NSAI Agrément

IRISH AGRÉMENT BOARD
CERTIFICATE NO. 11/0356

Butler Manufacturing Services Ltd.,
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BMS Stormbreaker™ System

NSAI Agrément (Irish Agrément Board) is designated by Government to carry out European Technical Approvals.

NSAI Agrément Certificates establish proof that the certified products are **'proper materials'** suitable for their intended use under Irish site conditions and in accordance with the **Building Regulations 1997 to 2019.**

PRODUCT DESCRIPTION:
This Certificate relates to the BMS Stormbreaker™ system primarily comprised of interlocking modular polypropylene units which, in conjunction with a satisfactory civil engineering design, will act as either an attenuation or infiltration vessel as part of a sustainable drainage system.

The system consists of individual units manufactured from black polypropylene and assembled on polypropylene bases. The units when assembled are wrapped in membrane and buried below ground. The assemblies can be used for attenuation applications (temporary storage of storm water) or for infiltration/soakaway tanks to store storm water, which in turn will seep back into suitable surrounding ground over time.

When the modules are used for infiltration, they are wrapped in a permeable geotextile . When used for attenuation purposes an additional impermeable geomembrane is required. Flange adaptors are used for connecting the modules to PVC pipework. The BMS Stormbreaker™ system can be designed for use in green field, light and heavily trafficked areas, blue/green roof installations and large shallow installations, e.g. commercial plazas.

USE:
The product is used as a subsurface stormwater management system, for subsurface water storage or as a soakaway to manage rainwater run-off from impermeable surfaces prior to discharge as part of a sustainable drainage system (SuDS). Stormwater stored in this system is to be discharged into a public

drainage system or infiltrated into the ground locally. The system has not been assessed for use as primary storage for a rainwater harvesting system but can be used to accept overflow from such systems. Subject to site conditions, the BMS Stormbreaker™ system is designed as interlocking modules and can be built up to create the volumetric capacity required for an

- Attenuation system
- Infiltration system.
- Or a combined attenuation/infiltration system.

MANUFACTURE AND MARKETING:
The product is manufactured and marketed by:
Butler Manufacturing Services Ltd.,
Strokestown Road,
Longford,
Ireland
Phone: +353 43 3326100
Web site: www.butlerms.com
E-mail: info@butlerms.com

Part One / Certification 1

1.1 ASSESSMENT

In the opinion of NSAI Agrément, the BMS Stormbreaker™ system, if used in accordance with this Certificate, meets the requirements of the Building Regulations 1997 to 2019 as indicated in Clause 1.2 of this Certificate.

1.2 BUILDING REGULATIONS 1997 to 2019

REQUIREMENT:

Part A – Structure
A1 - The BMS Stormbreaker™ system, as certified in this Certificate, can be designed to ensure that the combined dead and imposed loads are sustained and transmitted to the ground in compliance with CIRIA C737[2].

Part D - Materials and Workmanship
D3 – The BMS Stormbreaker™ system, as certified in this Certificate, is comprised of proper materials fit for their intended use (See Part 4 of this Certificate).

D1 – The BMS Stormbreaker™ system, as certified in this Certificate, meets the requirements of the building regulations for workmanship.

Part H – Drainage and Waste Water Disposal.
H1 - The BMS Stormbreaker™ system, as certified in this Certificate, meets the requirements of the building regulations for the adequate disposal of surface water from the building.

Part Two / Technical Specification and Control Data 2

2.1 Production Description

This Certificate relates to the BMS Stormbreaker™, a subsurface Stormwater Management System, consisting of interlocking polypropylene chambers or units. The modular units manufactured from black recycled polypropylene are assembled on to polypropylene bases (eight bases per unit). Subsequent modular units are then added in an interlocking arrangement until the desired height is achieved.

The units, which have a high void ratio, are assembled to form an underground structure which can be used for storage of surface water or as a soakaway to form part of a sub-surface water management system.

The system does not cover collection or disposal of the surface water. Information relating to this matter can be obtained from the Certificate holder.

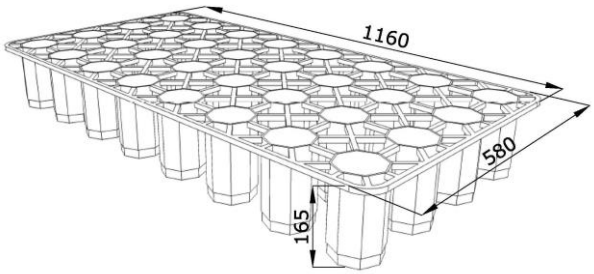


Figure 1 - BMS Stormbreaker™ Module

The BMS Stormbreaker™ system is suitable for use as an integral part of an overall surface water drainage scheme and can perform the function of either an attenuation tank or and infiltration/soakaway or a combination of both.

The BMS Stormbreaker™ is a registered trademark of Butler Manufacturing Services Ltd.

2.1.1 Ancillary Items

The BMS Stormbreaker™ units are installed with the aid of ancillary items outlined hereunder (§)

- Geotextiles
- Geomembranes - Impermeable membrane
- Oil Interceptors
- Stormbreaker Defender (Vortex Silt/Oil/Debris Separator)
- Pipe distribution network
- Inlet/Outlet manholes
- Stormbrake Outlet Flow Control
- Vent pipes
- Fittings/adaptors

2.2 Product Range

The BMS Stormbreaker™ system is designed as interlocking modules and can be built up to create the volumetric capacity required. The interlocking nature of the modular units lends itself to producing a stable monolithic arrangement.

The modular unit, which measures 1160mm x 580mm on plan, consists of thirty-two cylindrical columns, each with an octagonal cross section, which provide load bearing capacity and rigidity.

The unit depth of each module is 165mm (see Figure 1). Each unit has an arched rib design for load bearing and the cylindrical columns are rebated to interlock with each successive layer. The rebate results in a net layer depth of 145mm.

BMS Stormbreaker™ units are manufactured from certified recycled polypropylene granulates to an agreed specification. CIRIA C737[2] states that the use of recycled plastics is a positive development in the context of reducing the carbon footprint of construction materials. Module characteristic are given in Table 1 and further technical information can be found in section 4 of this certificate.

The base units are manufactured from polypropylene. Each base unit supports four cylindrical columns which results in eight bases per unit (see Figure 2). The base unit helps redistribute vertical load from the cylindrical columns uniformly to the ground and in doing so affords protection to the rebated end of the Stormbreaker™ unit.

