Using drainage geocomposites in landfill engineering

LANDFILL GUIDANCE GROUP
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1.0 Introduction

The Landfill by Design approach outlines the expectation that technical standards in landfill engineering should be based on site specific risk-based criteria backed by sound civil and geotechnical engineering and scientific calculations.

This guidance relates to the design and construction of drainage geocomposites in landfill engineering. Therefore, all references to geocomposites refer to drainage geocomposites only.

It does not cover the use of geocomposites for re-inforcement or liquid/vapour containment. It is recognised however that a geocomposite may be suitable for these functions. It is also recognised that a geocomposite may, in some circumstances, provide protection to an underlying geosynthetic barrier.

2.0 Material properties

Generally, geocomposites for the purpose of this guidance consist of one or more geotextiles and a polymeric drainage element which is required in order to provide the designed in plane flow. They are made from synthetic material rather than naturally occurring materials such as sand or gravel.

Their primary function is to provide a preferential drainage pathway for; infiltrating surface water (capping), groundwater (undercell or backwall drainage) and leachate (internal sidewall/basal drainage). Differences in the polymer and the manufacturing process can lead to significant variations in the properties of the final material with regards to the intended function. You must not assume that all geocomposites are equally suitable but that your design ensures that the proposed geocomposite is both fit for purpose and shall perform as intended for its design life.

Geocomposites made from post-consumer or post-industrial recycled materials should not be used.

The regulator will need to be confident that the desired material properties are uniform throughout the product and the manufacturer can supply quality control data to confirm this. In addition to design testing, the manufacturer's quality control programme and the construction quality assurance programme should be structured to demonstrate the desired properties are consistently achieved throughout the product. This should be demonstrated both in relation to properties relating to durability as well as those used for standard quality control. Proof of durability should be provided.

The development and use of new products is encouraged where they will result in improved environmental protection. The amount of evidence required will be proportionate to the risk of failure of the proposed new product.

Such evidence could be gathered from:

- a literature review;
- laboratory testing and modelling;
- field trials;
- site comparisons;
- research and development projects,
- or a combination of these routes.

It is recommended that manufacturers and landfill operators involve the regulator at an early stage in any such proposal in order to avoid abortive effort later on. The regulator will duly consider evidence submitted and test the proposal using its own experience and knowledge. It is recommended that manufacturers leave an additional period beyond the usual consultation period for landfill engineering works to allow the regulator to assess the proposal, and any subsequent negotiation or development which may be required.

3.0 CE marking & manufacturer's quality control

Since the late 1980's the CEN TC 189 committee has standardised testing methods and procedures to encourage continuity and consistency throughout the European Community. Since the early part of 2002 it has become a mandatory requirement to CE mark geotextile and geotextile-related products to demonstrate compliance with the European Construction Products Directive (Council directive 89/106/EEC) (CPD). Since October 2002, it has been a mandatory requirement to CE mark geosynthetics within the majority of EU member states. The CPD provided for four main elements:

- a system of harmonised technical specifications
- an agreed system of attestation of conformity for each product family
- a framework of notified bodies
- the CE marking of products

The Construction Products Regulations (CPR) (EU No 305/2011) repeals the CPD and became a legal requirement in all European member states in 2013.

The CPR aims to harmonise the methods of testing and the way in which manufacturers of products report on their performance values and the method of conformity assessment.

CE marking is a *passport* that enables a product to be legally placed on the market within any member state. ***CE marking does not mean that the product is suitable for an end use***. It simply means that the manufacturer has complied with the CPR and that it must report on the harmonised declared values set out within the standards.

For geosynthetics, there are several standards published by CEN TC 189 for CE marking based on product applications. The testing that needs to be performed on a product depends on the function that the product is required to perform within the application. The five functions are set out within EN ISO 10318; these are filtration; separation; reinforcement; protection and drainage.

