Earthworks Drainage

A guide to the selection and specification of drainage systems using ABG Fildrain geocomposite drainage systems

abg creative geosynthetic engineering

Drainage is a major consideration in all civil engineering projects. When designing surface water drainage, there are many modern materials engineers utilise to achieve an optimum design in terms of performance and economy. The same cannot presently be said about sub-surface drainage, although attitudes are changing.

Sub-surface drainage options have been limited to traditional crushed stone filter drains even though modern materials are available.

Sustainability is increasingly high on the agenda and this emphasis requires engineers to look again at the tonnage of clean crushed stone consumed by traditional sub-surface drainage requirements.

This change is being driven by clients who are asking for their projects to be designed to meet sustainability criteria and geocomposites enable significantly reduced volumes of crushed stone, whilst giving enhanced performance at lower cost.

The modern option of geocomposite drainage enables greater use of site won as-dug materials and this in turn minimises the number of vehicle journeys, both delivering and removing materials from site.

Contents

Fildrain

Fildrain is a geocomposite drainage system designed to collect and channel water to a carrier pipe for transportation to a suitable discharge point. It is usually specified as a direct replacement to traditional crushed stone drainage design.

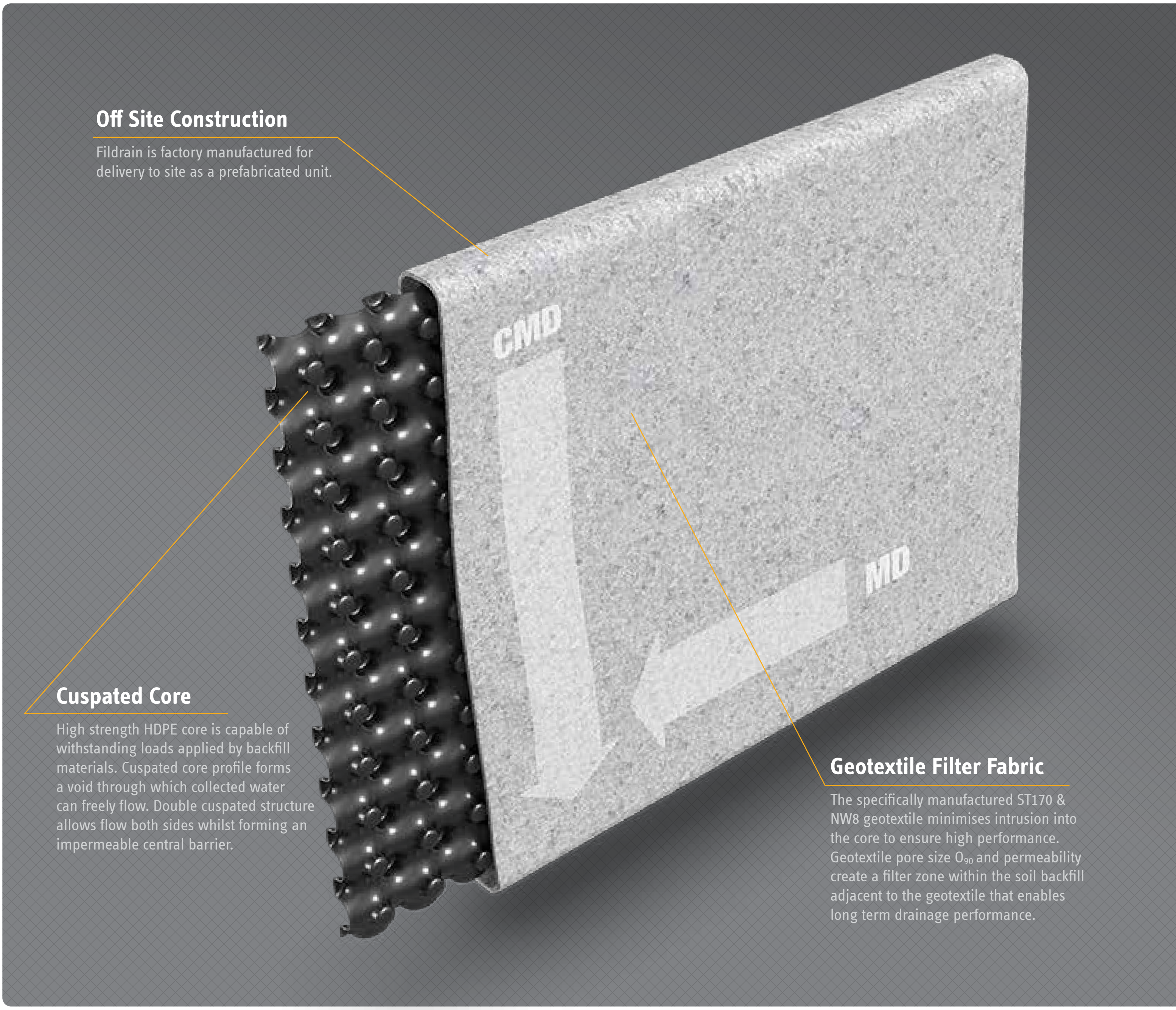
Crushed stone is not an efficient drainage material since it interlocks when compacted, leaving very little void space for water flow. Fildrain geocomposite comprises a cuspated HDPE core which is wrapped in, and thermally bonded to, a non-woven geotextile. Fildrain has a flow capacity many times that of traditional crushed stone due to the unique open structure created by the dimpled core profile, allowing unhindered water flow.

