Roads & Highways

TERRAM
Geosynthetics you can trust

Geosynthetics in highways and related applications

Geosynthetics have been used in civil engineering since the 1970's. One of the earliest applications was in the construction of highways where simple geotextile filters were placed between the sub-base and the subgrade to maintain the integrity of the stone layer.

The ability of a geotextile filter to allow the passage of water yet still prevent intermixing of stone and soil has meant these filter/separators are being used every day around the globe. At one end of the scale it could be a remote unpaved haul road or, at the other, a major highway connecting international business centres.

The uses and products have expanded over the years as technologists and engineers have innovated and exploited the unique properties of the products that have been developed and refined.

Geosynthetics are now being used to control erosion on cut slopes as a result of road widening schemes, for roadside drainage, as part of SUDS projects for infrastructure access and housing/ retail/commercial developments, and in the construction of retaining walls, bridge abutments and steep slopes.

TERRAM 1000 has been the most-frequently-specified geotextile in the UK for over 40 years.

Fiberweb and TERRAM™ products.

Fiberweb is the UK's largest manufacturer of geotextiles. Its product portfolio includes the original, trusted and proven TERRAM geotextiles, geocells and geocomposites together with the geonets and pavers manufactured by Boddingtons Ltd (acquired 2011). The UK manufacturing capability has been expanded and centralised at Maldon in Essex.

Fiberweb provides a unique range of value-engineered solutions for the construction of highways, railways, landfills, pipelines, coastal/ waterways defences and in landscape engineering. With unrivalled expertise and experience in geosynthetics, accumulated over a 40 year period since the first TERRAM products were launched, the Company remains committed to the development of innovative and cost-effective geosynthetic solutions.

The Company intends to lead the market in the design and manufacture of geosynthetics, and continue to provide ground-breaking solutions - the next generation of TERRAM products.

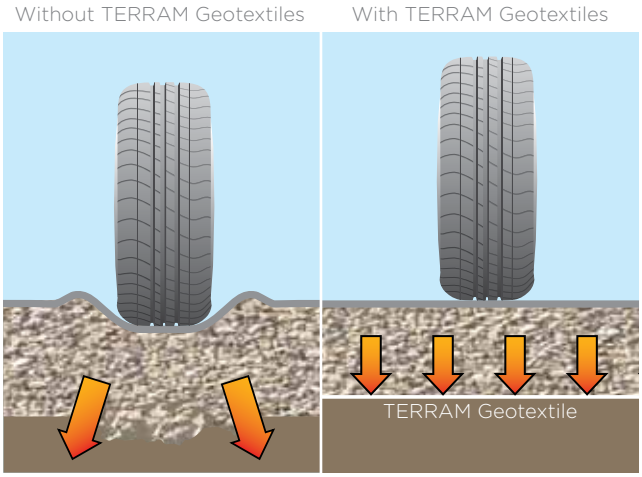
Improving granular layer performance

TERRAM Standard Geotextiles prevent intermixing of sub-base and subgrade layers. This intermixing causes a loss in bearing strength, as the stone layer becomes progressively contaminated, resulting in failure in the form of deformation. This can be remedied if it's an unpaved area/road by filling the ruts but even this can be uneconomic or unacceptable if stone has to be imported over long distances at a later date.

If it's a paved road then the intermixing could manifest itself as deformation at the pavement surface e.g. cracking and/or rutting, by which time the damage at the sub-base/subgrade interface cannot be repaired without re-construction and any repairs are cosmetic rather than structural. It is therefore better to pre-empt the problem by including a suitable geotextile.

Site-damage resistance

The geotextile must first be capable of withstanding the rigours of installation as this is when the textile is most susceptible to damage. If it is not sufficiently robust, and is capable of tearing or being punctured, then the product may be incapable of performing its design function. For example, the filaments of many low-cost, woven textiles can be easily teased apart, even during physical examination. They have little integrity and it is easy to imagine how they will perform when angular stone is placed on them and compacted. A textile filter/separator must have an apparent pore size which remains unaffected by loading. Any openings which are created or widened, or are caused by tearing/puncture, will allow subgrade particles to be pumped through to the sub-base.



Intermixing of the sub-base and subgrade prevents the full load-bearing capacity of the stone layer being mobilised and leads to failure. A suitable geotextile acts as a filter separator throughout the highway's life and acts to preserve the stone layer's integrity.

Radial load requires isotropic properties

The loading from a wheel at the sub-base/ subgrade interface is radial and this means that the geotextile should have isotropic strength to deal with it. It is not sufficient for the textile to have high strength in one or two directions as with woven geotextiles.

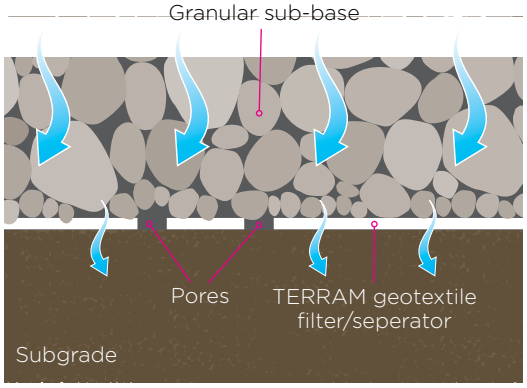
Sustained filtration

The geotextile must provide sustained filtration whilst also separating the two layers i.e. the textile must allow the free passage of ground water yet limit the passage of soil particles. This involves matching the pore size with the sub-grade's smallest particle size. This does not mean that the geotextile should have a pore size smaller than the smallest soil particle. It has been established that a geotextile helps create filtration by virtue of a natural filter that is formed against the surface of the textile.

The ultimate objective is to maintain the integrity of the granular layer and thus gain the maximum life from the structure. This can be achieved by allowing its maximum bearing strength to be mobilised throughout the road's width and depth, and throughout its life.

Typical paved and unpaved applications where geotextiles are used beneath granular layers include:

- Highways
- Car parks
- Hardstandings
- Access and haul roads
- Cycle ways and footpaths



A natural filter is established adjacent to the geotextile's pores.

TERRAM Standard Geotextiles **see page 19**

Geotextile selection

The thickness of a sub-base and/or capping layer should be determined using appropriate national design criteria. Other more simplified procedures may be adopted if these do not exist or are inappropriate.

For example, the nomogram shown is for the design of unpaved roads and may be used to check initial layer thicknesses for a paved road, see Fig. 1.

Where information is scarce, the following may prove useful for the selection and installation of the most appropriate TERRAM grade. These guidelines should not be used to replace more rigorous design and the experience of contractors familiar with the installation of geotextiles.

Subgrade strength and moisture content

The selection of the most appropriate TERRAM grade is largely dependent on the strength and moisture content of the subgrade. Site investigation should be used to assess these parameters. Fig. 2 may be used for guidance in the absence of field data.

Grade selection

The TERRAM grade must be sufficiently robust to resist installation damage. The lower the subgrade strength and the larger the stone, the more robust the grade needs to be.

Installation

The area should be cleared of any large objects, such as stones and tree stumps, before geotextile placement. Ruts and sharp undulations in excess of 100mm should be filled and levelled. Strong perennial weeds, such as thistles, should be treated with weed killer. Other vegetation can be left undisturbed, if this is allowable and not detrimental to the structure. The presence of surface vegetation can actually aid construction with very soft soils i.e. CBR <l% and un-drained shear strengths <10kN/m^2.