EN 13257: Geotextiles and 'geotextile related products' for solid waste disposal is the application standard that considers the use of geosynthetics in landfill engineering and identifies the characteristics that a manufacturer should report on a CE declaration based on a particular function. The functions covered within EN13257 are; filtration, separation, reinforcement and protection. It should be noted that the drainage function is not covered within EN13257 and therefore EN 13252: Geotexiles and geotextile related products – characteristics required for use in drainage systems should be used for this function.

Table 1 within EN 13257 and EN 13252 identifies the relevant characteristics that a manufacturer must publish on a CE declaration in line with specific functions. The 'harmonised characteristics' (H) within the table are those which a manufacturer is required to publish on a CE declaration to ensure compliance with the CPR, although the table identifies other characteristics which a designer may wish to consider.

A notified body audits the levels of control within the manufacturing process - The manufacturer is then issued with a certificate of factory production control under the guidelines identified within the EN application standards. The notified body should then perform regular checks on the manufacturer to ensure that the system is functioning adequately. A manufacturer is required to publish a CE declaration once a product has been CE marked. The declaration identifies properties and 95% confidence limits relevant to the areas of application and functions highlighted. It also contains a durability statement.

A manufacturer must supply a CE declaration for product delivered to site in accordance with EN 13257 (identified within this report for this application). The values and 95% confidence limits should then be used for evaluation of conformity with the specification in accordance with CEN/TR 15019: On-Site quality control. It must be noted that not all reported characteristics are suitable for conformity testing and that some test data must be supplied by the manufacturer.

It should be noted that the applicable standards relating to CE marking is subject to change.

3.1 Durability Data (Annex B – EN 13257)

Within Annex B of EN 13257 there is guidance on the testing that is required in order to make an assessment of the long-term durability of the product. Typically the tests that are required are:

Determination of resistance to weathering (UV)	EN 12224
Determining the resistance to liquids (acids & alkalis)	EN 14030
Determination of resistance to oxidation	EN ISO 13438
Resistance to soil burial	EN 12225
Resistance to hydrolysis	EN 12447

Note – Durability requirements will change in the near future with the publication of new standards

The results of these tests will determine the durability statement that the manufacturer publishes on its CE declaration, of which there are various options. Manufacturers are expected to provide evidence of testing performed to assess long term durability. It should be noted that these tests are not normally suitable for conformance testing and that such data should be provided by the manufacturer. The following requirements need to be achieved;

Durability (according to annex B: EN 13252)*:			
Resistance to weathering @ 50MJ/m2 radiant exposure[1]	EN 12224	Retained Strength	80%
Resistance to Oxidation (100 years)	EN ISO 13438	Retained Strength	50%
Resistance to liquids	EN 14030	Retained Strength	50%

1. 1-4 months UV exposure depending on location/season

** Durability test data can be supplied by the manufacturer – test frequency must not exceed 5 years.*
** Manufacturer may use alternative means of assessing oxidation to achieve 100 years.*

Some manufacturers may have conducted additional durability studies in addition to the requirements laid out by the CE marking system. These additional durability studies will often be considered by designers, especially in sites where there are harsh environmental conditions. It should be noted that for a range of products which are identical except for mass per unit area, the manufacturer will often test the product with the lowest mass and use these results for the entire range.

3.2 Manufacturer's Quality Control Data

It is essential that all of the material delivered to site complies with the agreed specification. The quality of the product plays a significant role in the performance of the selected geocomposite. The manufacturer's quality control data should include information on the nature (test types, test frequency, quality standards) of the quality control testing undertaken on the material in the factory. A model MQA template for a geocomposite drainage layer can be found in Appendix A.

3.3 Product Packaging & Identification

Each roll of geocomposite material delivered to site must have a label complying with EN ISO 10320 affixed to it. An EN ISO 10320 label should detail the following:

a	The manufacturer (ideally including their address and telephone number)
b	Product identification (product name, type and production plant location)
c	The geocomposite roll number
d	The roll length and width in metres
e	The roll weight in kilograms
f	The polymer type

Geocomposites shall be delivered to site in packaging, which will protect the product from damage during handling and storage. Packaging must be suitable to protect the product from UV degradation. Product must be kept in appropriate packaging until such time that it is required for installation.