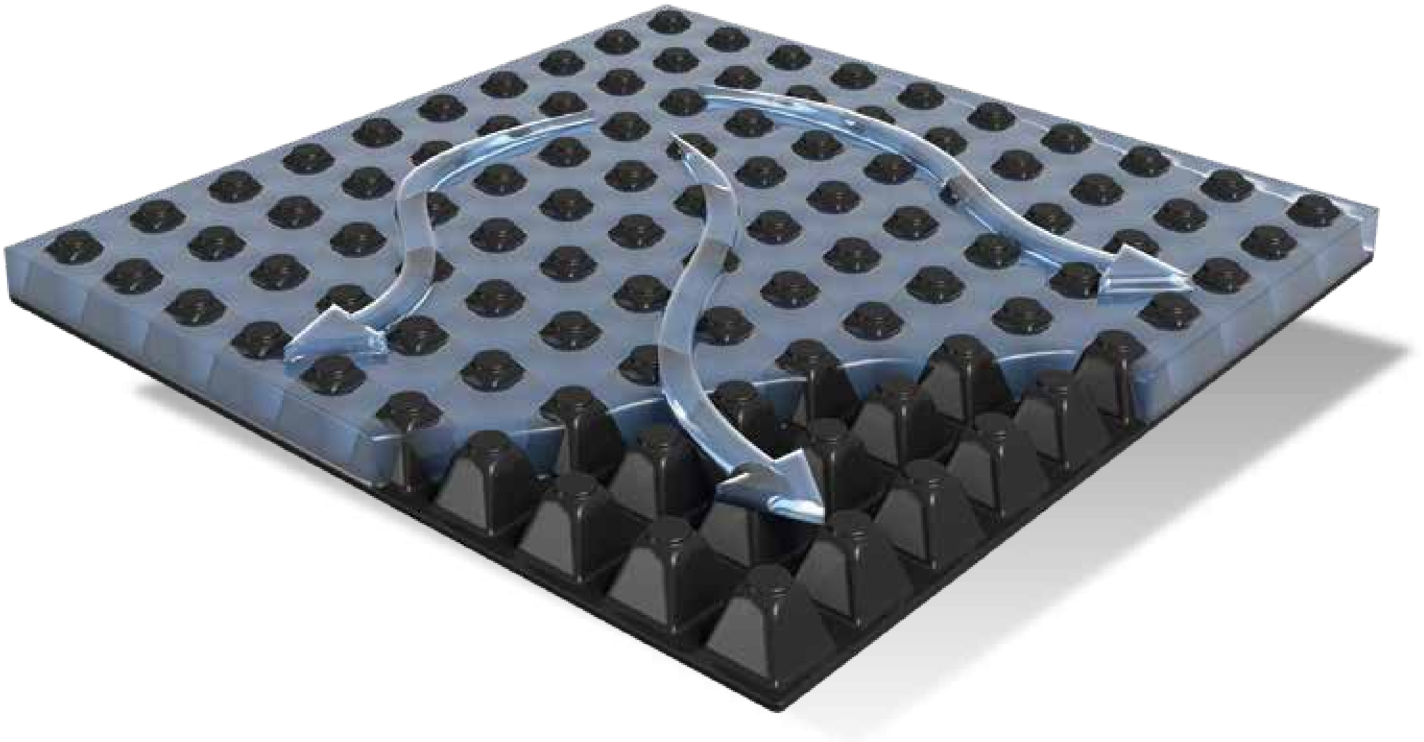
The Fildrain range of drainage products has many applications within Civil Engineering schemes; encompassing Highways, Sports, Mining, Rail and Building, amongst others.

Fildrain specifically has applications in the drainage of embankments, reinforced soil structures and cut off drains. Fildrain can be manufactured in bespoke configurations to suit project specific requirements; including widths, lengths, geotextile specifications and pipe fixing detail.

Fildrain is used in every situation that crushed stone drainage can be used and also where stone drainage is impractical, such as vertically behind geomembrane liners.

Fildrain is one product in an extensive range of ABG geocomposites tailored to specific markets.





Multi-directional flow

Crushed stone drainage has equal flow in all directions. For true equivalency, any geosynthetic selected must also have multi-directional flow in order to meet the requirements of the application.

Multi-directional flow means that in the event of localised obstruction, the liquid within the core simply flows around the affected area. In some applications, the predominant flow is in the Machine Direction (MD) but in most applications the predominant flow is in the CMD (Cross Machine Direction).

Fildrain has true multi-directional flow. Many other geocomposite drainage systems, including those based on geonets and random fibre cores, do not.

Cost Effective

Using Fildrain can significantly reduce the volume of drainage stone required on site. This offers a number of financial benefits through reduced material handling, material re-use and reduced disposal costs.

Minimises Environmental Impact

One vehicle load of Fildrain provides equivalent drainage to approximately 200 tonnes of crushed stone, greatly reducing the environmental impact associated with both quarrying the stone and HGV movements during installation.

Reducing HGV movements results in less exhaust emissions, reduced wear and tear on local infrastructure, reduced disturbance to local residents and less congestion and disruption to other road users.

All these benefits combined assist smoother site logistics and help clients to achieve their stated environmental policies and corporate social responsibility for sustainable development.

Space Saving

Fildrain requires a narrow trench for installation. This is especially beneficial when services are required to run along the verge of a highway since this reduces land take requirements.

Speed of Installation

Fildrain is efficiently and rapidly installed when compared with traditional systems, ensuring schemes are completed within the required time scale.

Design Considerations

The importance of achieving good earthworks drainage to reduce groundwater levels and control pore water pressure to increase bearing capacity, has long been established. Traditional methods use mineral filter layers, which is still the default position but there is now a wider range of techniques available.

Keeping the focus on good drainage, it was the US Corp of Engineers who in the 20th Century pioneered prefabricated drainage as an alternative to crushed stone drainage. Prefabricated drainage has evolved into geocomposite drainage and this continues to meet today's needs for off site construction, sustainability, carbon saving, cost saving and speed of installation. ABG pioneered the development of wide width geocomposite drainage in the 1990s for applications in large area earthworks, and have supplied millions of square metres, saving billions of tonnes of crushed stone.

Surface Water or Ground Water

Geocomposite drainage is suitable for dealing with ground water and ground water plus surface water, but not ideal for purely surface water. Surface water carries silt and detritus and this is best dealt with by pipes and channels. For situations with combined surface water and ground water, e.g. French Drains, the surface water must pass through a layer of filter stone before reaching the geocomposite drain. This filter stone, typically 300mm deep, will trap the silt and detritus and can be periodically excavated and replaced. Designing a geocomposite for filtered surface water or ground water to achieve a 120 year life is very simple.

Traditional Crushed Stone Drainage

Crushed stone or gravel is relatively abundant but not always of the correct quality to be used as drainage. It is expensive and has high carbon emissions associated with processing and transport. Graded crushed stone is often used to perform both as the filter and drainage, but this limits its drainage performance. Single sized crushed stone or gravel is more effective as drainage and is used with a geotextile filter. Crushed stone drainage is not often designed but is utilised based on standard specification e.g. Permeability 1 x 10-3 m/s and minimum thickness, e.g. 500mm. This leads to stone drainage layers being over or under capacity. Neither situation is ideal. To move from crushed stone drainage to geocomposite drainage, engineers first have to be able to calculate either the required flow or equivalence of the specified crushed stone drainage. In-plane flow in a drainage layer is governed by Darcy's Law (Q = k i t) where k is permeability (m/s), i is hydraulic gradient (no unit), t is layer thickness (mm) and Q is in plane flow capacity (l/m/s). So a 500mm layer of 1 x 10-3 m/s at hydraulic gradient of 1/100 has a capacity of 0.005l/m/s.

