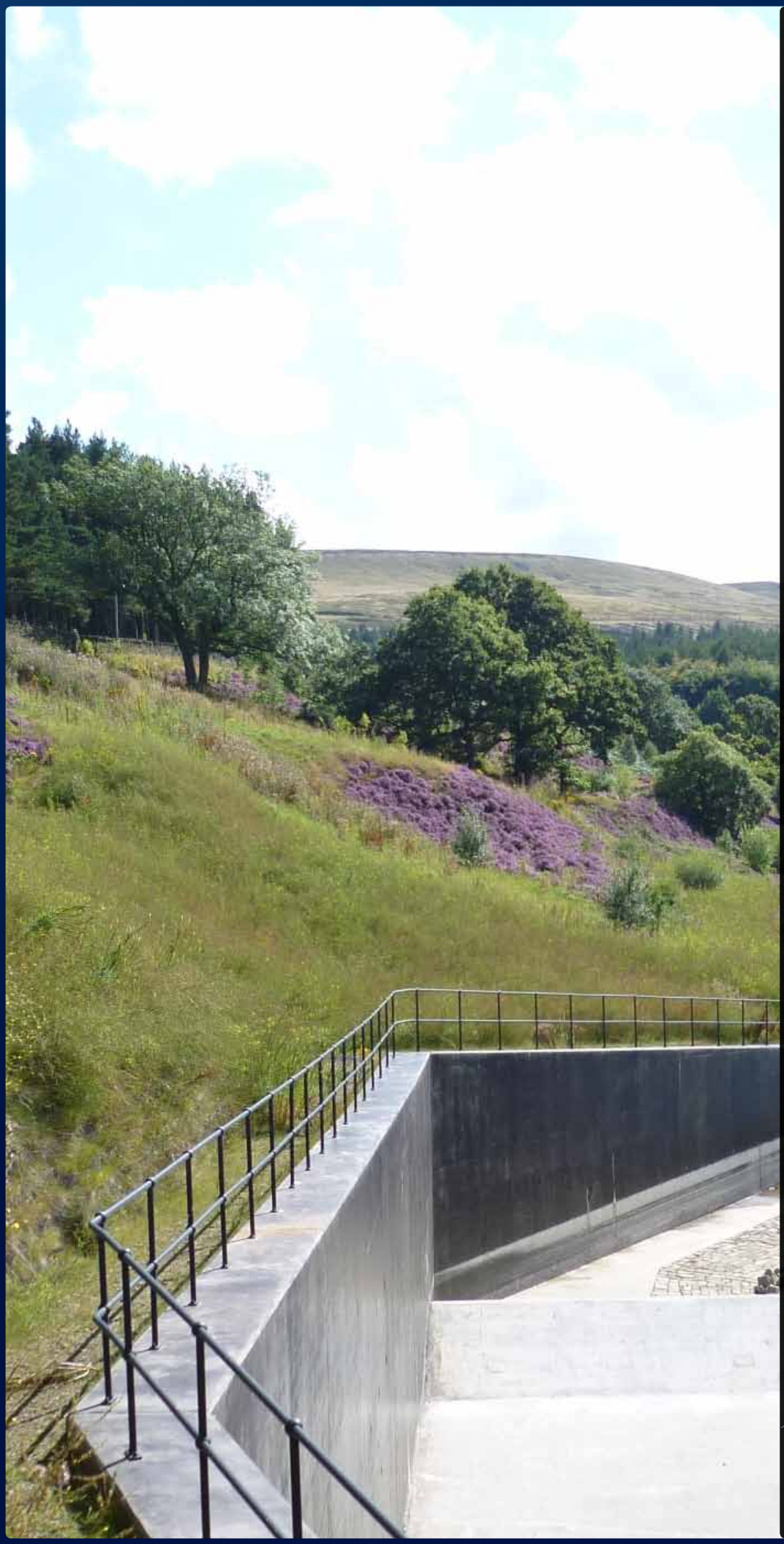

Retaining Walls

A guide to the selection and specification of ABG Webwall green retaining wall system

abg creative geosynthetic engineering

As the pressure on maximising the return from land use increases developments of all types are increasingly using retaining walls to maximise the usable space within the development site.

The construction of retaining walls is not new. The Romans used retaining walls in building their empire, many of the great European castles use retaining walls within their construction and the rice paddies in Asia have depended on retaining walls to build hillside terraces for thousands of years.

In new development sites the land can often vary from a gentle slope through to a much steeper hill. Retaining walls offer a reliable method of engineering the site to increase the usable space. There are many methods of constructing retaining walls from 'traditional' concrete and piling to crib walling, gabion baskets and soil nailing.

Increasingly 'green' vegetated wall systems are being utilised the most common of which employ cellular confinement systems. Construction of these walls offers many advantages over 'traditional' walls including reuse of on-site materials. This can help dramatically with achieving site waste management targets, the reduction of carbon emissions and reducing the costs associated with the project.