The geocomposite shall be clearly and indelibly marked with the product name and type. The product marking shall be easily legible and marked for example along the edge of the roll at regular intervals. The marking should be repeated at regular intervals no greater than 5 metres apart.
The manufacturers' Declaration of Performance should be made available for inspection in accordance with CPR.

4.0 Design

It is the Principal Designer who should determine the most suitable product to be used.

The objective of the design is to determine the properties required such that the proposed geocomposite will have adequate drainage properties during its operational design life and under the overburden stresses it will be subjected to. The geocomposite may also need to provide protection to an underlying barrier. It must also be robust enough to survive installation. The Principal Designer must assess the potential for stresses and strains within the geosynthetics, in-plane flow capacity during both construction and service including the potential reduction in flow capacity due, for example, to blockage from filtration or installation damage. Under the Construction (Design and Management) Regulations 2007 (CDM 2007) the Principal Designer must also consider temporary conditions during installation.

The table below outlines the issues designers must consider. This table is not exhaustive; it simply lists the common issues which apply to most landfill sites.

Environment	Issue
Physical	The required flow requirements for the whole flow length during the construction of the site, during its operation and for the full period of its post operational life (refer to the surface water management plan, hydrogeological risk assessment and leachate management procedures provided as part of the permit application). The required in- plane flow capacity in both long and cross direction at service conditions (essential for the stability of a cap). The nature of the layers either side of the geocomposite and their potential effects by damage or intrusion on the anticipated flow within the geocomposite. Anticipated changes in flow capacities over time due to clogging or intrusion into the internal voids. The likely stresses and strains imposed during the construction and infilling periods and potential creep. The anticipated range of cover-soil permeability for capping applications - anticipated impact of variability in the permeability if cover soil material is not supplied from a consistent source. The likely stresses and strains imposed by settlement and movement of the waste body especially in the cap. The duration of exposure to ultraviolet light. The likely temperatures expected adjacent to the geotextile and whether these may have a damaging effect upon the material properties in any way, especially creep. The interface strength between the materials around the geocomposite and its internal shear strength, particularly for installation on slopes. The overall stability of slopes incorporating these materials –a **slope stability assessment should include flow capacity calculations.** The bonding strength (internal shear strength) between layers of the geocomposite. Construction methods and geocomposite installed to manufacturer's installation instructions.
Chemical	The likely chemical interactions between the various elements of the geocomposite and the water/leachate/wastes in the site. There should be little or no chemical interaction. The polymeric structure of the component elements of the geocomposite and whether they will be prone to degradation which would affect its ability to function. The effects of mineral precipitation on the geocomposite performance.
Biological	The effects of microbial growth on the polymer of the filter geotextiles and strengthening elements. The effects of microbial growth on the characteristics of the filter geotextiles and strengthening elements. The potential for and result of root intrusion.

4.1 Site-specific Factor of Safety and Reduction Factors

Appropriate reduction factors should be introduced at a number of stages in the design. It is essential that the various factors applied to the design are clearly stated and explained.

The design should provide a factored set of specification values based on minimum performance for the hydraulic design and any other site specific design, such as slope stability and protection requirements, based on the issues outlined above.

The reduction factors should be applied to the laboratory measured flow capacity to determine a residual flow capacity before calculating the global factor of safety. Reduction factors introduced should include those which may reduce flow capacity of the geocomposite during its design life such as creep deformation chemical and biological clogging. Industry methods must be considered when selecting suitable reduction factors, such as GRI Standard – GC8: Determination of the Allowable Flow Rate of a Drainage Geocomposite.

At this point, designers should decide a material specification and forward the design (including the assumptions, reduction factors, site-specific factor of safety, justifications and material specifications) to the regulator for consideration.

To avoid unproductive effort or unnecessary cost, designers should submit their plans to the regulator before the material is purchased and is delivered to site. Once agreed with the regulator, the material specification provided must be complied with. Should there be any deviation from the specification this should only be with the agreement of the regulator. If the material fails to meet the specification in any way, the Principal Designer must seek further information on the cause of the fault. They must carry out a further technical assessment on the significance of the failure and the possibility that it may be present in other parts of the material. The technical assessment should be provided to the regulator.