Geocomposite Drainage

The simple realisation that it is the void space within a layer of crushed stone that achieves the drainage flow, led to the development of polymeric cores that have a high void ratio. The cores must also be flexible and have sufficient compressive strength. Such cores combined with a geotextile form a geocomposite drainage layer. The first generation polymer cores such as bi-planar geonets or random fibre were not very efficient, but latest generation modern cuspated cores are highly effective.

The cuspated core of Fildrain at just 4mm thick, when tested under simulated site conditions achieves an in-plane flow capacity of 0.04 l/m/s at hydraulic gradient of 1/100. This is 8 times that of a 500mm layer of drainage stone, at only 4mm thickness compared to 500mm! It is this reduction in layer thickness that enables the geocomposite drain to achieve project time and cost savings.

To be equivalent to drainage stone, the geocomposite must be able to demonstrate equivalent in-plane flow capacity under confining pressure in machine direction (MD) and cross machine direction (CMD). Having this true equivalence enables the geocomposite to be used at any orientation and allows flow to continue past any localised obstruction. Just like stone drainage, geocomposite drainage has a large surface area to collect water from the ground and guide this to the network of collection pipes.

Gas Flow

Whilst geocomposite drainage is most frequently used to drain water, it is also capable of venting gases. The flow capacity of gas is at a lower rate than the flow capacity of water due to the lower density of gas.

In-Plane Flow Capacity

The in-plane flow capacity of the geocomposite in MD and CMD when subjected to the design confining pressure is the key performance criterion. This is tested to EN ISO 12958 or ASTM D4716 using SOFT boundary platens to simulate soil backfill. The test places a specimen of geocomposite and a Neoprene soft foam in a transmissivity rig, jacked up to a confining pressure between 20 and 1,000 kPa, whilst water at the required hydraulic gradient flows through the specimen to give the in-plane flow capacity in (l/m/s). The Achilles heel of a geocomposite drain is a weak core or a geotextile that intrudes into the core or both. Fildrain with its unique cuspated core and laminated stiffened non-woven geotextile has been developed and manufactured to achieve minimal loss of performance even at pressures of 1,000kPa. Poor cuspated products, poor geonet products and poor products in general resort to using EN ISO 12958 with HARD or RIGID platens. As can be imagined, these metal platens fail to replicate the soil backfill, resulting in no geotextile intrusion, giving these products an artificially high in-plane flow value on the datasheet that will not be achieved on site. Reject all data sheets that give HARD or RIGID platen test results (unless the geocomposite is to be placed on concrete or something similarly rigid).

$$Q = (FoS)\ X\ \ Q_{SOFT}\ X\ \frac{1}{RF_{CR}}\ X\ \frac{1}{RF_{BC}}\ X\ \frac{1}{RF_{CC}}$$

Chemical Exposure

The polypropylene geotextile and polyethylene core of Fildrain have excellent resistance to a wide range of chemicals including acids, alkalis, salts, sulphates and petroleum. The Reduction Factors for Chemical Clogging (RF_{CC}) and Biological Clogging (RF_{BC}) for Fildrain are typically 1.

So why is geocomposite drainage not the default position? Maybe it is that crushed stone has been used for 4,000 years compared to only 40 years for geocomposite drainage. Maybe it's that crushed stone is now generic and geocomposite drainage is still proprietary. Maybe there is insufficient geocomposite information and what information there is, is confusing. In the markets that have embraced geocomposite drainage, engineer's initial concern has moved from contentment with high quality geocomposites designed well, into contempt that any geocomposite will do.

Geocomposite drainage must be designed and specified to achieve the desired performance or like any other material (steel, concrete, timber, etc.) they will fail.

Here we present sound technical advice based on ABG's 30 years of experience to confidently guide the new user and the experienced user.

Long Term Creep

The water flow capacity test to EN ISO 12958 or ASTM D4716 is a short term test that takes only minutes to perform. In use however, the geocomposite will be subjected to pressures for the whole design life of up to 120 years. All materials are subject to creep (including crushed stone), but plastics can be especially prone. Creep is defined as the continued reduction in thickness under a constant pressure over time. To assess the creep performance of Fildrain, ABG pioneered the application of the Stepped Isothermal Method (SIM) to measure the compressive creep of geocomposites. The method is now published as ASTM D7361 and ABG has an extensive library of creep data for Fildrain. The creep performance of Fildrain is excellent and provides the relevant in-plane flow reduction factors (RF_{CR}) for 120 year design life.

Compressive Strength, Mass and Thickness

These values that appear on data sheets must NOT be used in specifications as they are meaningless to design and performance.They are short term tests and completely irrelevant in determining performance. For example a 5mm product could be so full of plastic that it achieves almost no flow. Ditto a 900 gsm product. Compressive strength is measured at the point when a product is crushed flat. The only purpose in this value is for CQA to quickly determine that the correct grade of product has been supplied against its own datasheet.

Geotextile Filter Criterion - Filter Stability

The geotextile creates a stable filter zone in the soil adjacent to it by having a pore size that is compatible with the soil, a permeability that is many times higher than the soil and by allowing water to flow without a water head.

Geotextile

The geotextile is an integral part of the Fildrain geocomposite. In its standard forms Fildrain has either an NW8 or ST170 non-woven geotextile. These geotextiles have been selected, based on ABG's extensive knowledge, to be suitable for the majority of soils. Special geotextiles are available for specific situations and ABG's technical team are always pleased to confirm the suitability of the geotextile when the soil PSD has been provided. There are some soils that are particularly difficult, such as peat and ochre and these require special consideration.

Geotextile Filter Criterion - Pore Size

The geotextile creates a filter in the soil adjacent to the geocomposite. It does this by allowing some small/medium sized soil particles to pass through the geotextile but does not allow larger particles to pass. The geotextile pore size must be compatible with the soil particle size (PSD). The standard geotextile has a whole range of pores of sizes from 5 micron to 1,000 micron and is characterised by the O_{90} value. This is the value of which 90% of the pores are smaller. Typically the O_{90} will be 70 -120 microns. The geotextile pore size is tested to EN ISO 12956.