Vegetated retaining walls also offer other advantages such as an aesthetically pleasing finish that blends with the surrounding environment and the creation of green amenity areas within the development that may help attain valuable BREEAM and CEEQUAL points in instances where site ecology and biodiversity need to be maintained or increased.

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Retaining Walls

The construction of retaining walls is a core application for Webwall. They can be either unreinforced (for low heights) or reinforced using geogrids on taller structures (see following pages for more information).

They are constructed by laying successive Webwall panels each filled and compacted with site won materials until the required height is achieved. Use of local materials makes it an ideal solution for many sites where it offers a number of financial and environmental benefits.

Using Webwall allows the structure to be built quickly and easily in many cases using materials already available on site thereby minimising material movements on site.

Bunds

Webwall is ideal for the construction of reinforced bunds. Typical applications include secondary containment applications around tank farms and for noise barriers alongside highways, rail lines or airports.

Webwall is used to construct either one or both sides of the bund depending on the space availability and the required height and face angle. They can be constructed either as unreinforced or reinforced structures and using Webwall allows the structure to be built with steeper face angles and therefore smaller footprints than other methods allow. The face of the structure is easily planted with local species providing a vegetated face that helps the bund blend into the surrounding environment.

Facings

A progression from retaining walls is the use of Webwall as a facing system against a steep face that doesn't necessarily require any support, for example a cut rock face.

In this application the Webwall performs a much different function to that when used in retaining walls its primary purpose being to add an aesthetic vegetated face. Usually narrow (Type A) panels are used throughout the height of the structure. On higher or steeper structures Trigrid geogrid may also be specified but rather than adding reinforcement it is used to secure the panels to the face to prevent toppling.

As with other applications a vegetated finish not only offers a pleasing aesthetic quality but also protects the structure from damage.

Headwalls

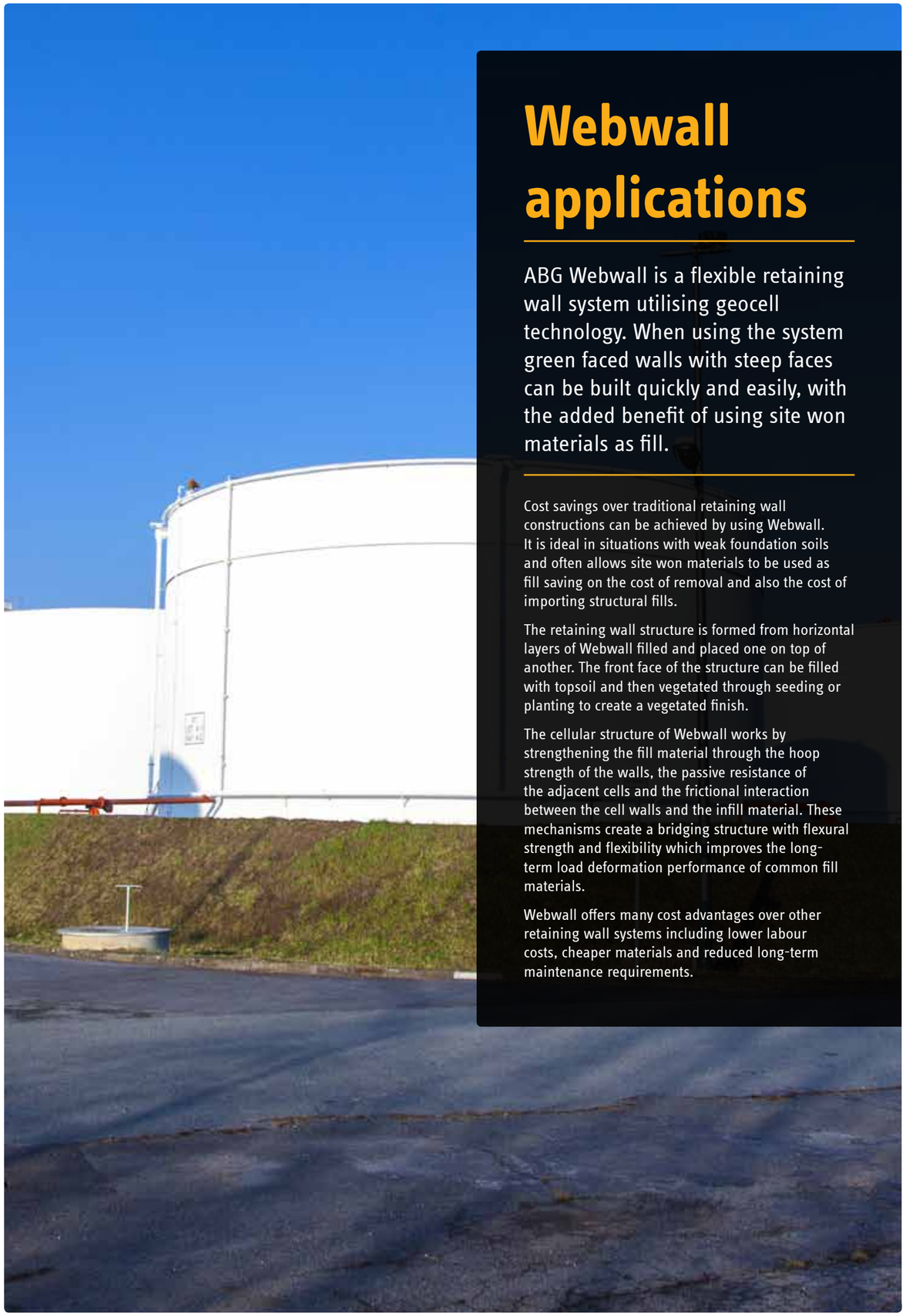
As the implementation of SuDS legislation comes into force there will be a greater requirement for providing water attenuation capability for developments. This may take the form of attenuation ponds capturing water from the site drainage which enters and leaves the pond via a pipe.