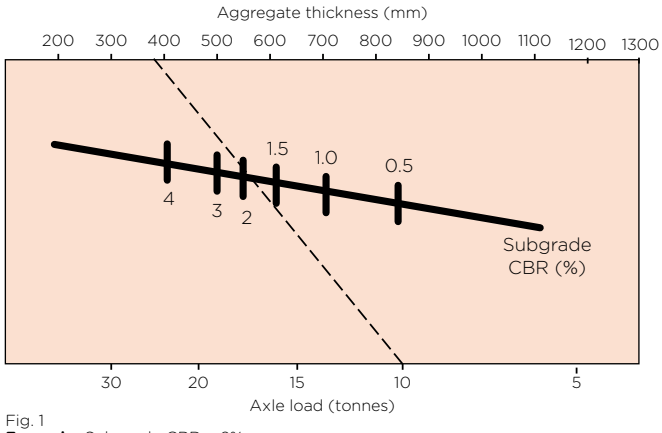


Fig. 1
Example: Subgrade CBR = 2%,
Axle load = 10 tonnes,
Stone thickness required = 350mm

Soil type	Plastic index %	CBR% Depth of water table below formation level >600mm	<600mm
Heavy clay	70	2	1
	60	2	1.5
	50	2.5	2
	40	3	2
Silty clay	30	5	3
Sandy clay	20	6	4
	10	7	5
Silt		2	1
Sand (poorly-graded)	non-plastic	20	10
Sand (well-graded)	non-plastic	40	15
Sandy gravel (well-graded)	non-plastic	60	20

Fig. 2 Some approximate CBR values for soils at their natural moisture content

TERRAM geotextiles can be unrolled directly onto a subgrade with adjacent and subsequent rolls overlapped between 300mm and 1000mm - the softer the subgrade, the greater the overlap. A combination of overlapping and sewing may be more economical where the subgrade strength is particularly low, or in other critical situations (see the 'Jointing methods for TERRAM Geotextiles' pdf document downloadable at www.terram.com).

Vehicles and plant must not run directly on exposed textile. Construction traffic should be restricted to areas of textile which have been covered with sub-base and preferably compacted to the minimum required depth.

Sub-base selection and placement

The sub-base must be well-graded, compactable and for permanent works, capable of transporting rising water and resistant to long-term degradation. Recommended grading bands for compactable granular materials are shown in Fig. 3.

The sub-base thickness will depend on loading and on the strength of the subgrade. The thickness should take into account the maximum anticipated axle load, both during construction and in service, and should be increased by 10-20% on bends or where a slightly inferior sub-base is used.

Sub-base should be bladed forward over the textile and graded down to the required un-compacted depth. Typical practice with a firm subgrade is to place the sub-base in layers which are compacted to 150mm using a vibro-roller.

With a soft subgrade it is prudent to place at least 300mm of lightly-compacted sub-base in one lift (500mm on an exceptionally soft subgrade) before overlaying this with a thinner layer of better-compacted material.

A very low-CBR subgrade, heavier traffic loadings, or a poorly-graded sub-base may require differing techniques. For example, heavy compaction with a very soft clay subgrade can lead to rutting and heave, and it may be necessary to increase the initial layer thickness and allow time for consolidation of the subgrade before the placement of thinner layers and applying more intense compaction.

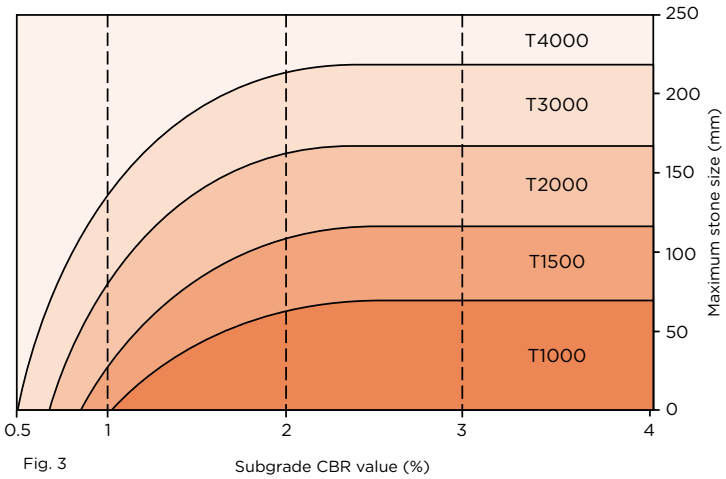


Fig. 3

TERRAM Standard Geotextiles **see page 19**

Drainage

TERRAM Geocomposite Drains are manufactured by bonding a compression-resistant net core between two geotextile filters or between a geotextile and a geomembrane. The grade of net dictates the composite's flow capacity.

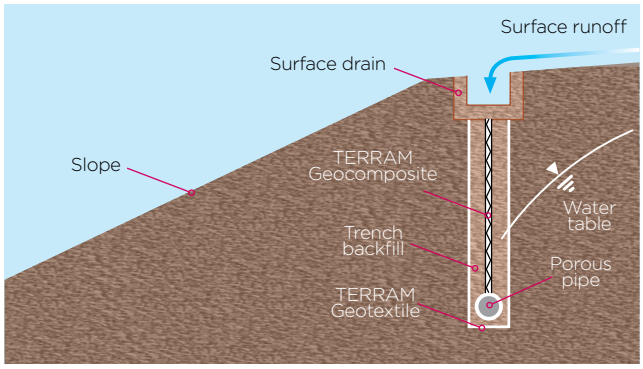
The filter/net/filter composites are used for general area drainage and are easy-to-install, factory-assured replacements for tradition stone installations.
The filter/net/membrane composites are used to drain from one side only and provide a barrier to the other – a cut-off drain. Both types can be deployed vertically or horizontally.

TERRAM Geocomposite Drains are preferred to stone as they are less expensive, and much easier to install; particularly against vertical faces such a bridge abutment. They are also lighter and more compact which means lower transportation costs and minimum traffic disruption.

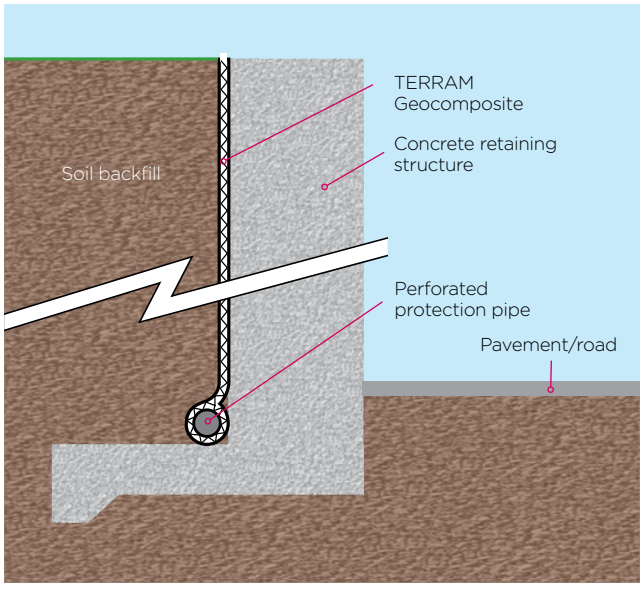
TERRAM Geocomposite Drains have factory-assured properties so there's no issue of stone grading and consistency. As most stone drains rely on a geotextile to prevent the ingress of fines, it's simpler to replace the stone with a drainage core such as a net.

Typical drainage applications include:

- Alongside roads.
- Within slopes.
- Around culverts, basements, reservoirs and other buried structures.
- At the rear of retaining walls and abutments.
- In the construction of tunnels.



Slopes and embankments. The drainage function is a critical element in the design of soil slopes and in slip repairs.