Geotextile Filter Criterion - Permeability / Perpendicular Water Flow

The geotextile must allow water (or gas) to flow freely from the soil into the core of the geocomposite. The rate of flow is expressed as the perpendicular water flow (l/m^2/s) and permeability (m/s). This is tested to EN ISO 11058 at 50mm water head. Typical values for a non-woven geotextile are 109 l/m^2/s and 67 m/s. This is 100 to 10,000 times higher than most soils; hence there is a large factor of safety!

Geotextile Filter Criterion - Break Through Head

It is imperative that water starts to flow as soon it comes into contact with the geotextile. This is termed the break through head. Fildrain geotextiles have zero break through head but this is not the case for all geotextiles, some will only allow water to flow once the head is at 100mm for instance. For deep drainage applications, the water head in the soil will be greater than 100mm and all geotextiles will function, but for shallow applications and situations of high soil suction, no flow will occur through the geotextile unless the geotextile has zero break through head.

UV Exposure Limits and Oxidisation

The polyethylene and polypropylene polymers used to manufacture Fildrain contain UV stabilisers and oxygen inhibitors. Geocomposites are always designed to be covered in use. The UV stabilisers enable exposure during installation and the oxygen inhibitors are active throughout the design life of the geocomposite at normal temperatures. For long time UV Exposure, ABG has XUV grades of Fildrain and for long term use at elevated temperatures, ABG has the UVAO grades of Fildrain.

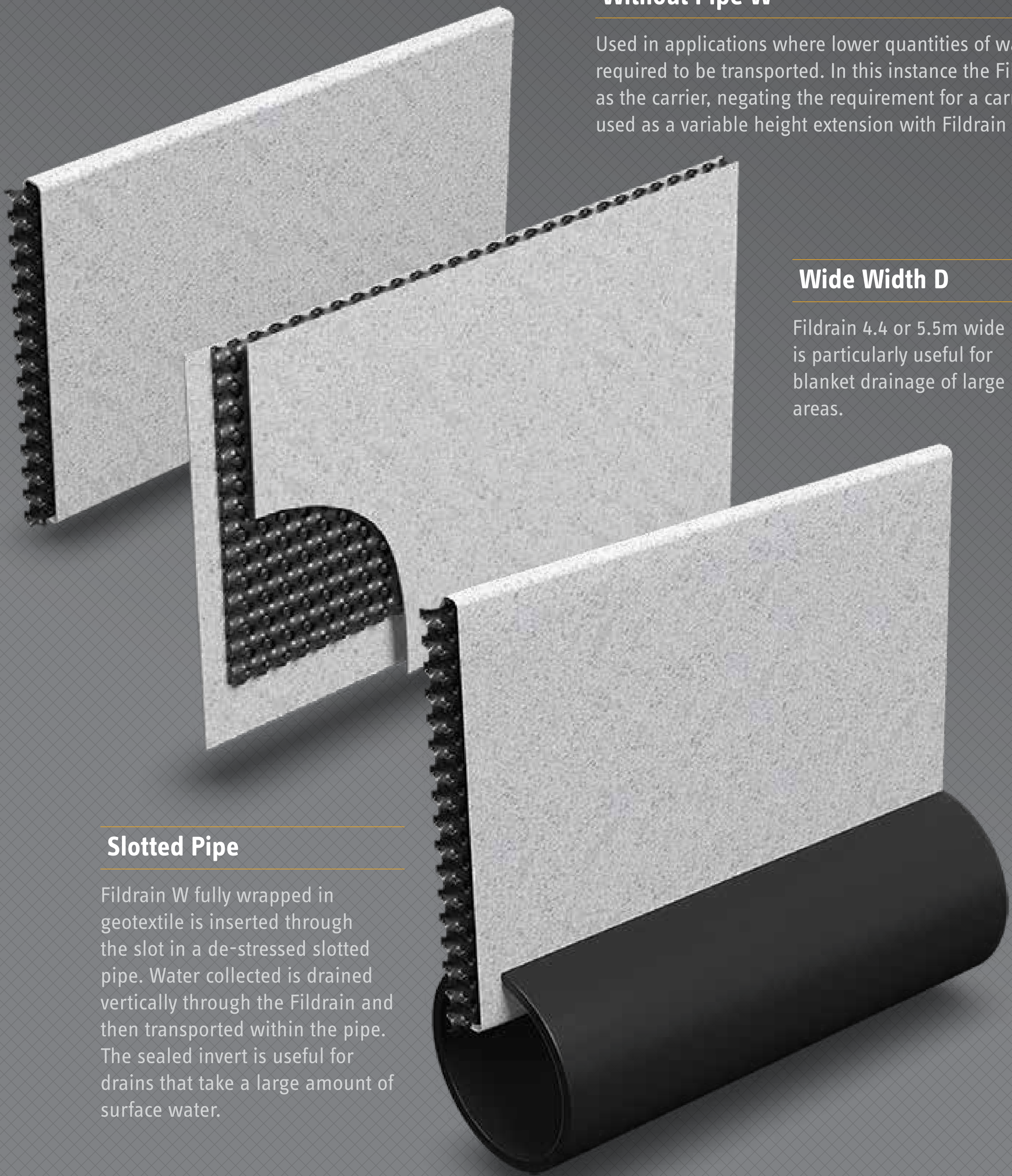
Attenuation

Fildrain is a geocomposite that is optimised for high performance water flow and is superior to crushed stone in this application. Crushed stone, however, can be used for water storage or water attenuation. Crushed stone has a porosity of 30%, so 1m^3 can store approximately 0.3m^3 of water. ABG supplies geosynthetic crates that have a porosity of 95% for these applications.