4.2 Design Testing

There are a number of test methods available to designers to demonstrate that a geocomposite will perform as predicted for the lifetime of a site and provide the required flow capacity.

For geocomposites where the geotextile is adhered to a core, separating the components to undertake testing will cause damage which will affect any tests done on the geotextile element(s).

If testing of the separate elements is required, then one possible solution would be to obtain samples before it is manufactured into a geocomposite. The tests required on the separate elements could then be performed.

The following will need to be considered in order to demonstrate that the geocomposite will perform as designed:

Frictional Properties - Determining the frictional properties of the geocomposite product to be used together with the interface shear strengths (often expressed as friction angle and adhesion) is required by the regulator. It is an important element of the design process and is essential where the geocomposite is to be installed on a slope.

The Industry Code of Practice(s) ‘Geosynthetic interface shear resistance testing’ and ‘Earthworks in landfill engineering’ provides more guidance relating to the interface testing of geosynthetic materials.

In addition to interface shear strength, the internal shear strength of the product needs to be considered. The internal shear strength indicates the bonding between layers of the geocomposite.

Samples used in the tests need to be appropriate and typical of the full scale production materials and be tested at representative confining and pore pressures.

Flow Capacity - Determining the flow capacity comprises two parts:

- The flow of water/leachate into the geocomposite through the filter geotextiles and;
- In-plane flow capacity through the geocomposite as required for the design.

Appropriate testing is available for both parts but particular attention is drawn to the standard in-plane flow capacity test (BS EN ISO 12958:2010) as the choice of platens which may be used in the test method can significantly affect the results obtained.

The choice of platens (hard or soft) should take account of the likely adjacent materials and the anticipated stresses and whether there will be a significant impact via point loading, particle intrusion or creep - all of which have the capacity to reduce the voids within the geocomposite and therefore its flow capacity.

Insufficient flow capacity can have a significant impact on the stability of any slopes constructed within a landfill site.

Creep – Determine the creep of the geocomposite under the anticipated loads, stresses and temperatures anticipated through the life of the site. Some materials behave significantly better than others in elevated temperatures and under stress. Consideration should also be given to compressive creep in shear compression where the geocomposite will encounter shear forces such as on a side slope.

Filter Performance – The filter geotextile attached to the core is a very important part of the design specification and must have the correct filter performance or it could block and significantly reduce flow to the core causing build-up of hydraulic pressure and load. The suitability of the filter geotextile must be assessed and demonstrated to be adequate.

For a drainage geocomposite to perform over its design life the filter geotextile must maintain its mechanical filter effectiveness (soil retention capacity) and the hydraulic filter effectiveness (allow water flow at a low pressure head, i.e. small hydraulic gradients between adjacent materials and geocomposite).

To demonstrate that the geocomposite can achieve the long-term design requirement of the permeability of the filter geotextiles consideration has to be given to the potential for reduction in permeability during service due to blocking of the pores or to infiltration of soil particles (clogging).

The thickness and pore structure of a geotextile should guarantee a depth filtration analogous to mineral grain filter and prevent the formation of a residue on the contact surface between the soil and the filter. The effective opening size O90 alone is therefore insufficient for determining the filter stability.

Protection – Determining the ability of the geocomposite to protect an underlying geosynthetic barrier will be required when the geocomposite is to act as a protection layer as well as a drainage layer. Guidance regarding the determination of the basal protection ability of the geotextile component of a geocomposite is provided in LFE 7 ‘Using nonwoven protector geotextiles in landfill engineering and LFE2 ‘Cylinder testing geomembranes and their protective materials’. Consideration will need to be given to the combined effect of loading the geocomposite on the underlying geosynthetic barrier.

The Manufacturer’s Data – (which should have been collated over a period of time) can often demonstrate the effectiveness of a material. The specification sheets showing the results of various tests should however be treated with caution and viewed as only a summary of various data. For confidence to be placed in such data, the regulator will need to spend time considering how and in what form the data has been presented.