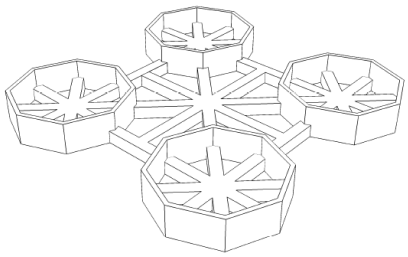


Figure 2 - Base units

2.3 Manufacturing

The modular units and base units are manufactured from recycled polypropylene by an injection moulding process.

Certified raw materials are supplied to the manufacturer to an agreed specification. The manufacturer carries out quality control checks on incoming raw materials before manufacture of the BMS Stormbreaker™ units commences.

An audit of the manufacturing process was carried out by NSAI. The manufacture's quality control procedures and product testing were assessed along with product traceability and satisfactory controls were in place at the time of the audit to meet these requirements.

The manufacturer demonstrated that satisfactory processes were in place to manage non-conformities and complaints should they arise.

The management system of Butler Manufacturing Services Ltd. has been assessed and registered as meeting the requirements of I.S. EN ISO 9001[3].

2.4 Delivery, Storage and Marking

The Stormbreaker™ units are supplied to site in packs of 52 (13 layers of four) units, stacked on a pallet and shrink wrapped. Each pack of 52 units carries a label bearing the product name and quantity. Stormbreaker™ units can be purchased and supplied pre-assembled if required.

The Stormbreaker™ units are clearly marked as recycled polypropylene. Palletised Stormbreaker™ units interstack and as a result they occupy approximately half their final insitu volume for ease of transport. Labels are attached to pallets which display the IAB Logo and Certificate number.

The polypropylene chambers are sensitive to UV radiation and as a result exposure to sunlight for prolonged periods must be avoided.

Base plates are packed in polyethylene bags. The packs of units should be carefully placed on level ground.

Individual chambers may be carried by one person; normal manual handling precautions should be taken. The mass of the unit is 6Kg.

§ Outside the scope of this Certificate.

Characteristics of modular unit		
Element	**Value**	**Units**
Unit dimensions (nom)	1160x580x165	mm
Unit volume (nom)	0.11	m^3
Storage volume (nom)	0.1034	m^3
Porosity (void ratio)	94	%

Table 1

2.5 Installation

2.5.1 General

Prior to commencing site installation, a full site investigation and design as outlined in Clause 3.1 of this certificate must be completed by a Chartered Engineer or suitable qualified person.

Once a location has been specified and invert levels checked, the entire area should be checked for buried cables and utilities. Designers and/or project managers' design stage (PMDS), as part of their assessment of Health and Safety, must consider all aspects of the site installation.

Designers should consider the following non-exhaustive Health and Safety issues

- access for plant such as excavators
- embankment of excavations
- installation of temporary works if necessary, for deep excavations.
- reducing local water table levels if necessary
- floatation both during and post installation

2.5.2 Installation Procedure

2.5.2.1 A trench is excavated to the required depth, dimensions, and formation levels. The plan area should be sufficient to allow compaction plant access around the sides of the excavation to place and compact backfill material. The base must be smooth and level without sharp drops or humps.

2.5.2.2 The base or formation is compacted and an adequate gradient built in to achieve self-cleansing. The base or formation level must be inspected for soft spots; any present must be excavated and replaced with suitable compacted granular fill material.

Slopes are battered to a safe angle or adequately supported. Safe access is provided to allow personnel to enter the excavation.

2.5.2.3 A 100mm thick, blinding layer of coarse sand is laid on the compacted base of the excavation.

2.5.2.4 The geotextile (and geomembrane, if an attenuation system) is laid over the blinding layer and up the sides of the excavation. When using a geomembrane, it must always be protected by a layer of geotextile. The geomembrane is inspected for damage and all welds are tested as required. Joints between adjacent sheets of impermeable membrane should be sealed correctly using proprietary techniques with a minimum lap of 50mm.

2.5.2.5 In attenuation systems, a second layer of geotextile is placed over the geomembrane to protect where it meets the stone filtration bed.

2.5.2.6 The distribution pipe(s) are installed and an appropriate seal is created where the pipes penetrate the geotextile and geomembrane.

2.5.2.7 The perforated distribution pipe(s) passing through the stone filtration bed are wrapped in a geotextile which prevents silts washing into the system (see clause 3.5.2.2 of this certificate).

2.5.2.8 Install 300mm filtration base of 25mm Round Clean Stone on top of the geomembrane.

2.5.2.9 The units are installed in accordance with the installation schedule for correct orientation. Wherever possible, continuous vertical joints should be avoided, and adjacent layers placed perpendicular to one another.

2.5.2.10 The units are placed in an interlocking manner and pressed down to connect together forming a solid connection. The internal column design allows units above and below to integrally clip together.

2.5.2.11 Drainage connections are made to the installation using proprietary adaptors. It is recommended by the certificate holder that all connections and air vent installations, in attenuation applications are made with a flange adaptor or top-hat connector, using thermal welding, adhesive or double-sided tape to form a seal.

2.5.2.12 The geotextile or geomembrane encapsulation to base, sides and top of installation is completed. Geomembranes when spliced or