Fildrain Configurations

Without Pipe W

Used in applications where lower quantities of water are required to be transported. In this instance the Fildrain itself acts as the carrier, negating the requirement for a carrier pipe. Also used as a variable height extension with Fildrain W[P] & W[F]

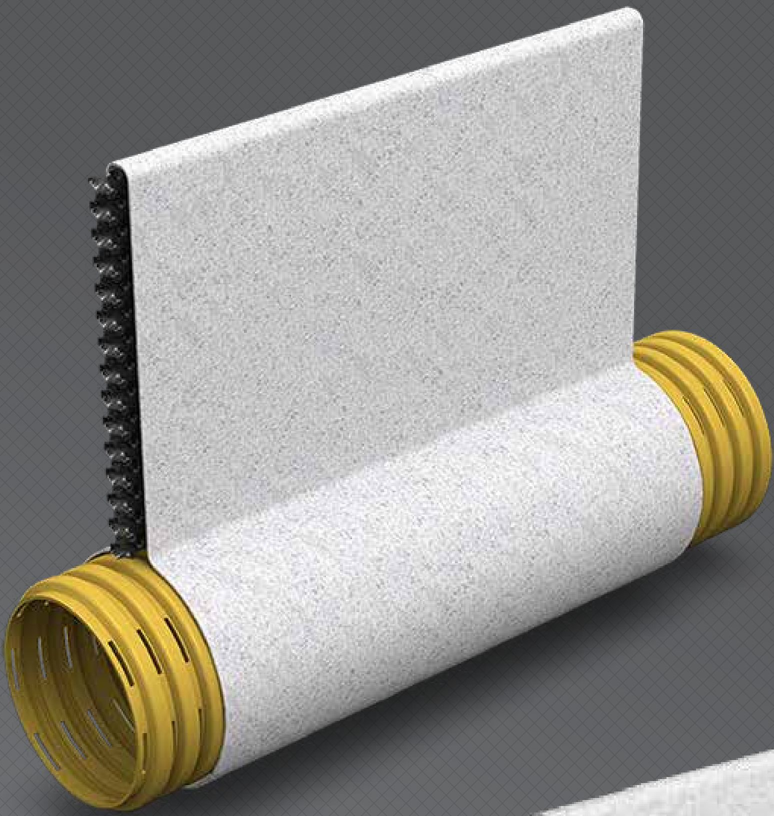


Wide Width D

Fildrain 4.4 or 5.5m wide is particularly useful for blanket drainage of large areas.

Slotted Pipe

Fildrain W fully wrapped in geotextile is inserted through the slot in a de-stressed slotted pipe. Water collected is drained vertically through the Fildrain and then transported within the pipe. The sealed invert is useful for drains that take a large amount of surface water.

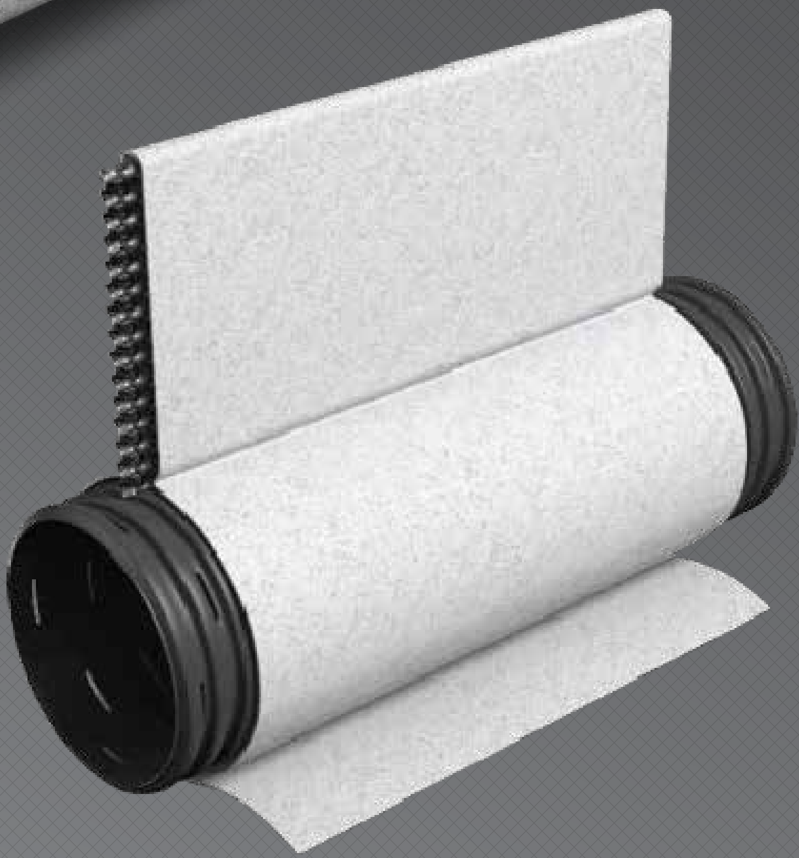


Pipe Sleeve W[P]

The Fildrain is constructed with an integral geotextile pipe sleeve to take a perforated drainage pipe up to 200mm diameter. Once on site the pipe is pulled through the sock before being placed into the trench.

Pipe flaps W[F]

Where drainage pipe with a diameter greater than 200mm is required, Fildrain can be manufactured with geotextile flaps that encapsulate the pipe. This allows the pipe to be positioned in the trench and then Fildrain to be positioned after.



Available Cores

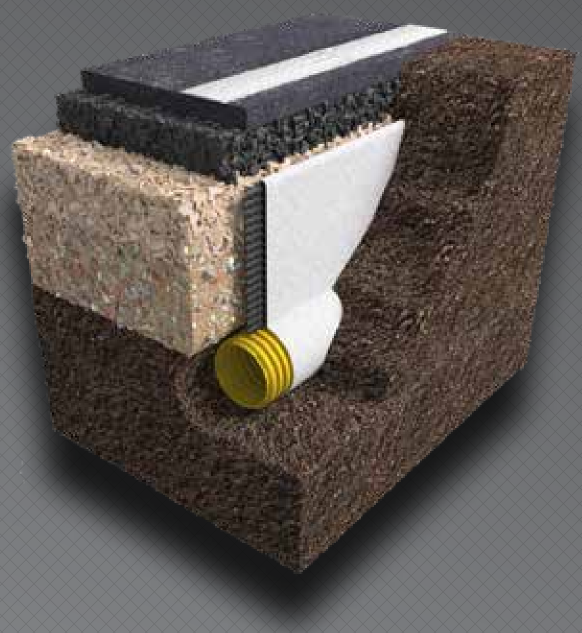
Property	Unit	4S	7S	7D	12S	25S
Core thickness	mm	4	7	7	12	25
Cuspate Configuration	Single	Single	Single	Double	Single	Single
Material	HDPE	HDPE	HDPE	HDPE	HDPE	HDPE

Surface & Sub-Surface Drainage

Fildrain provides an ideal alternative for 'traditional' stone constructions in the formation of surface and sub-surface drainage systems, saving time and money on construction projects.

Fildrain 12SW + 25SW

In many instances traditional detail can be replaced with a Fildrain SW. This allows the excavated material to be simply backfilled into the trench and requires no import of clean aggregate. At the end of each run, a Fildrain fitting is used to connect to the outfall pipe. A low cost system with low embedded carbon which is suitable for mechanical installation.