Retaining Structures. To maintain the stability of a retaining structure it is important to provide an efficient drainage system at the rear of a retaining structure to prevent the build up of pore pressure.

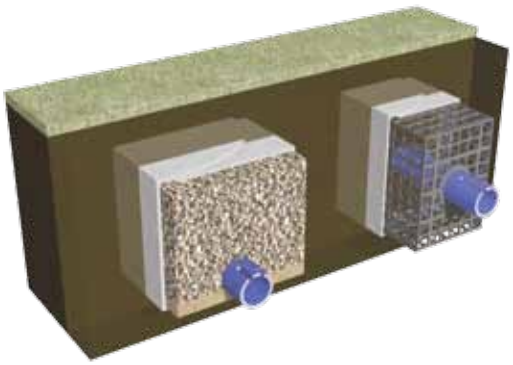
Sustainable Urban Drainage Systems (SUDS)

Paved areas and roof gardens require a light and versatile drainage system capable of a high in-plane flow. TERRAM Geocomposite Drains offer high flow rates, high compressive strength and good resistance to creep. Their use reduces manpower and minimizes the need for heavy materials making them ideal solutions for these applications.

Traditional drainage applications

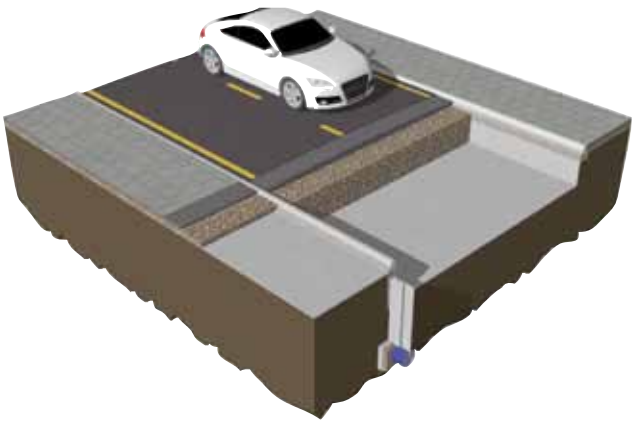
TERRAM Standard Geotextiles and TERRAM Geocomposite Drains are used in traditional drainage methods including Fin, Lateral, French and SuDS drains.

Standard Geotextiles used in a French Drain application.



Standard Geotextile used in a SuDS box drainage system.

Quick, easy to handle, efficient and cost effective drainage systems are necessary in areas of construction such as basements, culverts, car parks, reservoirs and many other structural and subsurface applications.



Vertical edge drains running parallel to a roadway are necessary to intercept the lateral flow of groundwater. A geocomposite fin drain saves on excavation and is quicker to install than a stone alternative.

TERRAM Standard Geotextiles
see page 19

TERRAM Geocomposite Drains
see page 20

Preventing frost heave

Frost heave is perhaps the most common cause of failure for pavements in cold climates.

Preventing frost heave beneath highways

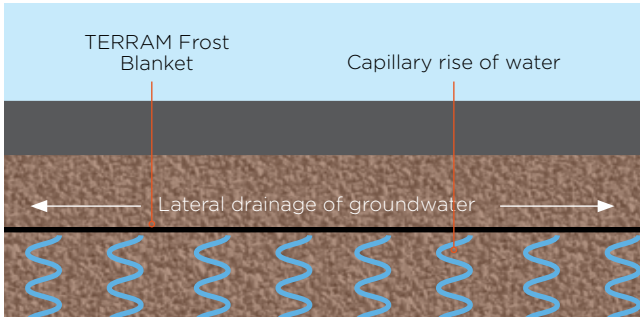
Frost-susceptible soils typically have a significant silt/fine sand content which allows the capillary rise of water. This water can turn to ice lenses in winter and further water is drawn up from the water table to balance the capillary forces. This cycle ultimately leads to heave at the surface which causes pavement cracking and uplifting.

This is further complicated as the upper ice thaws in winter. The volume of water held as ice is many times greater than water held by the soil under saturated conditions. The water cannot drain down through the soil as it is still frozen. The result is a further weakening of the highway as the subgrade's ground-bearing capacity is diminished.

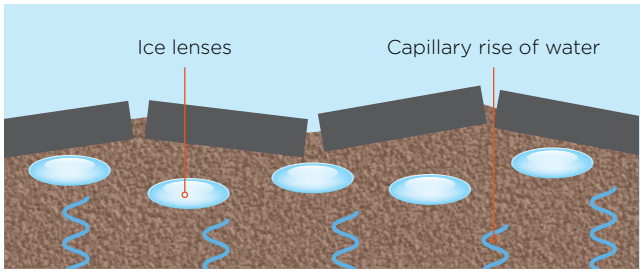
TERRAM Frost Blanket is a net-based geocomposite which provides the capillary break that the soil lacks and thus prevents the upward movement of water. Its installed cost is insignificant when compared with annual maintenance costs associated with such highway pavements.

Independent testing and field trials have confirmed the ability of TERRAM Frost Blanket to prevent the upward passage of water by capillary action.

- Babtie Engineering Laboratories, Geotextile materials to suppress frost heave in soils. TERRAM 230gm geotextile with hydrophobic enhancement, 07/05/02.
- US Army Corps of Engineers, Laboratory Investigation of the Use of Geotextiles to Mitigate Frost Heave, CRREL Report 90-6, August 1990.



TERRAM Frost Blanket prevents the capillary rise of groundwater and avoids the potential for damage during the freeze/thaw cycle.



Damage during the freeze/thaw cycle.

TERRAM Frost Blanket **see page 21**

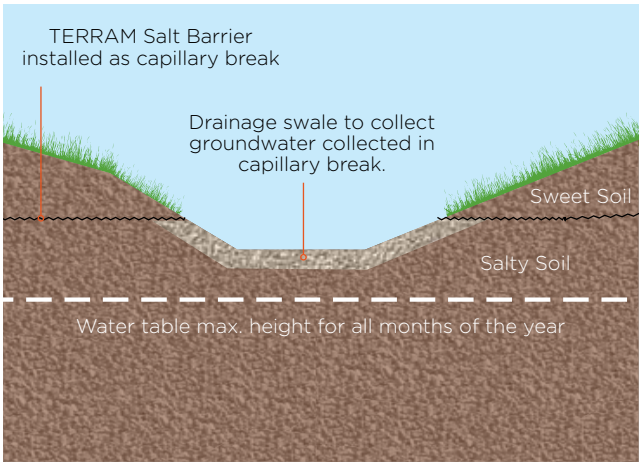
Preventing the capillary rise of salt water

TERRAM Salt Barrier has been specially developed to replace the granular layer and reduce environmental impact.

Preventing the capillary rise of salt water

TERRAM Salt Barrier is similarly effective in preventing the capillary rise of salt water that would otherwise contaminate sweet soil layers capable of sustaining vegetation.

This geocomposite can be used instead of the traditional 300mm thick stone layer which would have been used in the past. A much more environmental-friendly alternative, particular if stone is not locally available.



TERRAM Salt Barrier is designed to prevent the capillary rise of salt water into sweet soils.