Many of these ponds are promoted as an amenity asset within the development, forming a green area that benefits the local community through the creation of habitats for native wildlife. Using Webwall to create the headwalls around the pipes allows them to be vegetated lessening the visual impact of the headwalls in the pond.

Attenuation Ponds, Channels and Swales

The use of Webwall in the construction of attenuation ponds, conveyance channels and swales allows the banks to be constructed with a much steeper face than normally achieved with conventional techniques.

This is particularly important when constructing swales on a site where space is at a premium, such as supermarket developments when maximising land use is very important. Using Webwall allows the construction of a green bank with the required capacity but requiring much lower land take, freeing space for further development within the constraints of the site boundary.



Webwall applications

ABG Webwall is a flexible retaining wall system utilising geocell technology. When using the system green faced walls with steep faces can be built quickly and easily, with the added benefit of using site won materials as fill.

Cost savings over traditional retaining wall constructions can be achieved by using Webwall. It is ideal in situations with weak foundation soils and often allows site won materials to be used as fill saving on the cost of removal and also the cost of importing structural fills.

The retaining wall structure is formed from horizontal layers of Webwall filled and placed one on top of another. The front face of the structure can be filled with topsoil and then vegetated through seeding or planting to create a vegetated finish.

The cellular structure of Webwall works by strengthening the fill material through the hoop strength of the walls, the passive resistance of the adjacent cells and the frictional interaction between the cell walls and the infill material. These mechanisms create a bridging structure with flexural strength and flexibility which improves the long-term load deformation performance of common fill materials.

Webwall offers many cost advantages over other retaining wall systems including lower labour costs, cheaper materials and reduced long-term maintenance requirements.

Webwall in unreinforced structures

Webwall can be used in the formation of retaining structures without the requirement for additional reinforcing geogrids or geotextiles. In this application the heights of the retaining walls tend to be relatively low but offer the benefit of not requiring extensive excavation back into a slope to accommodate the reinforcement.

Using Webwall, 'unreinforced' structures may be constructed up to a retained (visible) height of around 1.8m; the actual total height of the structure would be 2.25m allowing for a minimum embedment (foundation) of 0.45m. This may be reduced in a domestic garden setting where the application is often less demanding.

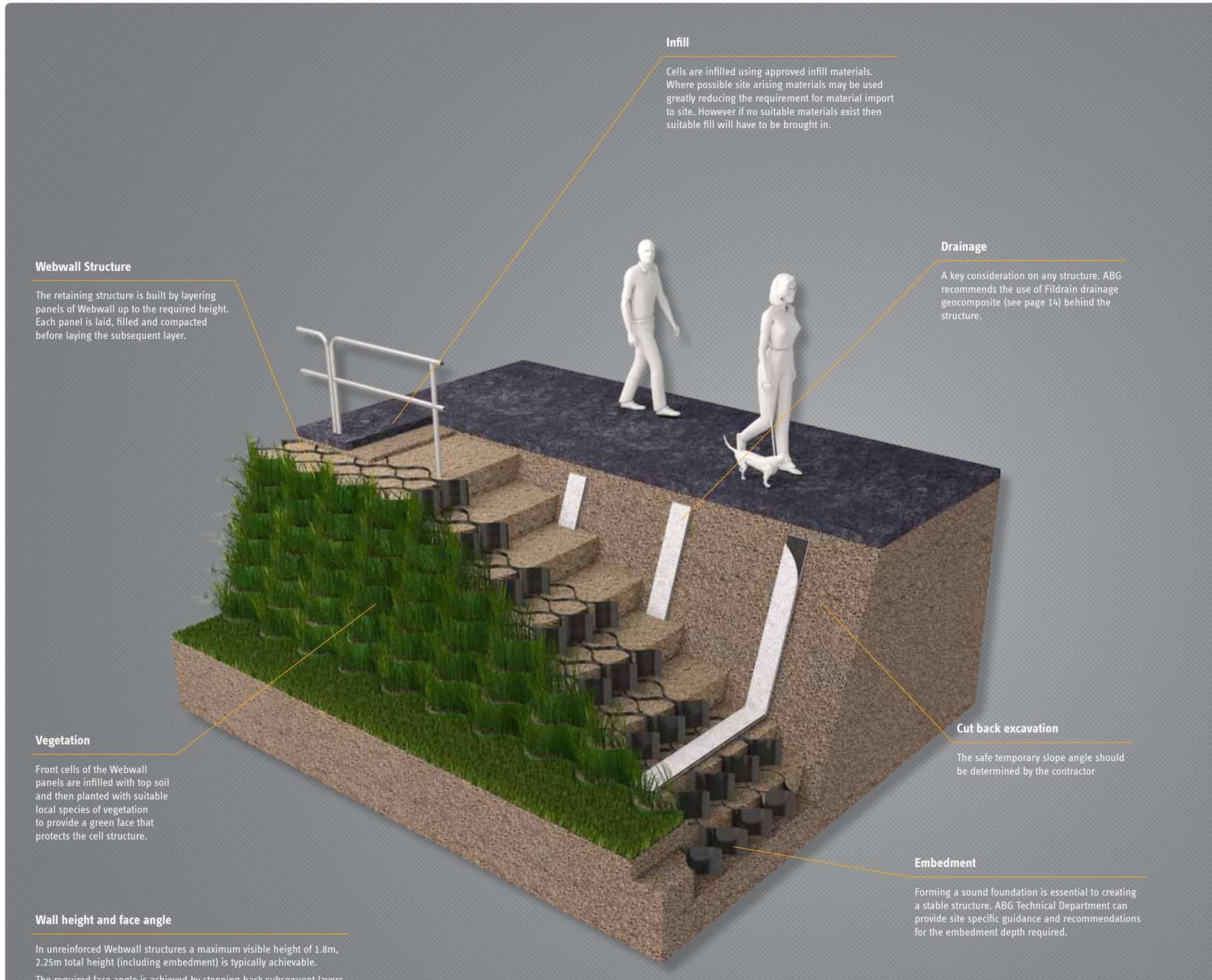
The depth of embedment is not fixed and may increase according to the requirements of the adopting authority or appropriate regulatory body, and whether service or drainage trenches may be dug in front of the wall.