Fildrain 7DW[P] or 7DW[F]

When high longitudinal flow capacity is required, Fildrain is combined with a perforated pipe, pipe diameter is typically 100mm but this could be over 1,000mm. Another low cost, low carbon solution.

French Drains

On a large highway project there could be as many as four French drains running the length of a highway in order to collect both ground and surface water from the verges, slopes and landscaped areas. These French drains have traditionally been specified with and constructed using crushed stone. Using Fildrain not only saves the stone but also requires less excavation width and so helps to accommodate all the projects features into a reduced land take. Using a Fildrain cuspated product will provide the required level of performance when used with a 300mm topping of crushed stone. When used in this application, Fildrain geocomposites offer the additional benefit of being extremely quick to install, saving valuable time during the construction phases.

Groundwater Drains

Control of groundwater is critical to achieving a stable formation. As a groundwater drain, Fildrain is installed either upright in narrow trenches of in large sheets to form a complete blanket across the formation. An ideal application for Fildrain G.

Capillary Break

For capillary break applications please refer to separate literature.

Gas Venting

Fildrain is also used to intercept and collect ground gas.

Cut-off Drains

A special form of groundwater drain intended to intercept the ground water flow and prevent it from passing into another zone. The use of geocomposites with a central impermeable barrier such as the cuspated cores of Fildrain makes a highly effective cut off drain. The geocomposite's central impermeable barrier means that lateral flow can be intercepted within a much narrower trench than with 'traditional' solutions.

Environmental Drainage

Please refer to Pozidrain literature for applications in Landfill and Mining.

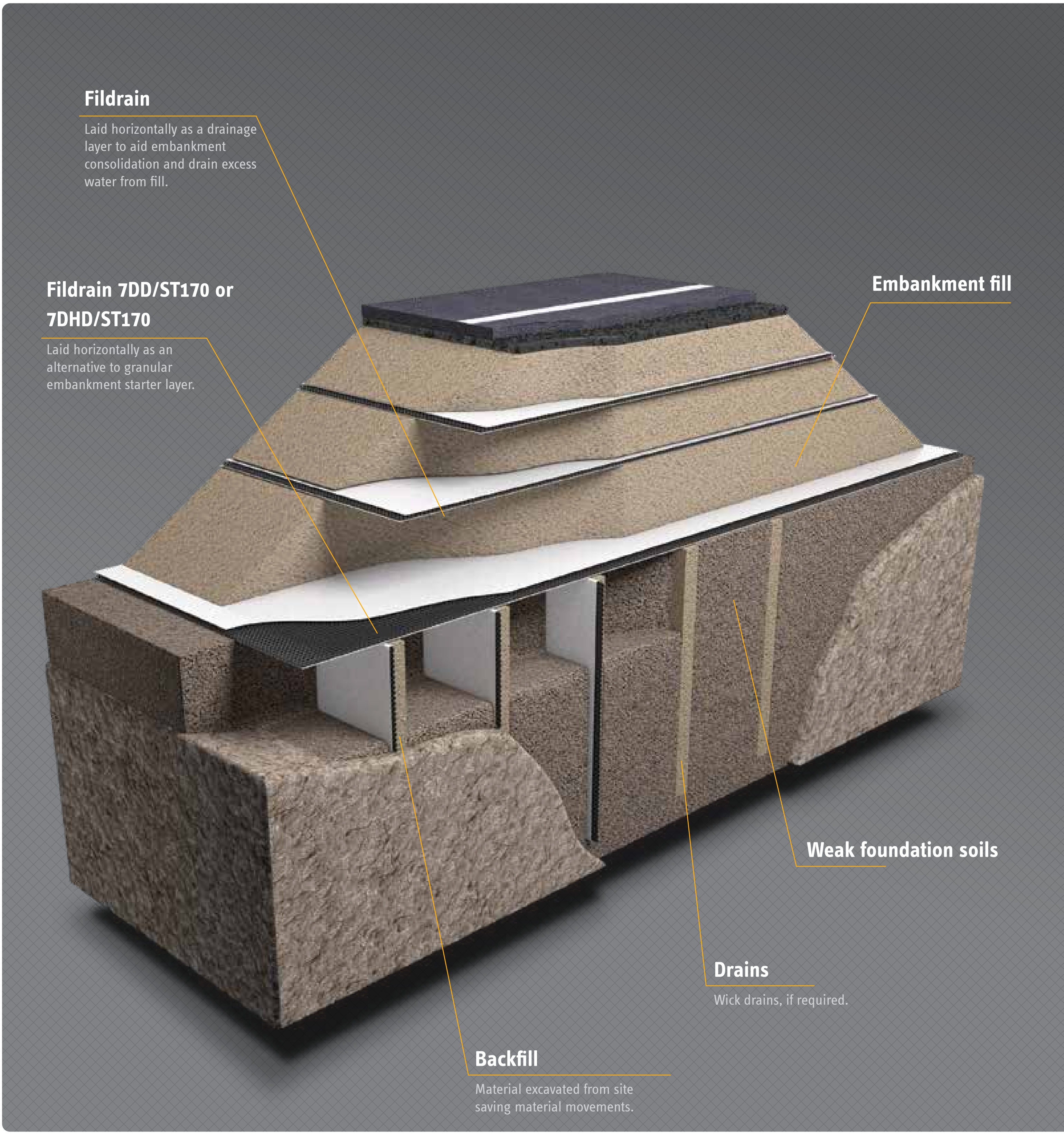
Fildrain 7DW

Incorporating a pipe with sealed invert is ideal when large volumes of surface water are to be collected. Supplied with de-stressed and slotted 6m twin wall pipe.

Traditional construction

Consists of an excavated trench, infilled with free-draining aggregate. This type of construction may require off-site material import and the removal of excavated materials. Trench width is typically 300mm to 500mm, a high cost option with a large carbon footprint.

Consolidation Drainage & Settlement Control



Many civil engineering projects require the construction of new embankments to meet required levels. Adequate drainage of embankments is key to their rapid construction, controlled settlement and long-term stability.

Embankment Starter Layer

A thick granular drainage layer is often placed onto the prepared formation before construction of an embankment. This layer serves two functions, one of which is drainage and the other is to protect the formation from heavy construction machines.

Introducing Fildrain 7DD/ST170 or 7DHD/ST170 will provide the required drainage capacity and this would be overlaid with at least 300mm of fill before tracking with construction plant.