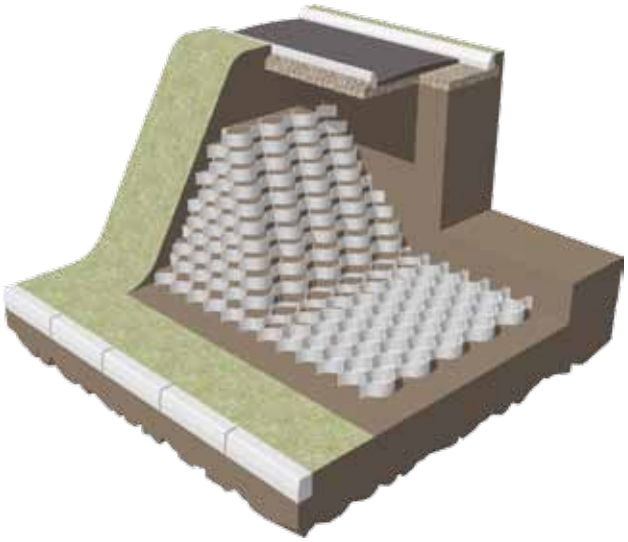
TERRAM Salt Barrier **see page 22**

Earth Reinforcement

TERRAM Geocell provides a cost-effective alternative to conventional earth retention structures due to its flexibility and suitability for use with a wide range of infill materials and foundation soils.

The system eliminates the potential for cracking, spalling, splintering or corrosion that can affect concrete, steel and timber based systems.

It can be installed almost vertically to form an effective, economical earth retention structure. TERRAM Geocell is used in horizontal layers to form a wall structure. This can either be the panels themselves to form a gravity structure or as a facing system in a composite wall working in conjunction with an earth reinforcement system to form a mechanically stabilised earth structure. TERRAM Geocell can be used with a variety of reinforcement techniques such as geotextile or geogrid earth reinforcement, soil nails, rock bolts, helical anchors etc.



Typically installations will utilise a composite wall construction creating a totally confined wall facing that is directly connected to the backfill using one of the earth reinforcement systems outlined above. Where construction restrictions do not allow this methodology, a gravity wall construction may be considered.

In this construction the TERRAM Geocell is built as a layered wall capable of resisting the internal loads and pressures to maintain structural integrity. Utilising the TERRAM Geocell in this application creates horizontal terracing on the facia of the wall. In some circumstances these can be utilised to create a vegetated cover for the facia.

As with slope protection, the individual cells maximise water collection and minimise run-off, by allowing precipitation to infiltrate the exposed surface; creating a suitable environment for vegetation growth.

When used in these applications, TERRAM Geocell offers a solution that fulfils a broad range of design requirements and construction conditions. The unique nature of TERRAM Geocell structures offer flexibility and allow for infilling with a wide range of materials including site infill soils (if suitable), top soils, sand, aggregates and concrete.

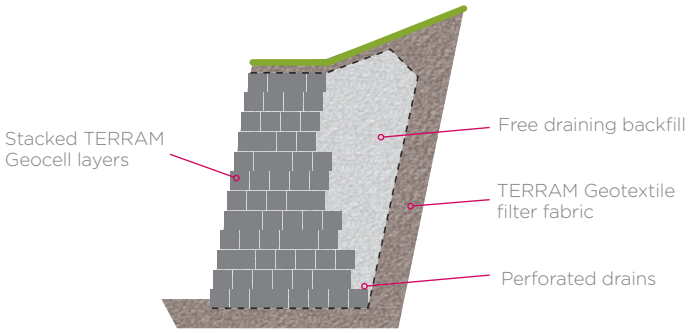
Design Considerations

- Wall Height
- Facia Angle
- Surcharge load on the top of the wall
- Overturning Stability (the consideration of the turning moment around the toe of the structure)
- Sliding Stability (shear strength at the base of the gravity wall)
- Foundation Bearing Capacity (the substrate must be able to support the applied load of the wall structure).

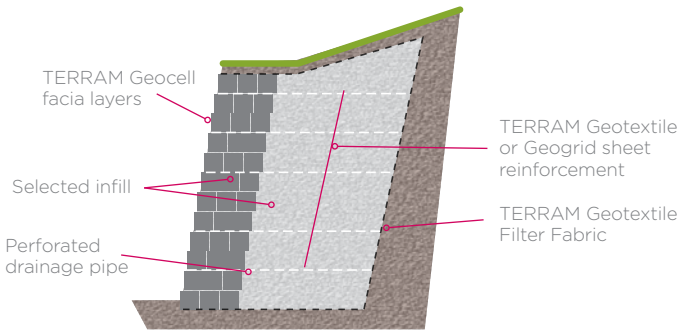
TERRAM work with specialist partners to provide independently validated solutions in accordance with best practice guidelines.

Typical Applications Include:

- Steepened Embankments
- Dams and Flood Defence Bunds
- Retention Bunds
- Green Walls
- Culvert Head Walls
- Sound Barriers.



GRAVITY WALL



COMPOSITE WALL

A complete design service including project design and on site technical support now available. Please contact us on 01621 874 200

TERRAM Geocell soil structures **see page 23**

Controlling erosion on highway slopes

TERRAM Geocells are three-dimensional blankets of interconnected cells which are placed on slopes, secured in position using pins, and filled with friable topsoil.

Controlling erosion on highway slopes

Once installed, a TERRAM Geocell provides immediate stability by confining the fill and greatly improves resistance to wind and run-off.

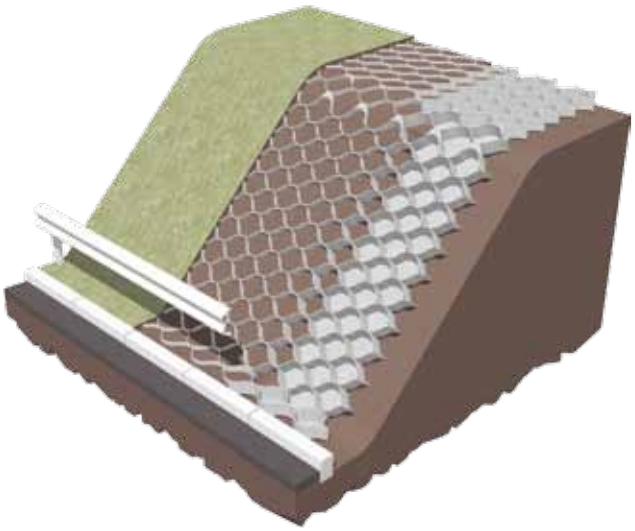
With a topsoil fill, the stability is further enhanced as vegetation becomes established and a geocell can be used to establish vegetation on slopes where establishing cover would otherwise have been a problem. The honeycomb of cells provides protection for the vegetation during the early, sensitive period of germination and growth.

The Geocells are formed from TERRAM Geotextile to confine the fill and the permeable walls allow drainage from cell to cell down the slope. Other geocells achieve this cell-to-cell drainage by perforating the walls but this process can lead to weaknesses. Geocells fabricated from impermeable materials suffer from weiring - water cascading down the slope from cell to cell – and this causes ongoing loss of soil from the cells.

Many variables affect the installation and performance of a slope-protection geocell, including slope angle, slope stability, the infill type, rainfall levels and irrigation (if included). It is important therefore that due consideration is given to all relevant criteria on a project by project basis.

Typical applications include:

- Cuttings and embankments
- Noise-deflection and environmental bunds
- Abutments
- Soil nailing cover
- Balancing ponds
- Steepened slopes
- Drainage ditches



A TERRAM Geocell with its distinctive array of interconnected cells.

TERRAM Geocells are anchored to slopes using U shaped - TERRAM Fixing Pins - these combined with the weight of the soil prevents slippage.