The limiting height in a particular situation will depend on the nature of the underlying and retained ground, the slope of the ground both behind and in front of the wall and any surcharge load that the ground is required to carry. Please bear in mind that the clay soils common in southern and eastern England have often much lower internal friction angles than those from further north and west. The face angle of the wall also has an influence.

Typical construction details and panel layouts for Webwall in unreinforced structures of various heights can be seen on page 12-13 of this guide.

In situations where cutting into an existing slope is required, ABG recommends that a minimum 0.3m wide working strip be excavated behind the base panel, to allow for the installation of drainage or compaction of backfill.

As with all retaining or reinforced structures, consideration needs to be given to drainage of the structure. ABG Fildrain drainage geocomposite provides an ideal drainage solution when laid in strips behind the structure although other 'traditional' solutions may also provide the required drainage.



Webwall Structure

The retaining structure is built by layering panels of Webwall up to the required height. Each panel is laid, filled and compacted before laying the subsequent layer.

Infill

Cells are infilled using approved infill materials. Where possible site arising materials may be used greatly reducing the requirement for material import to site. However if no suitable materials exist then suitable fill will have to be brought in.

Drainage

A key consideration on any structure. ABG recommends the use of Fildrain drainage geocomposite (see page 14) behind the structure.

Vegetation

Front cells of the Webwall panels are infilled with top soil and then planted with suitable local species of vegetation to provide a green face that protects the cell structure.

Cut back excavation

The safe temporary slope angle should be determined by the contractor

Wall height and face angle

In unreinforced Webwall structures a maximum visible height of 1.8m, 2.25m total height (including embedment) is typically achievable.

The required face angle is achieved by stepping back subsequent layers of Webwall. A guide to the step required to achieve specific face angles is available. The overall face angle should not generally exceed 70° to the horizontal, in order to leave sufficient space for planting.

Embedment

Forming a sound foundation is essential to creating a stable structure. ABG Technical Department can provide site specific guidance and recommendations for the embedment depth required.

Webwall in reinforced structures

On taller structures or structures in poor ground conditions Webwall can be used with additional soil reinforcement techniques such as geogrids.

In these structures the Webwall acts as an effective facia system working in tandem with the geogrids and forming a flexible structure capable of withstanding the demands of the surrounding environment.