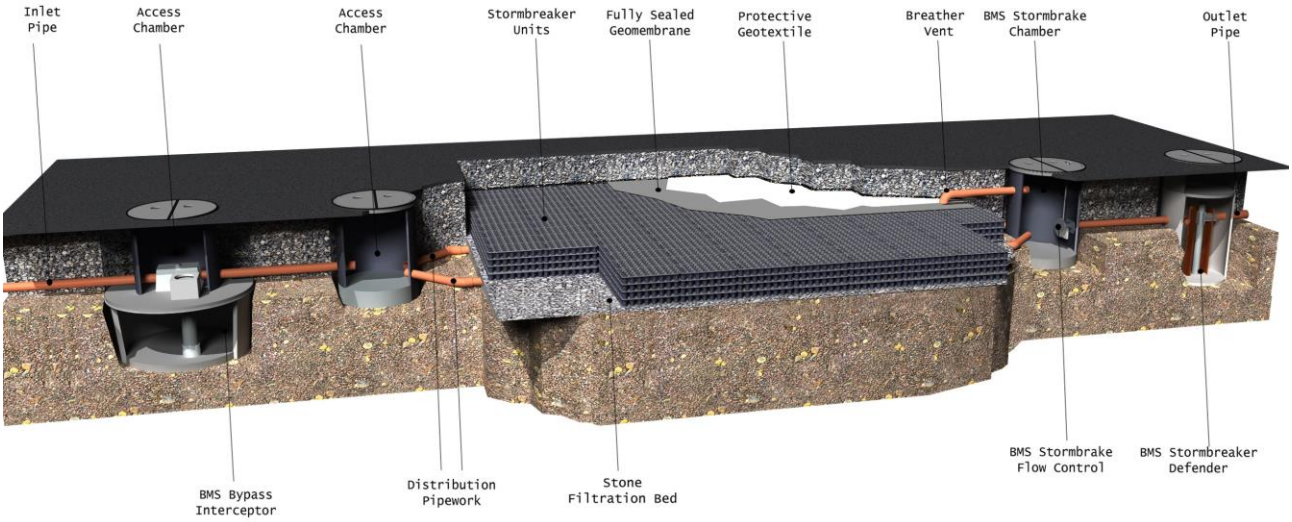


Figure 3 - Typical layout

jointed on site are welded with double seams. The geomembrane is inspected for damage and all welds are tested as required.

2.5.2.13 Inspection chambers are installed as per design requirements. When placed over the Stormbreaker™ units, the inspection chambers are sealed to the geomembrane with a flange adaptor, using thermal welding, adhesive, or double-sided tape to form a watertight seal.

2.5.2.14 The installation is backfilled with Type 1 or 2 sub-base or Class 6P (side fill only) selected granular material in accordance with the MCHW, Volume 1. The backfill is compacted in 150mm thick layers.

2.5.2.15 A protective layer of coarse sand 100mm thick should be placed over the top of the units that are wrapped in either a geotextile (infiltration system) or a geomembrane with protective geotextile (attenuation system). Backfilling is continued with:

- trafficked areas (e.g., car parks) — Type 1 or 2 sub-base material compacted in 150 mm layers in accordance with the MCHW, Volume 1. Compaction plant must not be allowed over the top of blocks until a minimum cover of 400 mm has been placed and, in any case, the load must not exceed 2300 kg per metre width.
- landscaped and non-trafficked areas — selected as-dug material with size of pieces less than 75mm compacted to 90% maximum dry density. Compaction plant over top of system must not exceed a load of 2300 kg per metre width.

2.5.2.16 The pavement construction or landscaping is completed over the system.

3.1 Design General

The BMS Stormbreaker™ system design must be in accordance with the Certificate holder's instructions. Guidance on the application of sustainable drainage systems (SUDS) for new developments, such as the Subsurface Stormwater Management System, can be found in the TII Publication DN-DNG-03072 Design of Soakaways and the 2015 SuDS Manual C753[6] published by the Construction Industry Research and Information Association (CIRIA).

3.2 Design Options

The system is suitable for the control of storm water run-off from impermeable surfaces and can be utilised in three ways.

- Infiltration (recharge/soakaway) — water is collected in the units during rainfall and allowed to drain away by soaking into the surrounding ground over a substantial period after the rain has stopped.
- Attenuation (detention) — water is collected in the units during rainfall and released at a reduced flow rate through a flow control device e.g., BMS Stormbrake Flow Control, into an appropriate outfall. This reduces peak flows in the watercourse and therefore, minimizes the risk of flooding.
- Combination system — water is collected in the units during rainfall and able to flow out of the tank via infiltration and through an outlet flow control device to an appropriate outfall.

3.3 Site Investigation

Design of the appropriate system for a specific project must always be preceded by a detailed audit of the proposed site to establish:

- existing factors and considerations applicable to the site.
- predicted factors relating to the site's use following the planned development, and the parameters within which the installation is required to function.
- the type of function of application suggested by this audit.

3.4 Drainage system selection and design.

Once the project criteria have been established from the site audit, there are two main parts to the design procedure: system design (Clause 3.5) and structural design (Clause 3.6). The design selection flow chart in Table 2 can be followed to establish the optimum stormwater management design solution.

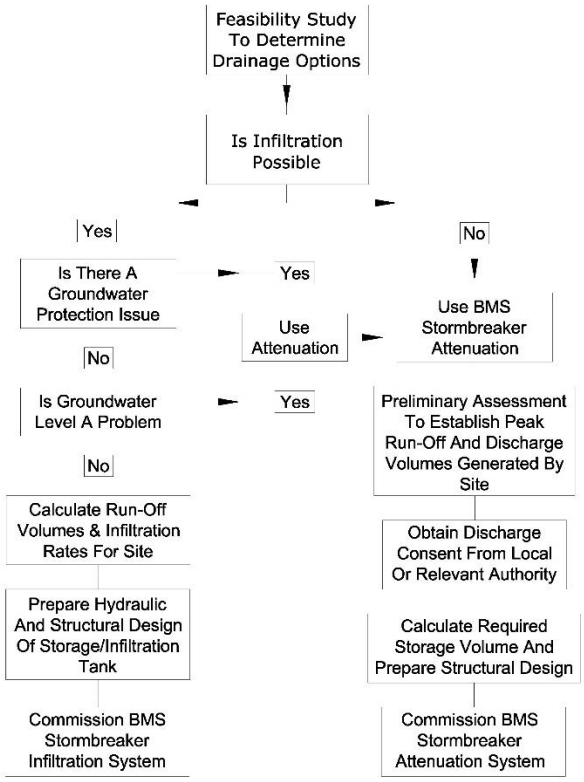


Table 2 - Design flow chart

3.5 System Design

3.5.1 Infiltration

There are two design approaches, either of which may be adopted:

- the Construction Industry Research and Information Association (CIRIA) Report 156[4] Infiltration Drainage — Manual of Good Practice
- or BRE Digest 365[5] Soakaway Design.†

† Further information on the design of sustainable urban drainage systems (SUDS) may be obtained from CIRIA Report C753 which is The SUDS Manual 2015.