TERRAM Geocell erosion control **see page 24**

Load platforms and tree root protection

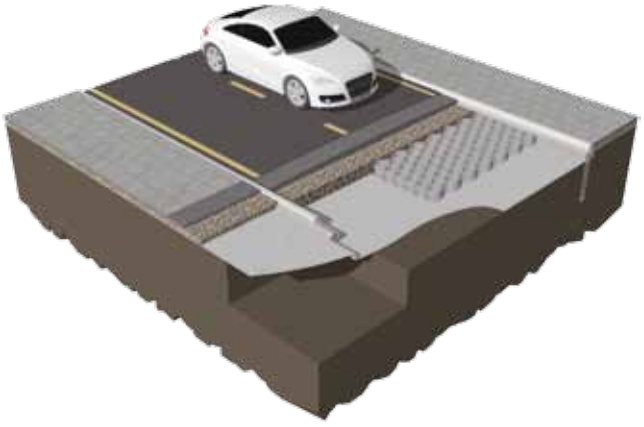
TERRAM Geocell load platforms, once filled with a free-draining granular material, act as a mattress that spreads traffic loads laterally to reduce vertical deflections. The fill is confined within the individual cells by hoop stress.

Load platforms

TERRAM Geocells are also used to construct semi-rigid platforms over poor soils and over areas where there's a no dig-restriction.

Tree Root Protection

Where an access road, woodland path or driveway is required in tree sensitive areas, TERRAM Geocells should be used. A no-dig construction using geocells protects the roots distributing downward forces laterally allowing the tree roots to remain undisturbed (see Arboricultural Advisory and Information Services APN12: Driveways close to trees) .



TERRAM Geocell load-platform.

TERRAM Geocell load-platform.

TERRAM Geocell tree-root-protection.

TERRAM Geocell tree root **see page 25**

Grass and gravel surface stabilisation

Constructing stable grass and gravel surfaces for trafficking.

There are many products and techniques for increasing the stability of low-load-bearing ground but most have been developed with paved areas in mind. It is only in the last thirty years or so that the demand has grown for unpaved solutions.

It is now possible to construct green roads and car parks which are not only pleasing to the eye but retain their appearance and continue to perform when other non-engineered alternatives are worn and unattractive.

TERRAM solutions, including GrassProtecta, BodPave 85 and Truckpave, can be used with grass or gravel. All solutions are porous which means they are source-control compliant for SuDS installations.

The products have been developed with different trafficking requirements in mind. The demand can vary from occasional foot traffic to frequent, heavily-loaded vehicles so it's important to deal with a company who can supply the full range of solutions rather than a one-size-fits-all approach.

TERRAM TruckPave
see page 26

TERRAM Bodpave 85
see page 27

TERRAM GrassProtecta
see page 28

Demarcation and warning layers

Demarcation and warning layers for underlying contaminants and services.

If the filter/separation functions are required for construction over contaminated land then there is an additional benefit that TERRAM products can provide – high visibility so that they also warn operators during excavation at a later date.

TERRAM Hi-Vis is a bright orange geotextile used to mark areas of soil prior to backfilling. Manufactured using orange fibres, it has the same filter/separator benefits of TERRAM Standard Geotextiles but provides a visible separation of clean and contaminated soils. Future excavations will see the visible barrier of the contaminated soils beneath.

TERRAM Indicator Mesh is available in red to protect bridge deck membranes and also act as a depth marker during re-surfacing operations. The mesh is a proven alternative to using red sand and is much easier to install.

TERRAM Detectamesh detectable underground warning tapes, provide two functions when installing highway pipelines, drainage, cables and communication fibre optics: 1; Provides a visible warning to future excavators of the utility service beneath. 2; Contains a traceable element to enable the detection of plastic pipes and un-energised cables using a cable avoidance tool, preventing damage to the services.

TERRAM High Vis
see page 29

TERRAM Indicator Mesh
see page 30

Product pages

TERRAM Standard Geotextiles

TERRAM Standard Geotextiles enhance the performance and design life of granular layers by providing the filtration and separation functions. Typical uses for TERRAM Standard Geotextiles include ground stabilisation (between the sub-base and subgrade) and around drainage materials.

Preventing intermixing of granular materials and soils

TERRAM Standard Geotextiles provide an effective solution to the problem of constructing a stable granular layer over soft foundation soils. When stone is placed directly on a soft subgrade, the imposed load often causes intermixing of two layers. This results in contamination of the stone layer and a resulting loss in bearing strength, surface rutting and deformation at the sub-base/ subgrade interface.

Preventing the ingress of fines into drainage media

Whether it's a granular drain or a geosynthetic alternative such as open geocellular units, TERRAM Standard Geotextiles are ideal for preventing the ingress of fines.

Features:

- Engineered to provide high strength and high elongation at break
- Manufactured from high tenacity UV stabilised virgin polypropylene fibres to provide long term durability in all soil types
- Manufactured using a randomly orientated web to provide completely isotropic properties
- Excellent uniformity with high permeability and low pore size for soil filtration

TERRAM filters/separators are used extensively in the construction of:

- Paved and unpaved roads
- Railways.
- Car parks and hardstandings.
- Cycleways and footpaths.
- SuDS installations.
- Green roofs.

Product Grade	T700	T900	T1000	T1300	T1500	T2000	T3000	T4000	T4500
Roll Width(*) m	4.5/6	4.5/6	4.5/6	4.5/6	4.5/6	4.5/6	4.5/6	4.5/6	4.5/6
Roll Length m	150	150	100	100	100	100	100	50	50

*All products can be manufactured up to a maximum width of 6 metres.

TERRAM product specifications can be downloaded freely from **www.terram.com**

TERRAM Geocomposite Drain

TERRAM Geocomposite Drains are manufactured by bonding together textiles, membranes and nets in different combinations to create easier-to-install replacements for conventional granular layers.

The textile provides the filter function so this allows liquids and gases to pass into the net core but prevents soil particles from washing into and clogging the core. The net collects the liquids and gases which can then be conveyed to collection points. Membranes are used to provide the barrier function and prevent the passage of liquids and the majority of gases.

A composite must:

- be robust to survive installation and service life.
- be stable under load to resist deformation that could ultimately restrict flow.
- have good chemical resistance.

Its filter must:

possess an apparent pore size to suit the soil and prevent the ingress of fines provide sustained performance without blocking TERRAM Geocomposite Drains are proven to satisfy these criteria and stand the test of time. The products have established an impressive track record in building and construction projects across the world for over forty years.

Features:

- Manufactured using TERRAM T1000LE, a unique geotextile filter developed for its high tensile modulus and ability to prevent soil ingress into the void space of the drainage core
- TERRAM drainage cores are manufactured from HDPE nets which have been engineered to have good flow under high loading

	B1	1A1	1B1	1BZ	1C1	1D1	1D1 Light	1E1
Roll Width m	2.0/3.8/4.0	2.0/3.8/4.0	2.0/3.8/4.0	2.0/3.8/4.0	2.0/3.8/4.0	2.0/3.8/4.0	2.0/3.8/4.0	2.0/3.8/4.0
Roll Length m	25/50/100	25/100	25/50/100	25/50/100	25/50/100	25/50	25/50/100	25/50

TERRAM product specifications can be downloaded freely from **www.terram.com**

TERRAM Frost Blanket

TERRAM Frost Blanket is a purpose-designed, protection geo-composite for mitigating the effects of frost heave.

Installed horizontally, it forms a capillary break to prevent the rise of groundwater into the frost zone thereby reducing the potential for damage as a result of the freeze/thaw cycle (frost heave).

TERRAM Frost Blanket has been installed with great success on a number of significant projects around the world including Kazakhstan and Siberia.

For more information visit www.terram.com to download our Frost Blanket guidance document.

Composition

Drainage core with a filter bonded to both sides.