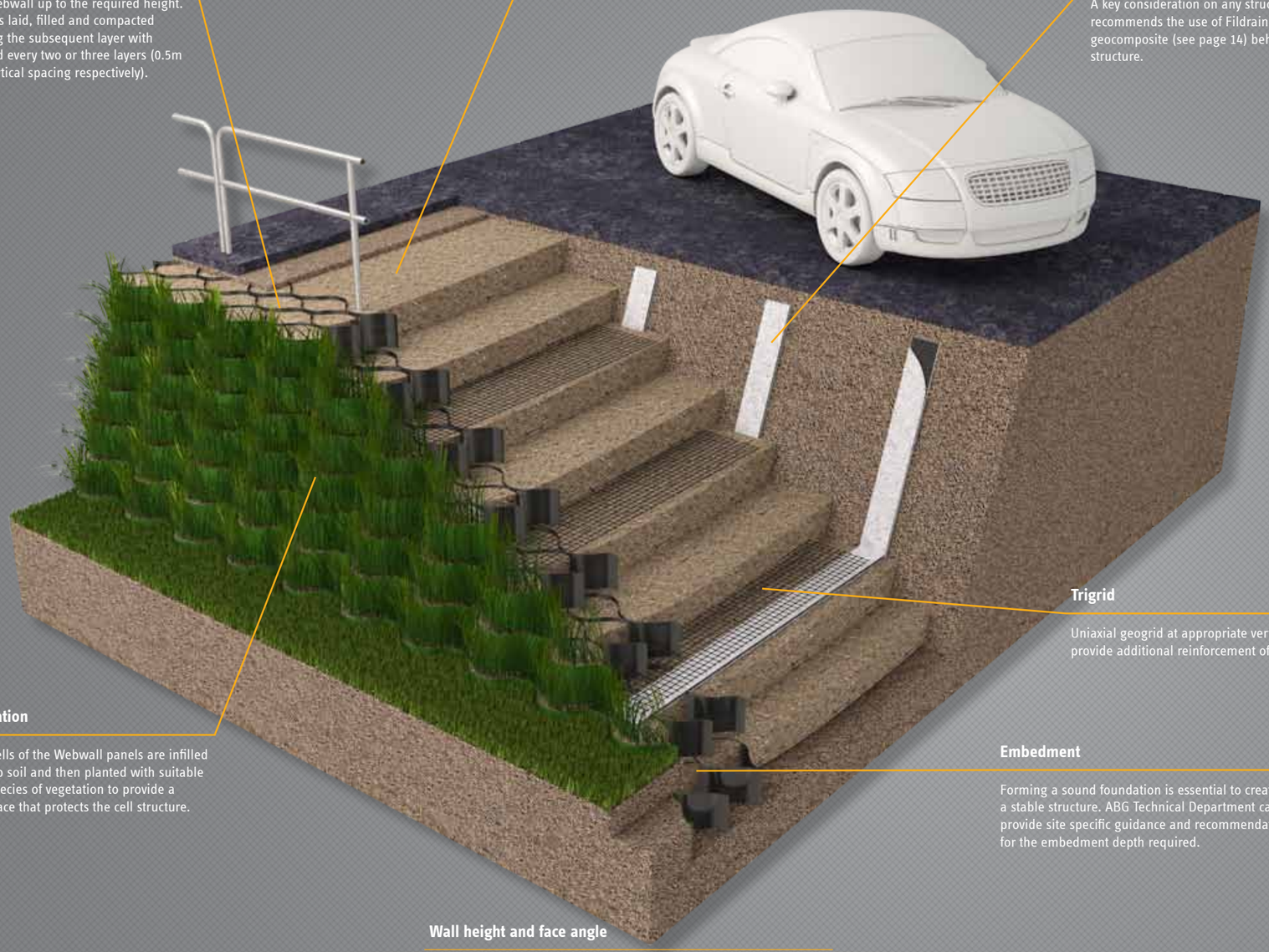
Reinforced Webwall constructions are used where the retained height exceeds that possible when using an unreinforced Webwall structure. Their maximum height may be limited only by the underlying ground conditions and the space available behind the wall being sufficient for the required length of reinforcement.

As an initial guide, the reinforcement length is likely to be between 0.7H and 1.0H (where H is the overall height of the wall). The minimum embedment is generally 0.45m, but requirements may vary as for unreinforced walls.

Reinforced Webwall structures are generally constructed of Type A panels throughout (see page 12-13). The spacing, length and strength of reinforcing grids depends on the ground conditions, backfill material, wall face angle, slope of ground and any surcharge loading. In general, grid strengths are chosen to suit vertical spacings of 500 mm or 750 mm, *i.e.* between every second or third panel of Webwall, each panel of Webwall having a rise of 250mm.

Reinforced Webwall structures are generally designed to use site arising materials or general 'acceptable' fill as backfill around the reinforcing elements, in order to minimise the need for haulage and consumption of high quality granular materials. However, the maximum particle or clod size must be limited to 75mm in order to avoid excessive damage to the reinforcement and to allow compaction with light plant.

As with all retaining or reinforced structures, consideration needs to be given to drainage of the structure. ABG Fildrain drainage geocomposite provides an ideal drainage solution when laid in strips behind the structure although other 'traditional' solutions may also provide the required drainage.



Webwall Structure

The retaining structure is built by layering panels of Webwall up to the required height. Each panel is laid, filled and compacted before laying the subsequent layer with geogrids laid every two or three layers (0.5m or 0.75m vertical spacing respectively).

Infill

Cells are infilled using approved infill materials. Where possible site arising materials may be used greatly reducing the requirement for material import to site. However if no suitable materials exist then suitable fill will have to be brought in.

Drainage

A key consideration on any structure. ABG recommends the use of Fildrain drainage geocomposite (see page 14) behind the structure.

Vegetation

Front cells of the Webwall panels are infilled with top soil and then planted with suitable local species of vegetation to provide a green face that protects the cell structure.