Volumetric data per unit (0.58m) for single width trench applications				
No. of units high	Volume (m^3)		Side Area (m^2) Perimeter x H	Base Area (m^2)
	Gross	Nett*		
Base	0.0135	0.0126	0.0696	0.6728
1	0.0976	0.0917	0.5046	
2	0.1951	0.1834	1.0092	
3	0.2927	0.2751	1.5138	
* Nett storage volumes are based on a void ratio of 94%				

Table 3

Stormbreaker™ unit									
Volumetric data for cuboid installation (Storage volume V's internal side surface area)									
No. Of units high	2 x 2 units Area = 2.691m^2			4 x 4 units Area = 10.765m^2			8 x 8 units Area = 43.059m^2		
	Vol (m^3)	Side (m^2)	a_{s50} (m^2)	Vol (m^3)	Side (m^2)	a_{s50} (m^2)	Vol (m^3)	Side (m^2)	a_{s50} (m^2)
2	0.784	1.079	0.539	3.137	2.158	1.079	12.547	4.315	2.158
4	1.518	2.088	1.044	6.071	4.176	2.088	24.285	8.352	4.176
6	2.251	3.097	1.549	9.006	6.194	3.097	36.023	12.389	6.194
8	2.985	4.106	2.053	11.940	8.213	4.106	47.761	16.426	8.213
10	3.719	5.116	2.558	14.875	10.231	5.116	59.499	20.462	10.231
No. Of units high	2 x 4 units Area = 5.382m^2			2 x 8 units Area = 10.765m^2			2 x 10 units Area = 13.456m^2		
	Vol (m^3)	Side (m^2)	a_{s50} (m^2)	Vol (m^3)	Side (m^2)	a_{s50} (m^2)	Vol (m^3)	Side (m^2)	a_{s50} (m^2)
2	1.568	1.438	0.719	3.137	2.158	1.079	3.921	2.517	1.259
4	3.036	2.784	1.392	6.071	4.176	2.088	7.589	4.872	2.436
6	4.503	4.130	2.065	9.006	6.194	3.097	11.257	7.227	3.613
8	5.970	5.475	2.738	11.940	8.213	4.106	14.925	9.582	4.791
10	7.437	6.821	3.410	14.875	10.231	5.116	18.594	11.936	5.968
No. Of units high	4 x 6 units Area = 16.147m^2			4 x 8 units Area = 21.530m^2			4 x 10 units Area = 26.912m^2		
	Vol (m^3)	Side (m^2)	a_{s50} (m^2)	Vol (m^3)	Side (m^2)	a_{s50} (m^2)	Vol (m^3)	Side (m^2)	a_{s50} (m^2)
2	4.705	2.517	1.259	6.274	2.877	1.438	7.842	3.236	1.618
4	9.107	4.872	2.436	12.143	5.568	2.784	15.178	6.264	3.132
6	13.509	7.227	3.613	18.012	8.259	4.130	22.515	9.292	4.646
8	17.910	9.582	4.791	23.881	10.950	5.475	29.851	12.319	6.160
10	22.312	11.936	5.968	29.750	13.642	6.821	37.187	15.347	7.673
All volumes are net storage volumes i.e. 94% of overall volume. All units AxBxC = Length x Width x Number of units high a_{s50} (m^2) = internal surface area of the soakaway to 50% effective depth.									

Table 4

3.5.1.1 Infiltration Design

Design should be carried out in accordance with I.S. EN 752-4[1] or BRE Digest 365[5]. It is suggested in I.S. EN 752-4[1] that a storage volume equal to 20 mm multiplied by the area to be drained may be used.

Prior to selection of an infiltration system, designers are required to assess the suitability of soil for infiltration. Designers must assess if infiltration could wash fines from adjoining soil leading to voids and ultimately settlement or collapse.

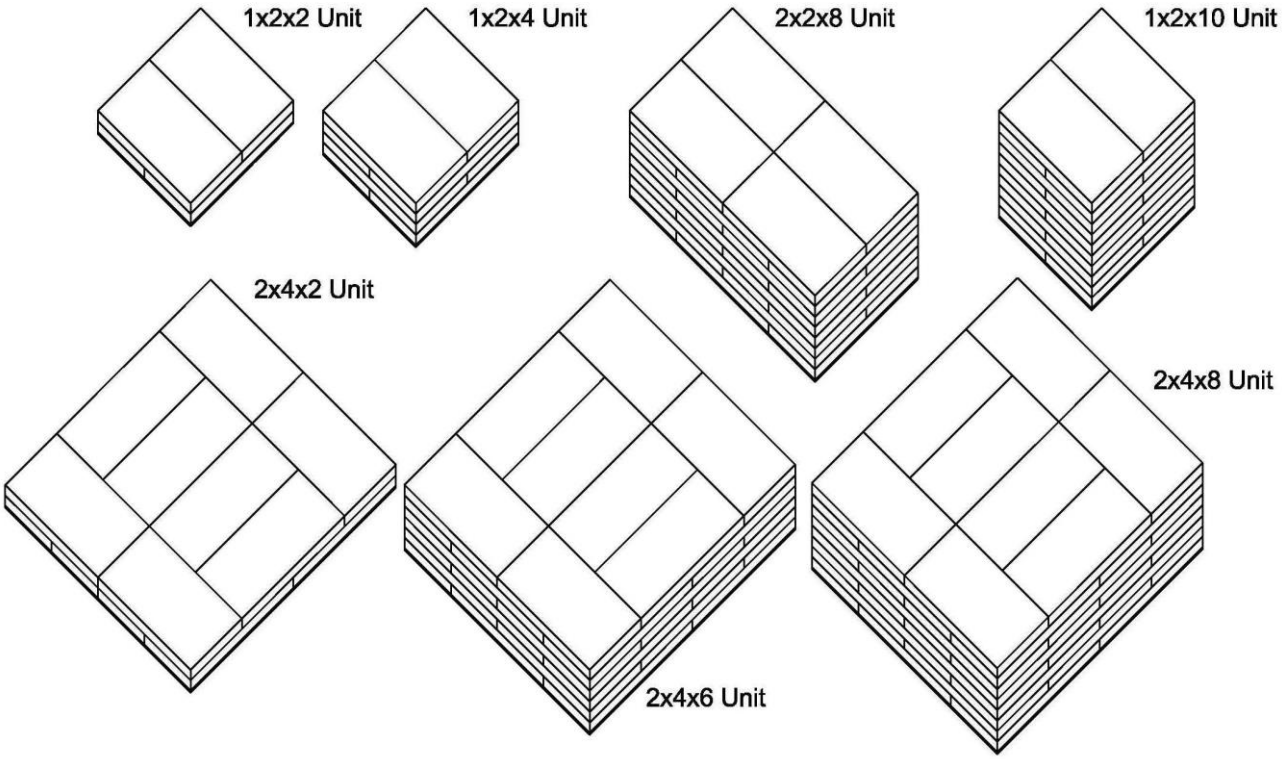


Figure 4 - Sample Stormbreaker™ configurations

Designer should refer to CIRIA Report 156 for further guidance of design selection and considerations.