Upper filter

T2000LE white high tensile modulas geotextile.

Core

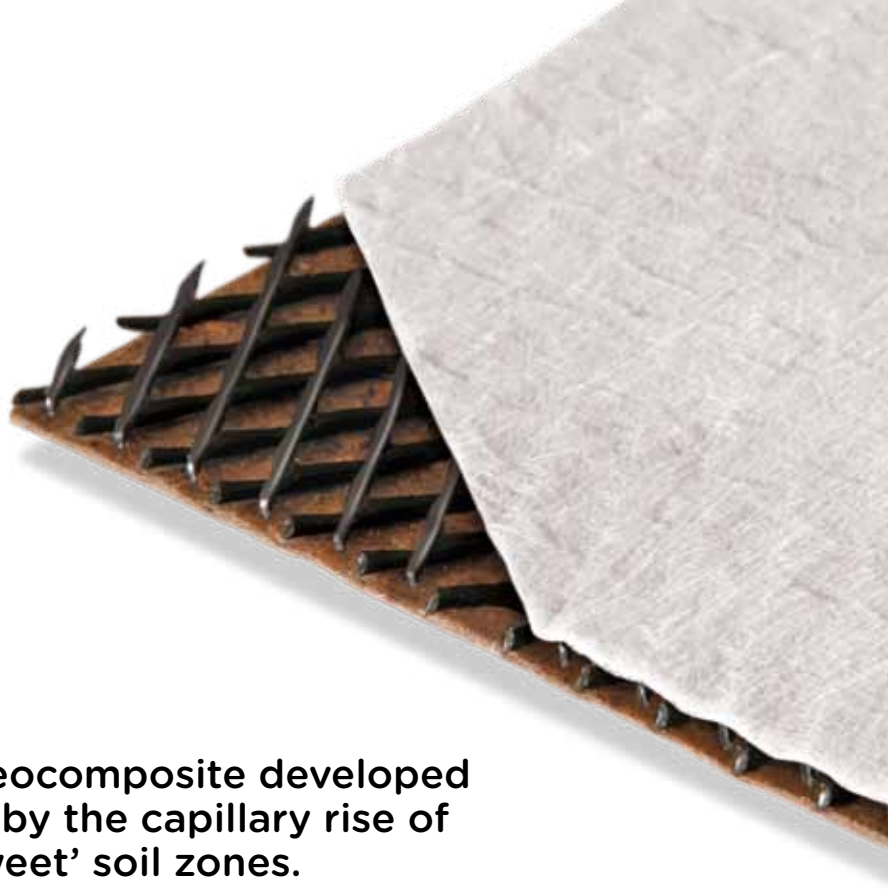
Extruded polyethylene (PE) net.

Lower filter

T2000LE brown high tensile modulas geotextile with hydrophobically enhanced fibres.

Physical Properties - Composite (Typical values)	
Roll Width m	2.0 or 4.0
Roll Length m	25 or 100
Filter Overlap (one side) mm	100

TERRAM Salt Barrier



TERRAM Salt Barrier is a geocomposite developed to prevent damage caused by the capillary rise of saline groundwater into 'sweet' soil zones.

Soft landscaping in areas with saline groundwater has traditionally required a 300mm layer of crushed stone to intercept the groundwater and allow successful cultivation.

TERRAM Salt Barrier has been specially developed to replace this granular layer and reduce the environmental by avoiding the use of a primary resource and the attendant transportation costs.

It has a proven record on a number of high-profile projects in the Middle East where it was extensively used in the Palm Jumeirah Development.

Composition

Drainage core with a filter bonded to both sides.

Upper filter

T2000LE white high tensile modulas geotextile.

Core

Extruded polyethylene (PE) net.

Lower filter

T2000LE brown high tensile modulas geotextile with hydrophobically enhanced fibres.

Physical Properties - Composite (Typical values)	
Roll Width m	2.0 or 4.0
Roll Length m	25 or 100
Filter Overlap (one side) mm	100

TERRAM product specifications can be downloaded freely from **www.terram.com**

TERRAM Geocell soil structures

TERRAM Geocell Series 500 provides a cost-effective alternative to conventional earth retention structures.

TERRAM Geocell is flexible and can be filled with a wide range of fill materials. The TERRAM Geocell is fabricated from geotextile which means that the 0.58m wide x 0.53m long x 250mm deep cells have permeable walls and there is no potential for cracking, spalling, splintering or corrosion associated with concrete, steel and timber facings.

The system is supplied as compact panels which are expanded on site to form a honeycomb area of cells measuring up to 10.6m x 5.5m. This, the largest panel, weighs 28kg.

TERRAM Geocell Series 500 can be installed almost vertically by placing one horizontal layer on top of a filled layer. The cellular panels can be used to form the face or they can be used to face a composite wall in conjunction with horizontal reinforcement elements such as geogrids or with soil nails, rock bolts, helical anchors, etc.

One further facing detail is to step subsequent layers to form horizontal terracing which allows vegetative cover to be cultivated in topsoil-filled cells.

The cells can be filled with site-won materials (if suitable), topsoil, sand, aggregates and concrete.

Applications include:

- Steep slopes.
- Dams and flood bunds.
- Retention bunds.
- Green walls.
- Culvert head walls.
- Sound bunds.

Panel Grade	20/04	20/06	20/08	20/10	20/12	20/14	20/16	20/18
Cell Nominal Diameter mm	500	500	500	500	500	500	500	500
Cell Length (L) mm	580	580	580	580	580	580	580	580
Cell Width (W) mm	530	530	530	530	530	530	530	530
Cell Depth mm	250	250	250	250	250	250	250	250
Panel Length mm	10606	10606	10606	10606	10606	10606	10606	10606
Panel Width mm	1450	2031	2611	3191	3772	4352	4932	5513
Panel Weight kg	7.3	10.2	13.2	16.1	19.1	22.0	25.0	27.9
Cells per m² (nominal)	6	6	6	6	6	6	6	6

TERRAM product specifications can be downloaded freely from **www.terram.com**

TERRAM Geocell erosion control

TERRAM Geocell is a relatively shallow cellular confinement system which is used to combat erosion on slopes up to 1:1.

TERRAM Geocell is fabricated using a geotextile so it is permeable and allows water to flow between cells encouraging drainage and vegetation. It is supplied as compact man-handleable panels ready to be expanded on site to 5m x 7m or 6m x 3m areas with a honeycomb of diamond-shaped cells that are 100mm, 150mm or 200mm deep.

Once placed and secured on the slope, the geocell can be filled with soil or a mineral fill. The result is that the confined fill is able to better resist the erosive effects of wind and run-off. The expanded panels should be fixed at every perimeter cell and at 1m centres throughout using steel fixing pins.

The geocell is flexible enough to be formed around trees and other obstacles.

Seeded topsoil is the most suitable fill for less-exposed slopes, with small shrubs offering improved protection, whilst a granular material offers the highest protection.

The TERRAM Geocell confinement system is suitable for:

- Cut or fill embankments.
- Dams or spillways.
- Revetments.
- Abutment protection.
- Geomembrane protection.
- Soil-nailing cover.
- Landfill capping.

Panel Grade	22/20	25/10	25/15	35/10	35/15
Cell Nominal Diameter mm	220	250	250	350	350
Cell Length (L) mm	275	295	295	415	415
Cell Width (W) mm	230	250	250	370	370
Cell Depth mm	200	100	150	100	150
Panel Length mm	6176	5175	5175	5199	5199
Panel Width mm	3227	7300	7300	7438	7438
Panel Weight kg	20	17	25	11	17
Cells per m² (nominal)	30	26	26	12	12

TERRAM product specifications can be downloaded freely from **www.terram.com**

TERRAM Geocell tree root

TERRAM Geocell is a cellular confinement system used to protect tree roots from damage caused by heavy vehicles; particularly where a Tree Protection Order (TPO) is in force. Conventional construction would be invasive and trees are sensitive to disturbance.