Trigrid

Uniaxial geogrid at appropriate vertical spacings provide additional reinforcement of structure.

Embedment

Forming a sound foundation is essential to creating a stable structure. ABG Technical Department can provide site specific guidance and recommendations for the embedment depth required.

Wall height and face angle

Reinforced Webwall structures are likely to be required where the visible height exceeds 1.8m, 2.25m total height (including embedment). This may vary according to site conditions.

The required face angle is achieved by stepping back subsequent layers of Webwall. A guide to the step required to achieve specific face angles is available.

The overall face angle should not generally exceed 70° to the horizontal, in order to leave sufficient space for planting.

Type of Structures

Webwall may be designed and constructed as an unreinforced wall, in which the Webwall panels and the material backfilling them form a wall that is sufficiently stable to fulfil its function and satisfy the relevant Code of Practice.

Alternatively, Webwall may be designed and constructed as a tied-back or reinforced wall, in effect a facing to a block of soil reinforced with geogrids.

Unreinforced walls are often referred to as a ‘gravity’ walls, however this is misleading since both types of wall rely on their weight for stability.

The choice of which type of wall is best for any specific application is largely dependent on the project specific conditions, however generally unreinforced walls are best suited to lower heights or less steep batters.

Drainage Requirements

Drainage is a major factor in designing a successful retaining wall. ABG recommends that a continuous drain be provided below or behind the bottom panel of a Webwall, so that the wall and its backfill material do not sustain groundwater pressures.

Where this is not possible, drainage paths must be provided through the wall by means of appropriately spaced strips of Fildrain. These strips are generally placed on top of the first layer of panels above finished ground level in front of the wall.

It is recommended that drainage be provided between the Webwall and the material it retains, up to its full height; again the use of strips of Fildrain of width and spacing appropriate to the local conditions is recommended. These must be connected to the basal drain, if present, or otherwise be continuous with the strips passing through the wall.

Face Angle

Retaining walls are more stable and structurally secure if they slope back into the retained slope. The variance from the vertical is called batter and how far the wall can be battered back should be considered at the outset. This is largely dependent upon the working space on site.

Webwall should be constructed with a face angle to the horizontal not exceeding 70°, corresponding to a 100mm set-back of successive panels; a greater set-back is preferable as successful planting is essential for the long-term protection of the wall face against UV light.

Please be aware that the set-back tends to reduce during backfilling and compaction of fill within the cells, so it is best to start with a generous set-back. A Webwall may not be the most cost-effective option for slopes flatter than approximately 45°.

Topsoil and Planting

Topsoil or pre-bagged growing media should be used to fill, or partially fill, the front cells of a Webwall and should be left relatively loose to promote plant root growth.

The soil should be placed in a friable condition, with sufficient compaction only to ensure that significant voids are not left. Where a vegetated surface is required over a Webwall, it is recommended that a minimum of 100mm depth of topsoil is placed over the filled cells. Planting pockets may be created by hand excavation within individual cells and backfilling with topsoil or growing media.

Foundation design

A retaining wall is only as good as the foundation on which it is built. The foundation of a Webwall must provide adequate bearing capacity and sliding resistance. In many cases the local soil, or a general fill material, will provide an adequate foundation for Webwall. A simple ground investigation by trial pits is usually acceptable.

In wet or weak ground, a layer of compacted granular fill or concrete blinding may be required. The foundation should be validated by the project engineer before commencement. It is worth noting that the foundation materials should extend below the depth susceptible to frost.

Selection of Fill Materials

Webwall constructions are generally designed to use site arising materials or general ‘acceptable’ fill as backfill behind the wall and around the reinforcing elements if used, in order to minimise the need for haulage and consumption of high quality granular materials.

Granular material (sand, sandy gravel or gravelly sand, including crushed rock, concrete or brick) is to be preferred as structural backfill. Friable clayey sand or clayey gravel (‘hoggin’), or sandy clay loam are also acceptable. Very soft clay should not be used. Soft or firm clay may be acceptable for small projects where placement and ramming are carried out by hand. If stiff or hard clay is the only material available, it must be broken up by rotavating, or by excavating in thin slices, to produce a gravel size aggregate. The maximum particle or clod size should not exceed 75mm for any backfill material.

Where mechanical compaction is employed, appropriate compaction plant is considered to be either a vibrating plate, typically 400mm to 500mm wide and weighing 100kg to 130kg, or a single drum vibratory roller 500mm to 700mm wide and weighing 150kg to 450kg (all weights and dimensions stated are approximate). For smaller projects and for cells along the front edge, a hand rammer or timber post may be used and the cells may be filled in two or more layers.

A high degree of compaction of all types of fill cannot be expected, since heavy plant would be required for a single 250mm thick layer of soil to be fully compacted. The basic objective of compaction is to ensure that the Webwall units are adequately filled without leaving large voids, while not causing damage to, or distortion of, the cell walls. At the same time, a high degree of compaction is undesirable in those parts of Webwall in which it is intended to establish vegetation.