Fildrain is laid across the width of the embankment and the backfill placed on an advancing face. The geocomposite must have sufficient compressive strength for the forces under the full height of the embankment and ideally have a core with a central barrier that protects the formation from water ingress and re-hydration due to rainfall.

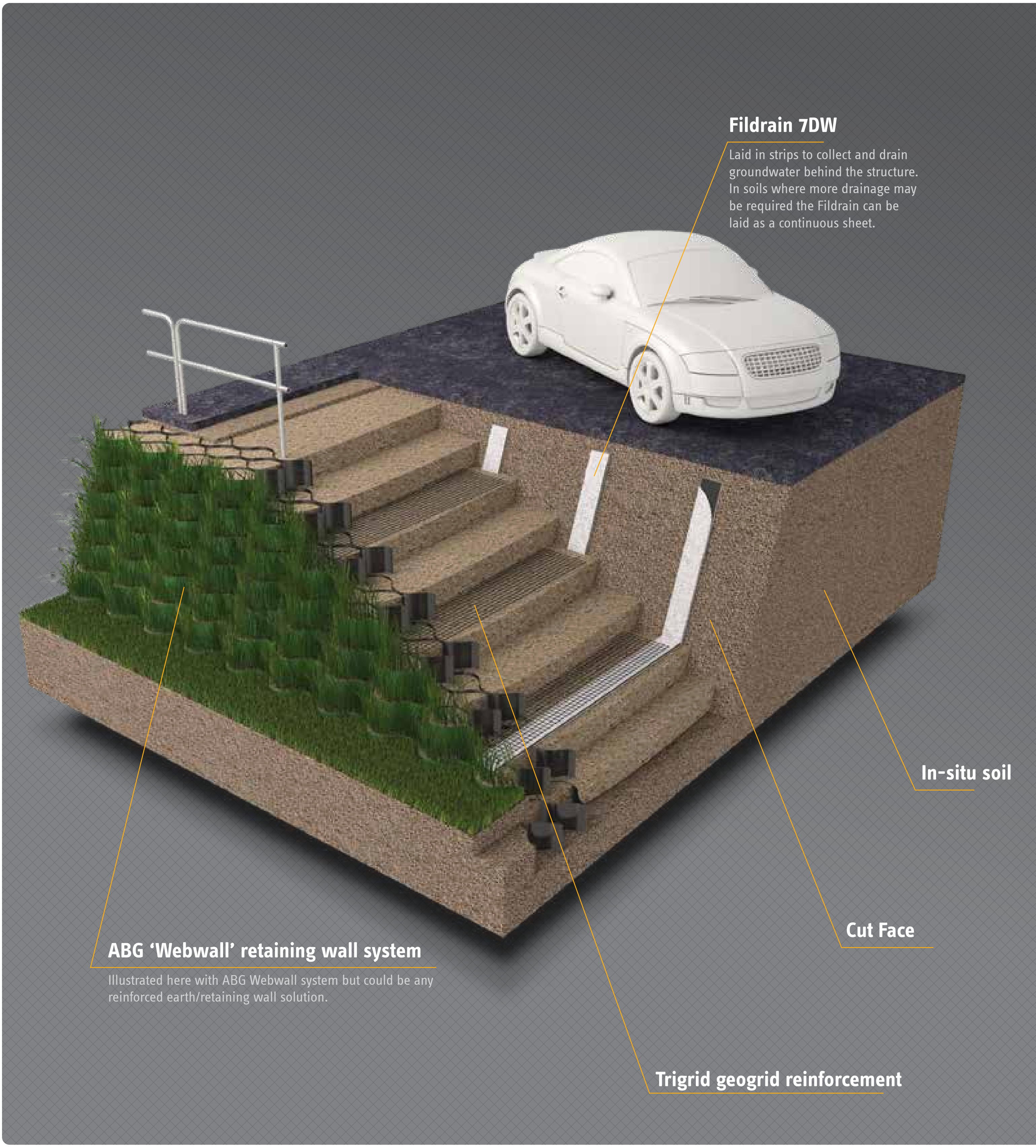
Consolidation Layers

Earthworks are usually on the critical path in the programming of the project works and soft soil embankments are no exception. The speed of construction of the embankment depends on the rate at which the pore water pressure can dissipate as the embankment height progresses. Fildrain is so effective at reducing pore pressures, that it significantly increases the range soils that can be considered as suitable fill. Fildrain has a central core that is impermeable to restrict vertical movement of water, which means that each layer of Fildrain acts as a roof to the fill below, preventing rainfall from slowing consolidation. Consequently the weather window for earthworks is extended. Using Fildrain instead of crushed stone utilises more fill, which is cost saving and has a positive impact on the earthworks balance.

Settlement

Control of settlement within specified limits is key. Fildrain has been accessed for 114 year loading conditions for full height embankment construction to ensure long term settlement is minimised.

Reinforced Soil Drainage



Reinforced soil is widely used as an economic solution for construction of steep slopes and walls. As with wall structures it is essential to provide a drainage layer at the rear to relieve water pressure.

New Walls

Reinforced soil is cost effective but unlike concrete retaining structures drainage must be placed against the cut face. This is incredibly difficult to do with layers of crushed stone. Fildrain, however, provides the required drainage and can be simply rolled into position up the cut face as construction of the reinforced soil progresses.

