contact. Avoid excessive grease.

D.5.5 Place the Top Clamp of the cell of the cell on the base and clamp it firmly to achieve a tight seal.

D.5.6 Apply positive test gas pressure to both sides of the cell, flushing out all air before closing the outlet vent. A recommended flushing time is at least 10 min at a flow rate of approximately 100mL/min.

D.5.7 Introduce an approximately 20-mm liquid slug (keeping it intact) at the top of the capillary (it is recommended to add the liquid slug to the capillary with a syringe fitted with a long thin needle to aid proper insertion) and close the upper outlet vent after the slug rests on the bottom of the capillary (After lowering the liquid slug into the capillary, sufficient time must be allowed for drainage down the inner wall of the capillary before beginning to take a series of readings). The capillary shall be clean and free of obstructions.

D.5.8 Adjust the pressure across the specimen to maintain the exact pressure differential desired.

D.5.9 Small leaks around connections and joints can often be detected with soap solutions, but in some cases it may be necessary to immerse the cell in water while applying gas pressure, in order to observe bubbles at leak sites. Small leaks occurring on the high-pressure side of the cell shall not be considered significant.

D.5.10 After a time interval estimated to be sufficient for attaining steady-state, begin measuring the displacement of the slug, using a stop watch and distance scale maintained on the capillary or cathetometer. Take measurements at the top of the meniscus.

D.5.11 On completion of the run, return the slug to its starting position by slightly opening the low-pressure vent.

D.5.12 Repeat the measurement as necessary to assure the attainment of a steady-state condition.

D.6 Calculation

D.6.1 Plot the capillary slug position versus elapsed time and draw the best straight line through the points so obtained.

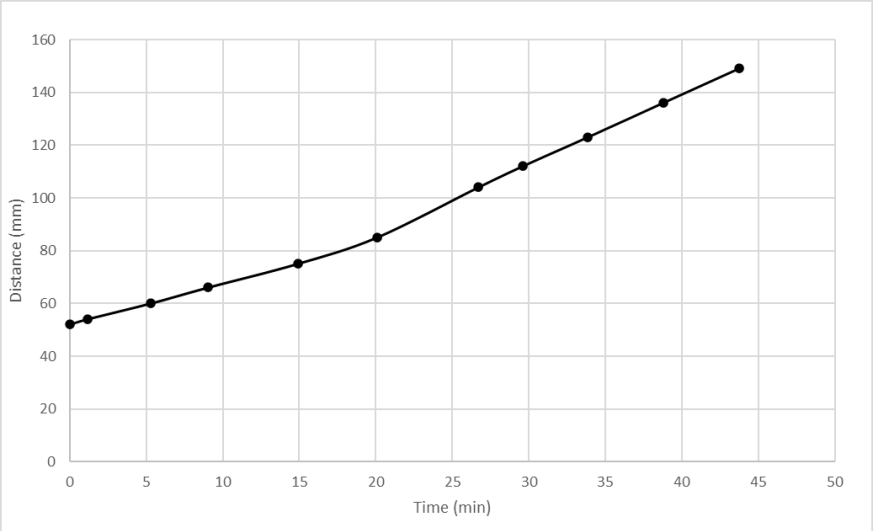

Table D.6.1 Example graph of capillary slug position versus elapsed time.

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D.6.2 Calculate the volume-flow rate, V_r, in microlitres per second of transmitted gas from the slope of this line as follows:

$$V_r = \text{slope} \times a_c$$

where:
slope = rate of rise of capillary slug, mm/s, and
a_c = cross-sectional area of capillary, mm^2.

D.6.3 Calculate the gas transmission rate (GTR) as follows:

$$GTR = p_o \times V_r \,/\, ART$$

where:
A = transmitting area of specimen, mm^2,
p_o = ambient pressure, Pa,
R = universal gas constant (R=8.3143 x 10^3 L.Pa/(mol.K)), and
T = ambient temperature, K.

D.6.4 Calculate the permeance, P, as follows:

$$P = GTR \,/\, (p - p_o)$$

where p is the upstream pressure in pascals.

D.6.5 A test result is defined as the value obtained from individual determination of the permeance of a specimen.

D.7 Report

D.7.1 The report shall include the description of the sample, the sample thickness, the test gas used, the test temperature and the pressure difference used.

D.7.2 The report shall include each measurement obtained and the units of choice, typically ((cm^3)(cm)/(cm^2)(sec)(atm)) or ((cm^3)(cm)/(cm^2)(sec)(Pa)).

D.7.3 Any deviation from the procedure described in this paragraph.

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