Anchors

Many retaining walls require some form of anchoring. With Webwall, steep faced or tall structures are usually designed using geogrid reinforcement laid into the soils behind to provide the necessary anchorage. Other systems can be used, for instance soil nailing could be considered if there is insufficient space behind the structure for geogrids.

Setting Out

Determining the on-site placement at the start of construction is an essential consideration. Planning ahead will help avoid the expense and time it takes to relocate a wall or to modify retained areas once installation is complete. Setting out must include line, level and face batter.

Design Considerations

The design of any retaining wall requires consideration of seven key factors: the type of structure, drainage requirements, face angle, foundation design, materials selection, site position and how the structure will be anchored.

Webwall design is affected by all these factors plus issues such as the angle of friction and cohesion of the retained soil, the bearing capacity of the foundation, the slope of the finished surface behind and above the wall, whether and how much surcharge is present and the presence or absence of groundwater.

When designing Webwall as a reinforced wall, the strength and spacing of the reinforcing grids and the properties of the soil used in the reinforced block are major considerations.

With so many variables, it is only possible to produce a limited range of ‘standard’ wall designs, especially for reinforced walls. ABG Technical Department will be pleased to advise and to produce site-specific designs.

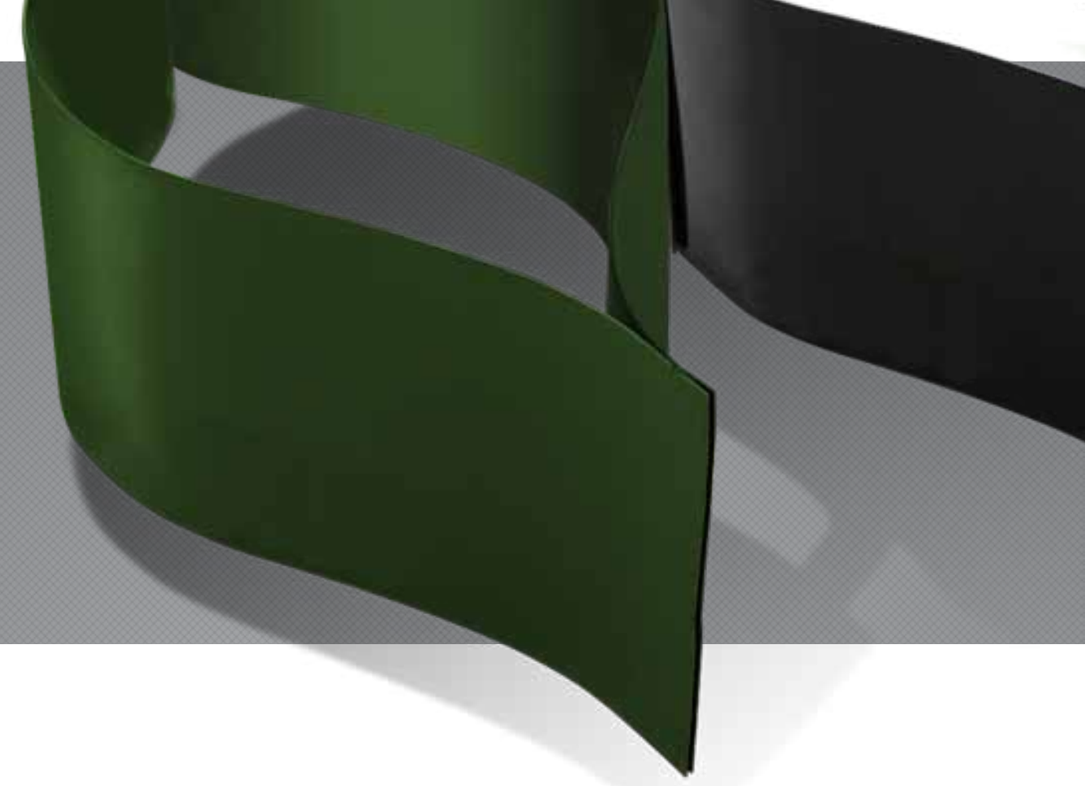
Webwall Technical Information

W ABG webwall is a flexible retaining wall system that utilises geocell technology. Using Webwall green faced walls with near vertical faces can be built quickly and easily with the added benefit of using site won materials as fill.

Cost savings over traditional retaining wall constructions along with a green vegetated finish can be achieved by using the Webwall system. It is ideal in situations with weak foundation soils and often allows site won materials to used as fill thereby saving on the cost of removal and also the cost of importing structural fills.

The retaining wall structure is formed from horizontal layers of Webwall filled and placed one on top of another. The front face of the structure can be filled with top soil and then vegetated through seeding or planting to create a vegetated finish.

It offers many cost advantages over other retaining wall systems including lower labour costs, cheaper materials and reduced maintenance.