When doubt exists over suitability of ground for infiltration, permeability figures should be derived by test (see BRE Digest 365).

3.5.1.2 Volumetric data and side surface area

When the BRE or CIRIA approach is used, the design volumes and areas for trench or cuboid type installations can be found from Table 3 and Table 4.

For calculations, the size and volume of the units are given in Table 1. The total areas of the base and sides are required as water is absorbed through the geotextile soil interface. Storage volume is 94% of the total volume. As an example, using Table 4, for a typical trench 2 units long and 2 units wide by 8 units deep, the net storage volume is 2.985m^3, the total side area 4.106m^2 or the internal surface area of the soakaway to 50% effective depth is 2.053m^2.

3.5.2 Attenuation

The design approach for attenuation systems should follow the principles outlined in the CIRIA C697 Suds Manual & the Greater Dublin Strategic Drainage Study (GDSDS).

The anticipated run-off volume (A) from a site must be calculated using the Wallingford Procedure. The rainfall event duration which generates the highest rate of run-off is determined by reference to the relevant Met Éireann publication. This is termed the critical rainfall event. To do this the drainage system needs to be tested for a range of storm durations for each return period, from 15 minutes up to and possibly exceeding 48 hours. This is done by using the Flood Studies Report (FSR) method.

The design return period can vary between local authorities. The critical rainfall event is then used in the Wallingford Procedure to determine the development's run-off volume (A). The allowable discharge rate from the site to an appropriate outfall is established but will normally be set by the Planning Authorities.

The outflow volume (B) to be discharged at this rate is calculated using the critical storm duration and subtracted from the run- off volume (A–B).

This defines the excess volume (C) to be stored in units constructed as an underground tank. The number of units needed to contain this excess is calculated on the basis that the storage volume is equal to 94% of the total volume of the tank.

Due allowance can be made for distribution pipes that may run within the tank sub-structure, the

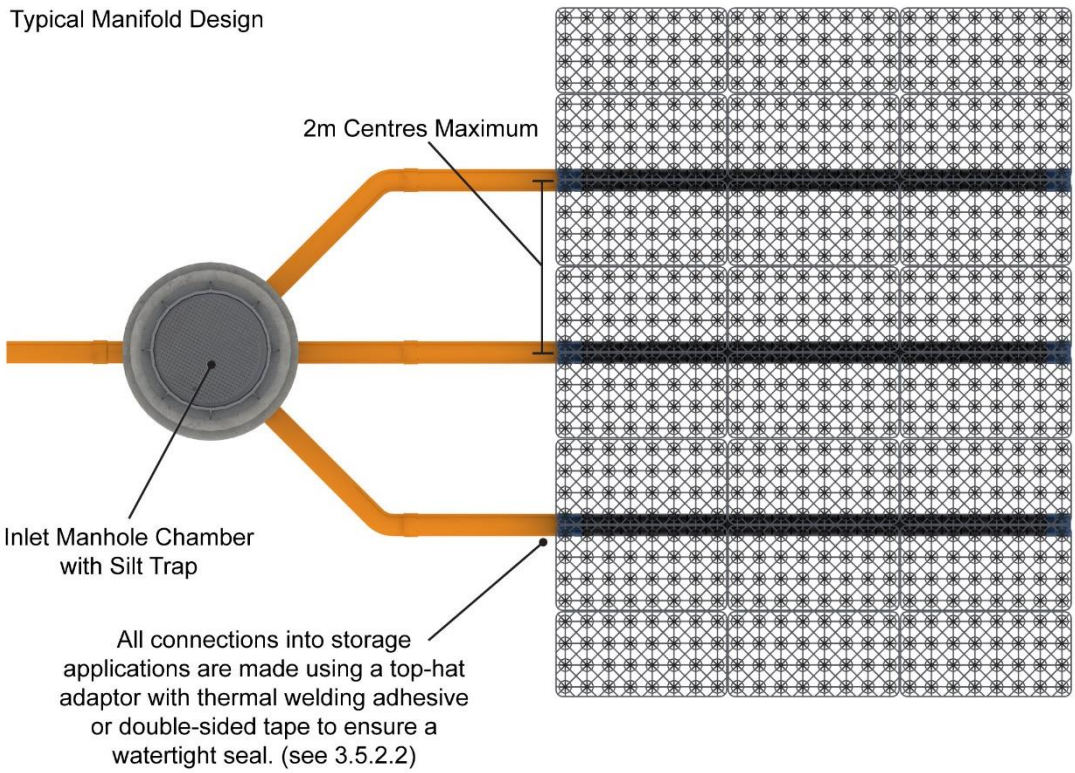


Figure 5

porosity of the hardcore formation retained within the geomembrane and above the outlet level of the distribution pipe(s).

In some situations when looking at a 1 in 100-year return period designers can be asked to increase storage capacity by 20% to allow for climate change.

3.5.2.1 Outlet Connections

The outlet of detention systems should incorporate a flow control device. The flow control device (BMS Stormbrake) and the connecting pipe work are not covered by the scope of this Certificate. It is recommended that all connections out of storage applications (using a geomembrane) are made using a flange adaptor. Thermal welding, adhesive or double-sided tape should be used between the geomembrane and flange adaptor to ensure a watertight seal.

3.5.2.2 Inlet Connections

Typically, a half-slotted distribution pipe running through the tank's formation hardcore is used to convey inlet and outlet (where appropriate) flow. The lower half of the distribution pipe is smooth and un-perforated to reduce the build-up of silt and assist with self-cleansing.

It is recommended that all connections into storage applications (using a geomembrane) are made using a top-hat adaptor. Thermal welding, adhesive or double-sided tape should be used between the geomembrane and flange adaptor to ensure a watertight seal.