Slip Repairs

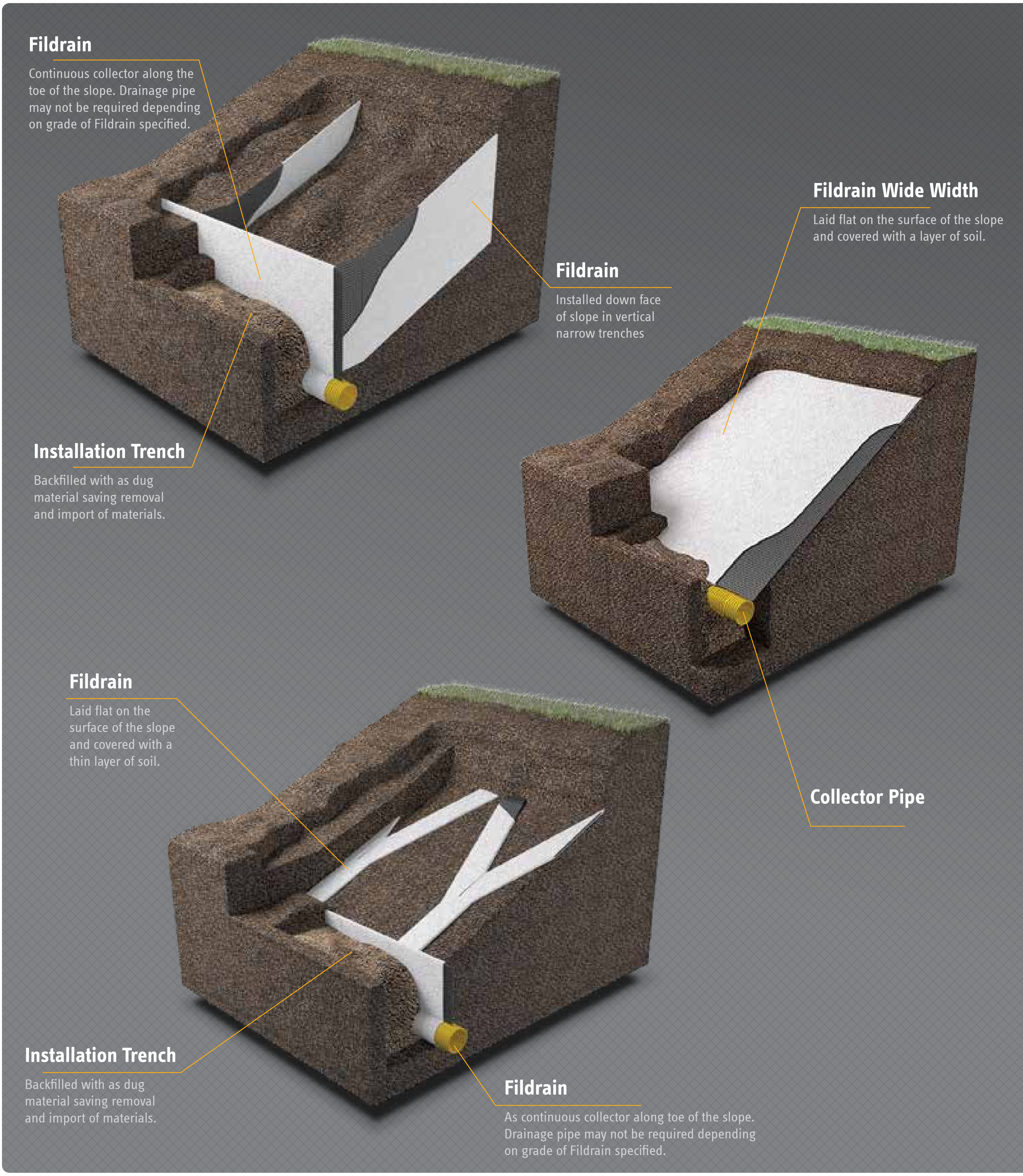
A rotational slip of a cutting is often repaired by excavation and replaced with reinforced soil. Typically, the slipped soil will be carted away and replaced with crushed stone. This is extremely wasteful, expensive and unnecessary. The slip will often have been mobilised by ground water making the soil wet and weak. By using Fildrain in the repair, the ground water will be intercepted and the existing soil made suitable for re-use.

Webwall

Webwall is an excellent facing to reinforced soil walls. Please see separate literature.

For ABG product datasheets, CAD details, design guidance and other technical information call +44 (0)1484 852096 or email enquiries@abgltd.com

Slope Drainage



Slope drainage is primarily required to collect seepage water emerging from permeable layers in soil slopes, or from open joints in rock slopes. It is there essentially to stop topsoil from slumping or being eroded by water from below.

When designing and constructing cuttings, the ground water level is reduced below the intended surface of the cutting slopes. Traditionally this is achieved with crushed stone counterfort drainage trenches. Installing any trench on a steep slope is not easy. Fildrain helps to make the process simple, in one of three ways

- Fildrain is installed upright in narrow trenches
- Fildrain is laid flat in strips before the topsoil layer is placed
- Fildrain is laid across the whole area before the topsoil is placed

In addition to new build, Fildrain is excellent for dealing with seepage that has appeared on existing cutting slopes.

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Associated Materials

Structural Drainage

ABG have vast experience in drainage solutions, used globally on major highway projects. Deckdrain is a geocomposite drainage system used to relieve external water pressure from behind retaining walls, bridge abutments, culverts and beneath block paved areas.

Erosion Control of Slopes

ABG has a complete range of products for erosion control of existing and newly formed steep slopes. Soil loss during heavy rain flow is a major concern for stability of the slope and the resulting silt pollution of local rivers. ABG will help select the appropriate solution, whether that is a light-weight or a heavy-duty biodegradable mat, a permanent erosion control mat or a geocell web which can provide veneer stability to the soil layers.

Cut and Cover Tunnels

Cut and cover tunnel design should anticipate drainage needs by managing the build up of hydrostatic pressure on the structure. ABG Deckdrain is a high-performance drainage geocomposite which provides an environmentally-friendly alternative to traditional structural drainage. ABG Deckdrain delivers factory-controlled high-flow capacity to the external faces of the tunnel. Quick and easy to install, the use of ABG Deckdrain eliminates the need for further protection of the waterproofing system.

Green Bridges

Green Bridges provide a haven for wildlife and create a safe passage to cross busy roads. ABG manufacture 'Roofdrain' which is a unique geocomposite system that provides attenuation and a water supply to sustain a strong root system for vegetation. Roofdrain also offers the additional benefit of providing protection to underlying bridge deck waterproofing. Roofdrain is available in differing sizes, is light-weight and easy to handle on site.

About ABG

ABG is a market leader in the design, development, manufacture and technical support of high performance geosynthetic systems for use in a wide range of civil engineering, environmental and building projects.

Formed in 1988, based in Meltham, in the heart of the Pennines, ABG have developed an excellent reputation for developing quality products and delivering outstanding service. The ability for rapid product development ensures that the most innovative, up to date and cost effective solution can be found for many engineering problems.

ABG's involvement in Earthworks drainage goes back over twenty five years and we now have a complete range of products developed specifically for use in this technically demanding application.

Technical support is provided by our trained and experienced staff, many of whom are Chartered Civil Engineers. This extensive support extends to full design, design validation, feasibility studies, cost advice and advice on meeting regulatory requirements.

Part of this technical support includes developing and driving knowledge within our active markets, including working with both international and local regulatory bodies on developing guidance and best practice in the use of innovative geosynthetics to solve complex engineering issues.

To discuss your project specific requirements contact:

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