There have been several examples of manufacturer’s data sheets being used to specify material with the data from these sheets being included in the CQA plan as minimum values. Subsequent conformance testing may then fall below these levels while still being within the manufacturer’s statistical product distribution. This confusion arises due to the data that is provided on manufacturer’s data sheets (in conforming to standard reporting requirements) rarely showing minimum values.

It is therefore essential that a manufacturers’ CE Declaration of Performance (DOP) is used in conjunction with a data sheet to establish tolerances prior to a product being incorporated within the design. The designer should always review the manufacturers’ tolerance limits along with the mean data supplied on standard product sheets to ensure that values do not fall below any minimum design requirements.

During construction the regulator will assess compliance in terms of the values provided within the Specification.

5.0 Handling and Installation

Geocomposites must be carefully handled and stored in such a way that the material properties are not adversely affected. Storage should be on a flat, free draining surface. The geocomposite rolls should be delivered and stored in light tight wrappings to protect the material from ultraviolet degradation.

Geocomposites should be stacked in line with the manufacturers' recommendations and not more than five rolls high and no other materials shall be stacked on top.

Movement of the geocomposite rolls shall be in line with the manufacturers' recommendations and must not result in damage to or the stressing of the geocomposite roll.

The geocomposite must be installed in such a way that any potential for damage is minimised to both the geocomposite and the underlying layers. Care should be taken during installation to ensure that the geocomposite is placed the correct way up and at the correct orientation. The geocomposite must be in continuous contact with the surface on which it is placed without stretching or bridging over humps and hollows. Care must be taken with any blades or sharp objects to ensure the geocomposite is not damaged. The method of placement shall minimise wrinkles.

Construction plant must not traverse over any area of geocomposite until sufficient depth of cover material has been placed. What constitutes sufficient cover together with the method of placement must be justified as part of the design. A field trial must be undertaken where concerns exist regarding the suitability of the method of placement. No plant machinery should be allowed to pass directly onto the exposed geocomposite.

The method of placing overlaps/seams/joints between adjacent geocomposite sheets must be in accordance with the manufacturers' requirements and must not prevent or impair the anticipated in-plane flow.

The upper geotextile components on adjacent panels should be joined together in order to ensure no soil or deleterious material can enter the drainage core. This helps prevent uplift of the material due to wind. This jointing may be performed by heat bonding or sewing the two geotextiles together.

When used on slopes the geocomposite should be rolled out parallel to the slope and should extend from the top of the slope to the bottom in one panel. Horizontal joints should not be used. The geocomposite should be anchored securely at the top of the slope in either an anchor trench or a suitably designed run-out.

In order to minimise the potential for slope instability to occur, geocomposites must only be placed where there exists the ability to remove the liquid that is collected. For example, where a geocomposite is placed to the flank of a cap, an operational toe drain must be in place prior to the placement of the cover soils.

6.0 Construction Quality Assurance

Construction Quality Assurance (CQA) has a role to play in all aspects of landfill engineering. Whilst CQA techniques don't guarantee that works have been carried out in accordance with the specifications, they should give confidence that the following requirements have been met:

i) Effective mechanisms are in place to ensure the construction of the engineered systems will be to the standards and specifications agreed with the regulator and that quality materials and workmanship have been used;
ii) The design, construction and quality assurance processes are well documented to provide public confidence in the works.

Independent, third party construction quality assurance provides a level of confidence that the above requirements have been met. Where containment systems are specified in an environmental permit, will require validation by a suitably qualified and experienced independent engineer that the specified works have been carried out to the agreed standards.

CQA testing may only be undertaken at laboratories that have UKAS accreditation for the required tests. Accreditation is only given for individual tests so it's worth checking the laboratory has accreditation for all the tests you require.