A petrol/oil interceptor and/or a BMS Stormbreaker Defender may need to be incorporated where there is a likelihood of contamination or if the discharge requirement is particularly sensitive.

3.5.2.3 Manifold design

The capacity of the inlet pipe must be sufficient for the anticipated flow load. The flow load may be split between a number of pipes from the inlet manhole chamber. It is the recommended by the certificate holder that the maximum spacing of distribution pipes be not greater than 2.0m centre to centre. The maximum number of uPVC pipes from a single inlet chamber is recommended to be three. Where distribution pipes change direction, provide long radius bends to ensure the system can be adequately rodded. In cases where the Stormbreaker™ system exceeds a width of 6m then additional inlet and outlet chambers should be provided. It is recommended that there should be an inlet / outlet chamber for every 6m of width. For larger installations guidance on manifold design should be sought from the certificate holder.

Design Strength of BMS Stormbreaker™	
	Loading kN/m²
Quick vertical compressive strength (4 units)	463
Quick vertical compressive strength (single unit)	775
Lateral compressive strength (3 units restrained)	103
Estimate of compressive strength at 50 years	280
Characteristic strength (P_{ck})	252
Design strength§ (P_d)	144
§ A material partial factor (γ_m) of 1.75 has been applied based on - Factory production: with independent audited - Extrapolation of 8000 hr creep rupture test data to 50-year value - Only laboratory test data - Only laboratory data on single units - Allowance for Damage during construction	

Table 5 - Design Strength

3.5.2.4 Flow control

The outflow from the tank must be controlled to comply with the discharge rate consent for the site. Comparative features and benefits of these various control flow devices should be considered before selection. However, these devices are outside the scope of this Certificate.

3.5.2.5 Outflow and head calculations

The invert level of the outflow pipe should allow the tank to drain. As the tank fills, a depth of water develops on the upstream side of the outflow control, creating a driving head to push the flow through the control device. For design purposes, the head used in calculations is taken as that at the centre line of the outflow device.

3.6 Structural Performance

3.6.1 General

Stormbreaker™ systems may be placed under a wide variety of landscaped or trafficked areas and must be designed to carry all loads that will be applied, including dead and imposed loads.

The certificate holder provides a site-specific structural design for each project which follows the design methodology outlined in CIRIA C737 *Structural and geotechnical design of modular geocellular drainage systems*[2]. As part of that design, a site investigation report will form an integral part of the structural design.

When used for infiltration below trafficked areas and close to structures, it is important to ensure that the infiltrating water will not soften the soils or cause loss of fines and settlement.

In addition to dead and live loads, designers must consider flotation due to high surrounding water tables in times when the tank is empty. When flotation is likely to occur, sufficient overburden should be provided.

3.6.2 Structural Design Inputs

The certificate holder will carry out a structural design to comply with CIRIA C737[2]. Prior to commencing the structural design, a geotechnical site investigation will be carried out to acquire information on the site history, the site geology and the ground and groundwater conditions likely to be encountered at the site.

As part of the design process, the certificate holder uses the *"Design and construction classification and check proforma"* from Annex A1 of CIRIA C737[2]. The principle aim of the scoring system is to identify projects with high intrinsic complexity and/or where the consequences of failure are severe.

3.6.3 Design strength of units

The design strength of the Stormbreaker™ is the characteristic strength modified by the appropriate material partial factor.

$$P_d = {}^{P_{ck}}/_{\gamma_m}$$

Where:
P_d = design strength
P_{ck} = characteristic strength (at design life)
γ_m = material partial factor

Load factors for ultimate and serviceability limit state checks (γ_{LF})				
Persistent and transient design situations	Permanent actions		Variable action (unfavourable)(1)	Accidental action
	Unfavourable	Favourable		
ULS				
Vertical loads	1.35	1.0	1.5	1.0
Lateral loads – Combination 1 in EC7(2)	1.35	1.0	1.5	1.0
Lateral loads – Combination 2 in EC7(2)	1.0	1.0	1.3	1.0
Uplift	1.0	0.95	1.5	1.0
SLS				
All loads	1.0	1.0	1.0	N/A

Notes
Any variable favourable loads should be taken as zero, i.e., partial factor applied = 0.
Combination 2 in EC7 is an assessment of overall stability in the ground and should only be considered when assessing overall slope stability or overall stability of the units (i.e., overturning). Combination 1 in EC7 should be used to check the ability of the units to withstand the applied lateral loads.

- Persistent design situations = permanent works.
- Transient design situations = temporary works.
- Permanent actions = dead loads, such as earth pressure, weight of overburden above unit.
- Variable action = live loads, such as car or HGV loads.
- Unfavourable = destabilising. Favourable = stabilising.
- ULS = stability or collapse checks.
- SLS = checks against excessive deformation, settlement etc.
- Partial factors on loads are multipliers.

Table 6

Installation Depths				
Load Conditions	Recreational and non-trafficked Areas	Trafficked Areas		
		Non-Trafficked Areas (Adjacent to Roads)	Trafficked Areas (LM3)	Trafficked Areas (LM1)
Minimum Cover Depths (mm)	450	600	600	750
Maximum Cover Depths (mm)	4650	4000	4100	4000
Maximum Depth of Installation (mm)	5250	4600	4700	4600

Table 7 - Installation Depths

The characteristic strength is derived from load test data. The material partial factor needs to take account of a wide range of factors including:

1. Manufacturing process, and geocellular unit variability.
2. Extrapolation of test data, between test durations and design life and other selected key design periods.
3. Differences between strengths mobilised under different loading scenarios (e.g., laboratory compared with buried units).
4. Susceptibility to damage during construction, how the units are backfilled, including compaction pressures.
5. The global behaviour of the units, especially when multiple units are stacked together.
6. Environmental effects, exposure to chemicals, UV light, extreme temperatures etc.

The characteristic strength of the Stormbreaker™ units has been derived from a combination of compressive load tests and creep rupture tests as described in CIRIA C737[2]. The derivation of unit strength given in CIRIA C737[2] allows the designer to extrapolate a characteristic design strength for a specified design life (50 years) based on a series of creep rupture test data results.

The design strength and calculated characteristic strength for the 50-year design life are given in Table 5.