A TERRAM tree-root-protection geocell is suitable for:

- Access roads and parking areas.
- Driveways & paths.
- Temporary site access.
- Permanent woodland trails.

TERRAM Geocell is manufactured from one of the TERRAM Geotextiles range which means that air and water are free to move across the root area from cell to cell. The geocell is supplied in the form of flat-packed panels which expanded on site to form a much larger honeycomb area of interconnected cells. The panels are secured to the ground using steel pins which are also available to purchase.

The road or parking area can be constructed once the roots have been covered by the geocell and filled with a granular material. The geocell ensures that axle loads are spread laterally rather than applied vertically. This also minimises compaction beneath the traffic line which would be harmful to the roots as they could become starved of oxygen and moisture. Without the cellular system, loads would be transferred to the roots resulting in damage and the possible loss of trees.

Panel Grade	22/20	25/10
Cell Nominal Diameter mm	220	250
Cell Length (L) mm	275	295
Cell Width (W) mm	230	250
Cell Depth mm	200	100
Panel Length mm	6176	5175
Panel Width mm	3227	7300
Panel Weight kg	20	17
Cells per m² (nominal)	30	26

TERRAM product specifications can be downloaded freely from **www.terram.com**

TERRAM Truckpave

Manufactured from recycled plastics, TERRAM Truckpave cellular paving is robust, durable and capable of withstanding all levels of traffic up to and including coaches, dustcarts and HGVs.

TERRAM Truckpave's cells can be filled with either grass seed/topsoil or gravel, making them suitable for stabilising areas where a grass or stone surface is desirable. TERRAM Truckpave pavers are the economic, environmentally-friendly and lightweight alternative to grass concrete type pavers.

Applications include:

- Lorry, coach and car parks.
- Fire access roads and HGV service access roads.
- Road widening.
- Grass verges, incl' where HGV overrun occurs.
- Footpaths.
- Service yards and other areas where forklift trucks operate including loading areas.
- Lay-bys.

Benefits:

- Comply with the HSE manual-handling limit (concrete units exceed this limit).
- Meet SLW60 load category - vehicles up to 60t gross weight, 10t wheel load.
- Flexible and resistant to cracking.
- Plastic achieves greatly improved volume and quality of grass compared to concrete units.
- Available with anti-skid surface detail for additional traction on gradients.
- Pavers do not transfer heat and dry out soil infill.
- Non-standard colours can be manufactured subject to order quantity.

Product	TruckPave 80	TruckPave 100
Width (mm)	600	600
Length (mm)	400	400
Depth (mm)	80	100
Weight (kg)	9	12
Units/m²	4.17	4.17
Colour	Grey	Grey

TERRAM product specifications can be downloaded freely from **www.terram.com**

TERRAM BodPave™85

TERRAM BodPave 85 is an interlocking cellular porous paving system for ground reinforcement which can be installed with either a grass or gravel filled surface.

The design of TERRAM BodPave 85 pavers allows them to positively interlock with each other and resist shear. Once filled, they provide a high level of load-bearing performance. They are laid on a free-draining base and can be filled with either gravel for immediate frequent/intensive use, or with a seeded sand/soil to establish a grassed surface for occasional consecutive use. Both options mean that the resulting pavement is porous and in sympathy with the environment. Note: a grassed surface may not be suitable for every application.

The unique TERRAM BodPave 85 design resists lateral movement whilst accommodating expansion and contraction, promotes surface traction and stability and encourages grass growth by protecting the roots.

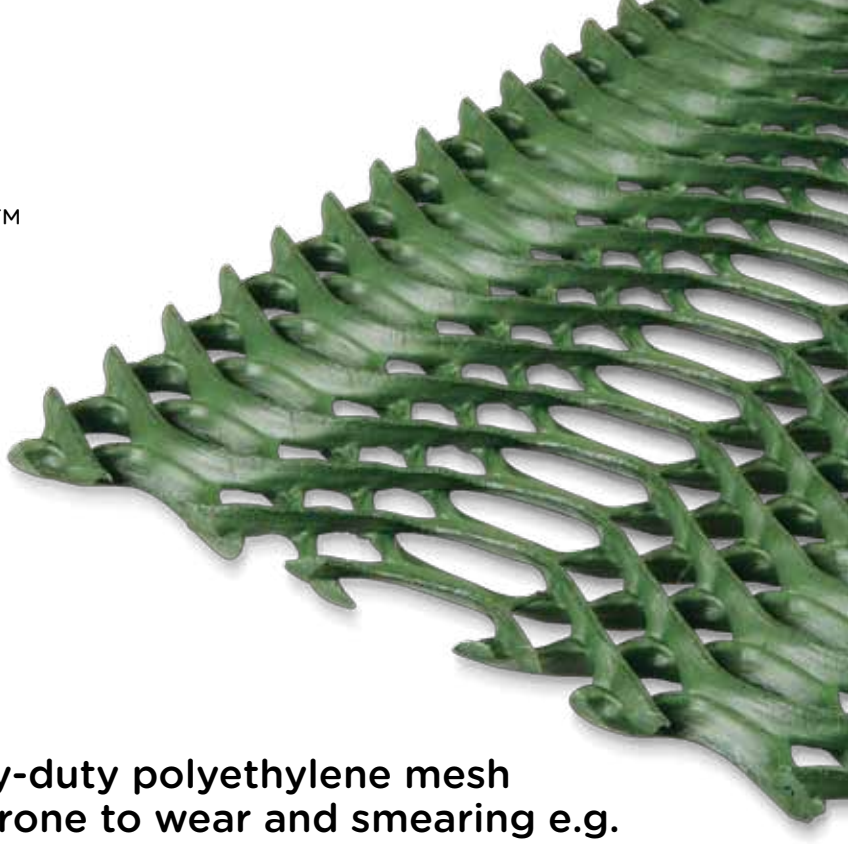
Applications:

- Car / coach parks.
- Emergency / HGV service access routes.
- Aircraft taxiways & helipads.
- Walkways and disabled access.
- Golf buggy paths.
- Driveways & residential parking.
- SuDS source control.
- TERRAM BodPave 85 is suitable for grassed surfaces, gravel retention and SUDS source control applications.

Characteristics	Black / Green* / Natural
Connection & locking type	Overlapping edge loop & cell connection with integral, self-locking, snap-fit clips
Basal support & anti shear	Integral 35mm long ground spikes (18/paver) with cross & T section
Dimensions	500mm x 500mm x 50mm deep (plus 35mm long ground spike)
Cell wall thickness	2.5mm - 4.4mm
Nominal internal cell dimensions	67mm (cruciform) & 46mm (round)
Quantity per m²	4 pavers
Weight	1.56kg (6.24kg/m²)

TERRAM product specifications can be downloaded freely from **www.terram.com**

TERRAM GrassProtecta™



TERRAM GrassProtecta heavy-duty polyethylene mesh reinforces grassed surfaces prone to wear and smearing e.g. permanent car parking and heavily-used pedestrian areas. The oscillated mesh structure provides traction and slip resistance.