6.1 Construction Quality Assurance Plan

With regard to drainage geocomposites, the CQA plan must contain the following information:

a	A summary of the geocomposite manufacturer's quality control procedures with a list of characteristics that the material will be required to achieve
b	Records of the delivery, handling and storage of the geocomposite on site prior to installation
c	Details of the conformance tests to be undertaken by the CQA engineer when the geotextile is delivered to site
d	Rejection criteria for the geocomposite. This will normally be performed in accordance with the accompanying CE documentation and relevant application properties (see section 6.2)
e	The remedial action to be taken in the event of non-compliance with any part of the specified criteria
f	The installation and jointing/overlapping techniques
g	Procedure for inspecting, testing and sampling joints if appropriate
h	Rejection criteria of the laid geocomposite if test results fail
i	Records of the source roll for each panel should be recorded along with the time/date of installation
j	The proposed level of supervision and quality control
k	The proposed format and contents of the validation report (see section 7.0)
l	Procedure for liaising with the regulator

The regulator will visit the site during installation to monitor and inspect the implementation of the CQA plan. The responsibility for establishing and implementing the CQA plan however remains with the permit holder.

Your CQA Engineer must keep a daily log recording, where appropriate, the following information:

Records of the delivery, handling and storage of the material
Weather conditions and whether the works are being undertaken within the weather windows specified within the CQA Plan
Periods of on-site supervision by CQA Engineer
Testing procedure and reports of field tests
Remedial action taken in the event of test fails
Personnel on site
Contact (site visits, phone calls) by regulatory or other parties interested in the construction
Any other matters detailed in the CQA plan

If you need to deviate from the CQA plan, the permit holder shall first receive approval from the regulator. The permit holder shall report any deviation from your contractor's method statement to the regulator.

Many problems have been encountered in the past due to differences between the agreed CQA plan and the contract documents. Therefore, it is strongly recommended you make every effort to avoid such discrepancies.

6.2 Conformance Testing

Conformance testing must form part of the overall CQA. It is undertaken to provide confidence the geocomposite installed at the site has the same properties as the specification and that the agreed properties are consistent across the whole of the geocomposite.

The following should be completely checked and documented by the CQA engineer:

The product marking and the information affixed to the geocomposite is in accordance with EN ISO 10320 (section 3.3).
The CE mark is affixed to each roll along with the notifying body's number.
The relevant CE declaration in line with EN 13257/EN13252 is available, and the reported values and tolerances are in line with the requirements of the design specification.
The conformance testing performed by the laboratory is performed in a laboratory that is UKAS accredited for each individual test.
All conformance testing is correctly evaluated against the requirements of the design specification.

6.2.1 Sampling for evaluation of compliance with the design specification

For sampling, EN ISO 9862 should be applied, except that samples should be taken not less than 5m from the end of the roll in machine direction and over the full width of the roll in the cross machine direction. The location of each sample should be described exactly. Each sample should be marked clearly with the manufacturers' name, product identification and roll/batch number. Where samples are taken from rolls prior to being installed, the rolls shall be re-wrapped and sealed in their protective packaging.

6.2.2 Evaluation of conformity by a simplified procedure

A delivery lot is considered to fail if one or more of the samples tested do not meet one or more of the declared values on the CE declaration or relevant applications properties.

The supplier may choose to replace the rejected lot or to carry out further testing (in accordance with 6.2.3) on new samples from the product delivered to the site. The results obtained on the previously tested samples should be included in the evaluation.

6.2.3 Evaluation of conformity by statistical procedure

This evaluation may be used, if there are five or more samples taken from the site.

The lot is accepted when:

- All the values measured are within the design specification or
- If one or more of the values measured are outside the design specification then perform the following calculation:

$(X - 1.645 * s) \geq Q_{min5\%}$ (lower limiting 5%-Quantile in case of minimum value) and/or
$(X + 1.645 * s) \leq Q_{max5\%}$ (upper limiting 5%-Quantile in case of maximum value)

Where:
X = mean value of the test results of the samples
S = standard deviation of the test results of the samples
$Q_{min5\%}$ = lower limiting quantile = lower specification value (in this case 5% nonconforming)
$Q_{max5\%}$ = upper limiting quantile = upper specification value (in this case 5% nonconforming)
This evaluation may be used, if there are five or more samples taken from the site.