3.6.4 Derivation of design loads

The characteristic loads are an estimate of the load to be placed on a structure during its design life. The characteristic loads derived for the permanent and temporary works need to be factored to allow for possible variations, in order to calculate the

design loads, (Q_d), in accordance with CIRIA C737[2] Equation 5.12:

Design Loads, $Q_d = \sum(Q_{ck} \times \gamma_{LF} \times \gamma_{df} \times \gamma_{sf})$

Where:
Q_{ck} = characteristic loads
γ_{LF} = load factor
γ_{df} = dynamic factor
γ_{sf} = site factor

The partial load factors given in Eurocode 0 (EC0) and EC7 are summarised in table 5.9 of CIRIA C737[2] and Table 6.

Dynamic factors are outlined in table 5.10 of CIRIA C737[2] and Table 5.11 of CIRIA C737[2] summarises the site importance factors.

The load and site importance factors are applied to characteristic permanent and variable loads (actions).

The dynamic factors are applied to variable loads (actions) generated by road traffic, for any situation (including accidental load cases) where the geocellular units are within the zone of influence outlined in Clause 3.4 of CIRIA C737[2].

3.6.5 Zone of influence

The zone of influence is defined in Clause 3.4 of CIRIA C737[2] and takes account for proximity of adjacent structures and slopes, embankments or soil heaps/stockpiles and retaining walls. It should be noted that an installation does not have to be directly beneath a particular loaded surface or area such as a road or railway for the imposed loading to affect the design.

3.7 Geotextile and Geomembrane.

3.7.1 Geotextile

A Geotextile membrane manufactured to I.S. EN 13252[7] is wrapped around the system in infiltration applications to:

- prevent soil and fine clay particles from washing into and clogging the stone surround to the distribution pipe network and the units themselves.
- prevent soil entering the units and in storage applications to give added protection to the geomembrane (when specified).

The selection of an appropriate geotextile for a specific infiltration installation should be considered carefully, with particular reference to the surrounding soil properties and required performance. Points to consider are:

- pore size — should be designed and specified to assist infiltration and prevent migration of fine soil particles.
- permeability and breakthrough head — the geotextile should not limit flow of water in the system and have a similar or greater permeability than the surrounding materials.
- puncture resistance — the geotextile must be able to resist the punching stresses caused by loading on sharp points of contact.
- tensile strength — the geotextile should have sufficient strength to resist the imposed forces (e.g. from traffic).

The geotextile should be selected according to specific site conditions. However, typically a 110g non-woven material will be suitable for most situations. Specialist advice shall be sought if surrounding soil characteristics exhibit a high degree of fines/low infiltration capacity and/or there is risk of damage from ground contaminants.

3.7.2 Geomembrane

A Geomembrane, manufactured to I.S. EN 13361[8] and/or I.S. EN 13362[9], is wrapped around the system in attenuation/storage applications where infiltration is not possible or permitted. The function of the geomembrane is to:

- prevent release of attenuated/stored water to surrounding ground.
- prevent inflow of pollutants from contaminated subsoil into the storage reservoir.

The specification and selection of the impermeable geomembrane must be correct for the installation envisaged, to ensure it performs to the level required. It is essential that the specified material:

- withstands the rigours of installation.
- resists puncture
- resists multi-axial elongation stress and strains associated with settlement.
- resists environmental stress cracking.
- resists damage from ground contaminants and remains intact for the full design life of the drainage system.

Joints between adjacent sheets of impermeable geomembranes should be sealed correctly using proprietary welding techniques.

3.8 Venting

For most chamber applications, venting back through the inlet piping is sufficient. However, some applications, where inlet piping may be submerged, require additional vent capacity. Additional venting is provided by additional vent pipe or a perforated manhole/inspection cover. (See Figure 3)

It is the certificate holder's recommendation that one 110mm diameter air vent per 7500 m^2 of impermeable catchment area to be drained is generally sufficient.

3.9 Resistance to chemicals

The components of the system are suitable for use in contact with the chemicals likely to be found in rainwater.

An assessment of the suitability for use of units on brownfield sites should be made only after a suitable site investigation to determine the possibility for chemical attack. Particular care must be taken where acids and organic solvents are present at high concentrations. Further information can be supplied by the Certificate holder.

3.10 Maintenance

The owner of the structure is responsible for maintenance. Butler Manufacturing Services provide a maintenance brochure which informs the owner of best practice inspections and maintenance schedules.

For soakaways to individual houses, the only necessary maintenance of the system is to keep gullies clear of debris such as leaves.

For all flow control devices, it is sensible to incorporate access (via a manhole or similar) to the location of the pipe entry, orifice or vortex control. This will enable easy removal of any blockage. The orifice itself may be protected by a debris screen.

When constructed in accordance with BMS installation guidance document, soakaways and attenuation systems are self-cleansing. In the unlikely event where debris or blockages occur it is prudent at design stage to provide access (via a manhole or similar) to clear blockages and allow for jetting clear silt build ups.

When inlet manholes incorporate silt-traps, owners should carry out frequent maintenance of these silt-trap manholes to minimize the risk of silts and other suspended partials entering the distribution pipe network.

3.11 Durability

The structural properties of polypropylene used in the components of the system will deteriorate with time and has been taken into account at the design stage by the application of suitable safety factors. In the opinion of the IAB, the BMS Stormwater units, when used in accordance with this Certificate, will have a life in excess of 50 years.

4.1 Overview of Test Programme

A test programme was carried out on the BMS Stormbreaker™ product to determine the strength and deformation characteristics of the unit and its assemblages. Testing was carried out according to the guidance provided in CIRIA C737[2] - *Structural and geotechnical design of modular geocellular drainage systems.*

The vertical and lateral compressive strength of the units was determined by conducting a series of full platen and concentrated loading tests on the BMS Stormbreaker™ product. Data from these tests was used to establish a 50-year design life for the product.

Results from additional cyclic loading tests provided an assessment of the performance of the units under repeated cyclic forces such as that imposed by dynamic traffic loads.

4.2 Vertical Compressive Load Testing

To ensure structural integrity of the BMS Stormbreaker™ is maintained - individually and in multi-unit assemblies, under both static (e.g. covering and surrounding soils) and imposed loading (e.g. pedestrian and vehicular traffic), the structural capacity of the units was determined by a programme of full platen and concentrated vertical compressive strength testing.

Loading was applied to a single BMS Stormbreaker™ unit and assemblies of stacked units, with and without lateral restraint, to simulate varying installation conditions.