Typical Panel Layout/Wall Height for Unreinforced Structures

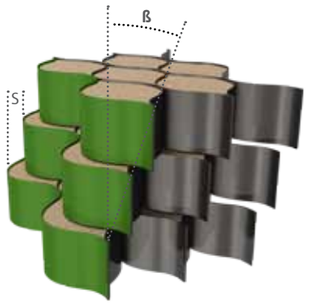
Note: Lesser or greater heights may be achievable depending on ground conditions, loading and geometry

				Webwall Layer	Wall Height (m)
			A	9	2.25
			A	8	2.00
			A	7	1.75
		A	B	6	1.50
		A	B	5	1.25
	A	A	B	4	1.00
	A	B	C	3	0.75
A	A	B	C	2	0.50
Base Panel	A	B	B	C	1	0.25

Diagram is illustrative and does not represent a design for a wall. It shows a typical construction build up of an unreinforced Webwall construction up to a height of 2.25m including embedment. Walls above this height are likely to require additional reinforcement. Advice should be sought from ABG Technical department prior to using Webwall.

For walls of lower height, panels are removed from the bottom of the table. i.e. a wall with a total height of 1m (including required embedment would consist of layers 6, 7, 8 and 9 with layer 6 being the base layer.

Face Angle information - Reinforced and Unreinforced Structures



Step (S) mm	Face Angle (ß)
95	70°
100	68°
150	59°
200	51°
250	45°
300	40°

Webwall Performance Specification

Panel Height	**mm**	250
Material	-	HDPE
Wall Thickness	mm	1.2
Colour	-	Standard Black with dark green facing strip (other colours available on request)
Effective Cell Diameter	mm	500
Cell Area	m^2	0.2
Oxidation Resistance HP-OIT (face)	mins	1,500
Material Tensile Strength	kN/m	24
Seam Tensile Strength	kN	3.5
UV Stability	-	Excellent
Life Expectancy (with plant cover)	years	120
Max Slope Angle (Vegetated Face)	°	70

Please contact ABG Technical Department on 01484 852096 or by email at geotec@abgltd.com to discuss your specific requirements. Data shown is indicative only, full datasheet containing latest test data, methods and tolerances is available on request.

Webwall Standard Panels

Panel Type		**Type A**	**Type B**	**Type C**
Panel Height	mm	250	250	250
Panel Depth	m	1.0	1.5	2.0
Panel Length	m	4.0	4.0	4.0
Number of cells across width	N°	2	3	4

Data shown is for standard panels, other bespoke panels may be required for your specific installation. Please speak with ABG Technical Department for further details

Further information about **Webwall** is available on the ABG website at **www.abgltd.com/products/webwall**

Drainage System

Fildrain drainage geocomposites offer a high performance economic alternative to traditional stone groundwater drainage solutions and have a proven track record in a wide range of civil engineering drainage applications.

The unique open structure created by the dimpled construction allows unhindered water flow through the core. This gives Fildrain a very high flow capacity, many times that of traditional crushed stone of the same thickness.

Fildrain is ideal for providing the drainage function within Webwall structures, it is much easier to install behind the structure than other drainage techniques and eliminates the requirement for aggregates, reducing the environmental impact of the project.

Fildrain installed as drainage strips behind Webwall installation

Geogrids and Geotextiles

ABG have a complete range of geogrids and geotextiles for use in civil engineering applications. Geogrids and geotextiles are primarily used for the reinforcement, separation and filtration of materials.

In reinforced Webwall structures, selecting the right geogrid is a major factor in delivering a successful project. ABG have both uniaxial and biaxial geogrids with a wide range of tensile strengths. This means the most appropriate, cost effective solution can be designed into the scheme from the outset.

Many Webwall projects utilise geotextiles within the structure too and again ABG offer a wide range of both woven and non-woven geotextiles meeting a wide range of performance criteria.

Abweb beneath crushed hardcore in plant yard

Erosion Control Mats

Erosion control products are essential in protecting soils placed on slopes from erosion through water and wind action in the period whilst the vegetation root structure is established.

ABG Erosamat erosion control products cover a broad range of erosion control requirements (including biodegradable or non-biodegradable and pre-seeded varieties) and can help with the surface protection of earth and reinforced soil slopes both during the construction phase and once the project is complete.

As with all ABG products, design advice on which materials are best for your specific requirement and their specification is available without obligation from the experienced in-house technical department.

Erosamat Type 1 installed on upper slope of Webwall installation

SuDSPave

A system of components that allows the construction of a holistic permeable pavement system that allows the collection, treatment, management and distribution of surface water.

The SuDSpave system is configurable to individual project requirements and consists a range of surface solutions to meet the aesthetic and performance requirements. A range of geogrids and geocells allow pavements to be constructed thinner and using less stone but still meet the structural requirements whilst high performance geotextiles help treat collected water to meet quality expectations. Finally geocomposites allow the formation of a free storage void across the area of the car park to attenuate collected water during storm events.

SuDSPave 440 infilled with gravel to form porous pavement

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 retaining wall construction and maintenance goes back over twenty five years and we 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.

Installation services are offered through Geogreen Solutions; a specialist in-house service providing installation on a wide range of ABG systems by highly trained and experienced operatives.

For further information or to discuss your project specific requirements contact ABG:

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