The lot is accepted when all the values measured are within the design Specification/DOP

Table 1 : Suggested CQA frequencies for drainage geocomposites

Material property	Test method	CQA test frequency
Physical:		
Product thickness under 2 kPa	EN ISO 9863-1	1/2500 m^2 or part thereof
Geotextile filter thickness under 2kPa	EN ISO 9863-1	1/2500 m^2 or part thereof
Characteristic opening size($_o$90)	EN ISO 12956	1/2500 m^2 or part thereof
Mass per unit area	EN ISO 9864	1/2500 m^2 or part thereof
Mechanical:		
Puncture resistance (CBR)	EN ISO 12236	1/6000 m^2 or part thereof
Wide width tensile properties	EN ISO 10319	1/6000 m^2 or part thereof
Tensile test for joints	EN ISO 10321	As required
In Plane Flow Capacity	EN ISO 12958	1/6000 m^2 or part thereof

a) Table 1 is provided for guidance. Testing frequencies should reflect the confidence in the material and the amount of quality control exercised by the manufacturer. The frequencies in Table 1 would be those for a product with good MQC.

b) The CQA Engineer should instruct further testing as necessary in order to maintain the quality of the geocomposite or where additional testing for other parameters is relevant to the design and/or installation.

c) Any geocomposite that fails to meet the requirements of the CQA plan should either be excluded from the permanent works or be reported to the Agency regulator together with a technical assessment by the CQA Engineer of its significance and any remedial actions considered necessary. Any geocomposite laid prior to the receipt of test results shall be at your own risk.

d) The choice of platens used for the In Plane Flow Test should take account of the adjacent site specific materials and should be tested at a pressure and hydraulic gradient that is relative to site conditions.

7.0 Validation Report

The validation report presents the final 'as built' record of the works and acts as the permanent record held by the regulator. It must provide a comprehensive record of the construction and be in such a form that it can be clearly understood, particularly in terms of the technical detail. The information in the validation report should mirror the agreed CQA plan and include all information relevant to the construction.

The following information must be included in the validation report as a minimum:

a	All of the information required in the CQA plan and other sections of this guidance
b	The results of all tests (passes and failures including remedial works and testing of remedial works related to the original failure)
c	Weather conditions
d	Delivery of materials
e	Plant and labour
f	Roll numbers deployed
g	Panels installed
h	Areas of non-conformance
i	Repairs
j	QA installation checklist
k	Records of site meetings
l	Progress photographs
m	Any other relevant information
n	As built drawings (see below)
o	Written confirmation by the CQA Engineer that all the details in the agreed CQA Plan have been complied with

The as-built drawings must detail the following:

a	construction details including levels, contours and slope angles
b	locations and identification marks of each panel
c	locations of damaged/repaired areas
d	locations of samples
e	locations of penetrations

Appendix A

Model MQA template for a geocomposite drainage layer

Characteristic	Test Method	Typical Test Frequency (MQA)
(1) Tensile Strength	EN ISO 10319	1 x 10,000 m²
(2) Elongation at maximum load	EN ISO 10319	1 x 10,000 m²
(3) Static puncture (CBR test)	EN ISO 12236	1 x 20,000 m²
(4) Dynamic perforation resistance (cone drop test)*	EN ISO 13433	1 x 100,000 m²
(5) Characteristic opening size *	EN ISO 12956	1 x 100,000 m²
(6) Water permeability normal to the plane *	EN ISO 11058	1 x 100,000 m²
(7) Water permeability horizontal to the plane	EN ISO 12958 (s/s i = 1, 20kPa)	1 x 100,000 m²
(8) Durability	EN 13252 According to annex B	1 every 5 year
(9) Resistance to weathering	EN 12224	1 every 5 year

Note: The geotextiles and related components must comply with LFE 7 in respect to durability and UV protection.
Note: Recycled polymer shall not be used.
Note: s/s refers to soft/soft platens

* only filter layer