TERRAM GrassProtecta mesh is available in two thicknesses: 14mm and 11mm. It is simple to install by fixing to the existing grass surface. The sward grows through the mesh apertures and knits with the filaments to create a strong, discreetly reinforced surface which is capable of withstanding vehicle loads, limiting damage and helping to reduce compaction by reducing direct contact with the soil surface. The grass can be mown, rolled and fertilised as normal during this period and the mesh soon becomes unobtrusive.

It is strongly advised that newly-installed areas remain untrafficked until the sward and the mesh have knitted - normally after a few weeks during the growing season, increasing to a few months out of season. Immediate use may restrict growth and limit the effectiveness of the installation.

The Standard (11mm) grade is suitable for:

- Light-usage, overflow car parks.
- Wheelchair (DDA) access routes.
- Golf-buggy paths.
- Heavily-pedestrianised paths.

The Heavy (14mm) grade is suitable for:

- Overflow car parks.
- Light-aircraft taxiways.
- Caravan sites and amenity areas.
- Some equestrian surfaces.
- Verge stabilisation.

Nominal dimensions	Standard (1.2kg)		Heavy (2kg)	
Width (m)	1	2	1	2
Length (m)	10	20	10	20
Thickness (mm)	11		14.5	
Weight/m² (kg)	1.2		2	
Weight/linear m (kg)	1.2	2.4	2	4
Roll weight (kg)	12	48	20	80

TERRAM product specifications can be downloaded freely from **www.terram.com**

TERRAM Hi Vis Geotextile

TERRAM Hi Vis is a non-woven orange geotextile used for separating contaminated/uncontaminated soils.

TERRAM Hi Vis geotextiles have a dual effect: its vivid colour warns of potential danger at the point of any future excavations and it can also prevent the upward movement of contaminated soil particles.

Preventing intermixing of granular materials and soils

TERRAM Hi Vis geotextiles provide an effective solution to the problem of constructing a stable granular layer over soft foundation soils. When stone is placed directly on a soft subgrade, the imposed load often causes intermixing of two layers. This results in contamination of the stone layer and a resulting loss in bearing strength, surface rutting and deformation at the sub-base/subgrade interface.

Preventing the ingress of fines into drainage media

Whether it's a granular drain or a geosynthetic alternative such as open geocellular units, TERRAM Hi Vis geotextiles are ideal for preventing the ingress of fines.

TERRAM filters/separators are used extensively in the construction of:

- Paved and unpaved roads.
- Railways.
- Car parks and hardstandings.
- Cycleways and footpaths.
- SuDS installations.
- Green roofs.

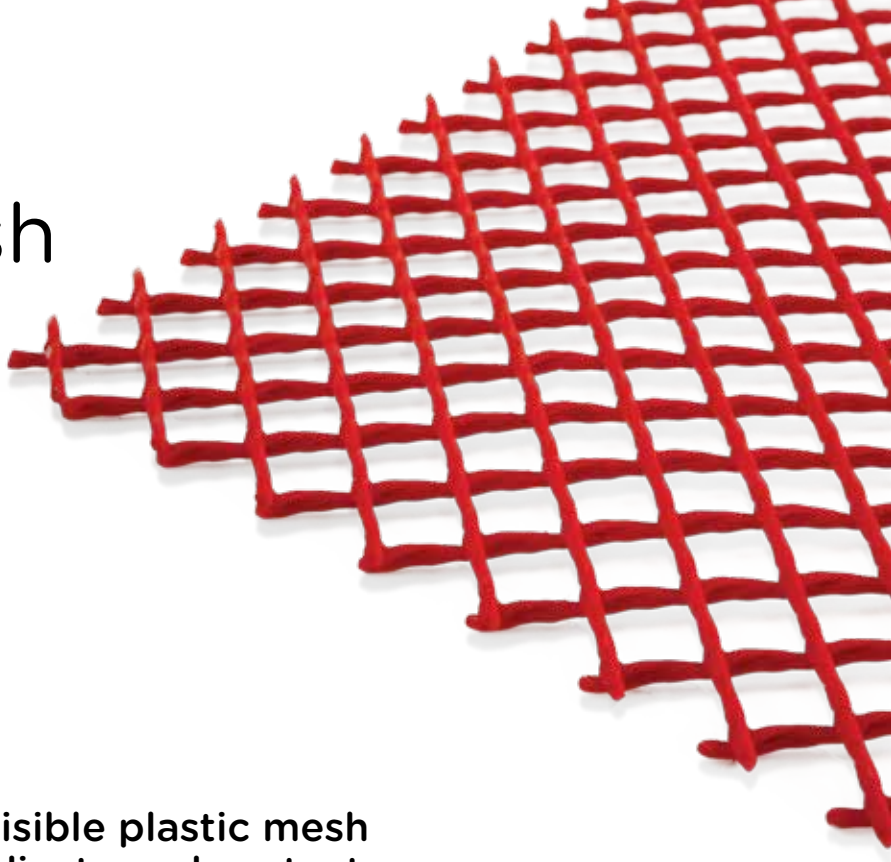
Features:

- Engineered to provide high strength and high elongation at break.
- Manufactured from high tenacity UV stabilised virgin polypropylene fibres to provide long term durability in all soil types.
- Manufactured using a randomly orientated web to provide completely isotropic properties.
- Excellent uniformity with high permeability and low pore size for soil filtration.

Product Grade	T1000 Orange Geotextile
Roll Width(*) m	4.5/6
Roll Length m	100

TERRAM product specifications can be downloaded freely from **www.terram.com**

TERRAM Indicator Mesh



Indicator Mesh is a highly visible plastic mesh used on bridge decks to indicate and protect the waterproof membrane.

TERRAM Indicator Mesh is laid over a layer of sand asphalt or a fine binder course which has been laid over the waterproof membrane on the bridge deck. A binder course is laid above the indicator mesh, before the bridge surface course is laid.

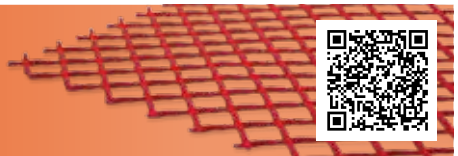
TERRAM Indicator Mesh is a great alternative to other depth indicator techniques such as red sand asphalt. The TERRAM Indicator Mesh ensures that future resurfacing contractors undertaking subsequent planing or repairs to the bridge surface and binder course are given clear warning that the waterproof membrane is below.

TERRAM Indicator Mesh is available up to 1.5m wide and in red, yellow or orange.

- Highly visible indication mesh.
- Manufactured from high density polyethylene.
- Rot resistant and chemically inert.
- Installation of Indicator mesh netting for a bridge deck construction to protect the waterproof membrane.
- TERRAM Indicator Mesh can also be used to indicate membranes on roads, or can be used to indicate areas of soil contamination.

Roll Width	Roll Length	Colour	Mesh Thickness
1.5m	50m	Red	3mm

TERRAM product specifications can be downloaded freely from **www.terram.com**



Tree shelters for highway landscaping

TUBEX
Advancing growth
www.tubex.com

Fiberweb manufacture tree shelters under the TUBEX brand for protecting trees from animal browsing, improving survival rates and increasing growth.

Further market specific literature available:

- Railways
- Grass & Ground Reinforcement
- Landfill
- Coastal & Waterways
- Pipelines / Utilities

Application specific literature, product data sheets, case studies and installation guides are available on request or can be freely downloaded from **www.terram.com**. Please contact our technical sales team for reference projects, to organise a CPD seminar and for further advice.

A leader in material technology application

By intelligently applying our high-performance fibre technology, we are helping industry solve its most complex material challenges, and providing our customers with the answers they will need tomorrow.

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THE NEXT ANSWER

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