The concentrated loading was applied through a steel plate measuring 250mm(W) x 250mm(B) positioned centrally on the test specimen(s). Full platen loading was applied to the BMS Stormbreaker™ specimens via loading plates with a test set up specifically designed for the BMS Stormbreaker™ product. From the series of vertical compressive tests on stacked units, a quick vertical compressive strength of 463kN/m^2 was determined for the BMS Stormbreaker™ product. A quick vertical compressive strength of 775kN/m^2 was determined for a single unit.

4.3 Lateral Compressive Load Testing

Lateral loading was applied to three assembled BMS Stormbreaker™ units in such a manner that the loading was distributed uniformly over the entire lateral surface area of the units. Hardwood load pads with a specific profile ensured that the lateral load was distributed uniformly through the unit. Two compression plates supported the test unit assembly in the vertical direction. Eight threaded bolts were sufficiently torqued through the compression plates to maintain a compressive force of approximately 16kN on the units. The bolts were located strategically to ensure that they did not interfere with deformation of the units during the tests. The test was run until a lateral deflection of approximately 55mm was recorded in the test units. The lateral compressive strength of the BMS Stormbreaker™ units was determined as 103kN/m^2.

4.4 Cyclic Compressive Load Testing

Five thousand (5000 No.) loading-unloading cycles were applied to an assembly of BMS Stormbreaker™ units to emulate 30/30 loading with a 250mm pavement build-up. The test units were monitored for lateral buckling during the cyclic test. A maximum deflection of 3.10mm was observed in the Stormbreaker™ units after application of the last test cycle.

4.5 50-year Design Strength

The strength of the BMS Stormbreaker™ unit for a design life of 50 years was derived in accordance with the procedures outlined in CIRIA C737[2]. Data from a series of creep rupture tests was used to derive a cautious estimate of the compressive strength of the units based on a log-log plot of mobilised strength *v* time to failure. The creep rupture tests were conducted with durations of up to 6000 hours to enable determination of the 50-year design life. A cautious estimate of the BMS Stormbreaker™ unit strength of 280kN/m^2 for a design time period of 50 years was determined from the test data.

The Characteristic Strength (creep rupture) for the BMS Stormbreaker™ product was subsequently calculated as 252kN/m^2. This allowed determination of the *design strength* (144 kN/m^2) using a partial factor of 1.75 as per the CIRIA 737[2] guidelines.

5.1 National Standards Authority of Ireland ("NSAI") following consultation with NSAI Agrément has assessed the performance and method of installation of the product/process and the quality of the materials used in its manufacture and certifies the product/process to be fit for the use for which it is certified provided that it is manufactured, installed, used and maintained in accordance with the descriptions and specifications set out in this Certificate and in accordance with the manufacturer's instructions and usual trade practice. This Certificate shall remain valid for five years from date of latest revision so long as:

a) the specification of the product is unchanged.

b) the Building Regulations 1997 to 2019 and any other regulation or standard applicable to the product/process, its use or installation remains unchanged.

c) the product continues to be assessed for the quality of its manufacture and marking by NSAI.

d) no new information becomes available which in the opinion of the NSAI, would preclude the granting of the Certificate.

e) the product or process continues to be manufactured, installed, used and maintained in accordance with the description, specifications and safety recommendations set out in this certificate.

f) the registration and/or surveillance fees due to NSAI are paid.

5.2 The NSAI Agrément mark and certification number may only be used on or in relation to product/processes in respect of which a valid Certificate exists. If the Certificate becomes invalid the Certificate holder must not use the NSAI Agrément mark and certification number and must remove them from the products already marked.

5.3 In granting Certification, the NSAI makes no representation as to;

a) the absence or presence of patent rights subsisting in the product/process; or

b) the legal right of the Certificate holder to market, install or maintain the product/process; or

c) whether individual products have been manufactured or installed by the Certificate holder in accordance with the descriptions and specifications set out in this Certificate

5.4 This Certificate does not comprise installation instructions and does not replace the manufacturer's directions or any professional or trade advice relating to use and installation which may be appropriate.

5.5 Any recommendations contained in this Certificate relating to the safe use of the certified product/process are preconditions to the validity of the Certificate. However, the NSAI does not certify that the manufacture or installation of the certified product or process in accordance with the descriptions and specifications set out in this Certificate will satisfy the requirements of the Safety, Health and Welfare at Work Act. 2005, or of any other current or future common law duty of care owed by the manufacturer or by the Certificate holder.

5.6 The NSAI is not responsible to any person or body for loss or damage including personal injury arising as a direct or indirect result of the use of this product or process.

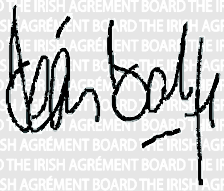
5.7 Where reference is made in this Certificate to any Act of the Oireachtas, Regulation made thereunder, Statutory Instrument, Code of Practice, National Standards, manufacturer's instructions, or similar publication, it shall be construed as reference to such publication in the form in which it is in force at the date of this Certification.

NSAI Agrément

This Certificate No. **11/0356** is accordingly granted by the NSAI to Butler Manufacturing Services Ltd. on behalf of NSAI Agrément.

Date of Issue: **March 2011**

Signed



Seán Balfe
Director of NSAI Agrément

Readers may check that the status of this Certificate has not changed by contacting NSAI Agrément, NSAI, 1 Swift Square, Northwood, Santry, Dublin 9, Ireland.
Telephone: (01) 807 3800. Fax: (01) 807 3842. www.nsai.ie

Revision: **17th September 2021** Updated in line with CIRIA C737[2] guidelines

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[2] CIRIA C737, *Structural and geotechnical design of modular geocellular drainage systems.*

[3] I.S. EN ISO 9001:2015, *Quality management systems - Requirements*

[4] CIRIA Report 156, *Infiltration Drainage — Manual of Good Practice*

[5] BRE Digest 365 1991, Soakaway design

[6] C753 2015, The SuDS Manual

[7] I.S. EN 13252:2016, *Geotextiles and Geotextile-related Products - Characteristics Required For Use In Drainage Systems*

[8] I.S. EN 13361:2018 & LC:2018, *Geosynthetic barriers - Characteristics required for use in the construction of reservoirs and dams*

[9] I.S. EN 13362 :2018, *Geosynthetic Barriers - Characteristics required for use in the construction of canals*