OUR BUILT ENVIRONMENT

Within the construction and landscaping sectors the use of geosynthetics has become fundamental in solving an increasingly diverse range of global geotechnical and environmental protection problems. Typical applications for geosynthetics include Soil Reinforcement, Ground Stabilisation, Filtration, Drainage, Protection and Erosion Control.

The ongoing impact of climate change and the requirement to deliver sustainable development is increasingly creating the need for more diverse and innovative solutions. These applications include cellular confinement, green roofs, pervious paving systems, geocellular tanks, basement construction and tree root protection systems. Through the ongoing commitment to achieve sustainability within the built environment, geosynthetics are being incorporated into major infrastructure projects such as renewable energy schemes such as on-shore wind farms and alternative forms of transport such as light rail networks.

TERRAM® is a market leader in the design and manufacture of innovative geosynthetics, providing a unique range of value-engineered solutions that also help minimise the environmental impact of construction.

As part of this commitment Terram has developed an innovative solution for ground and slope stabilisation, erosion control and retaining structures – the Terram Cellular Confinement System.

The forces of nature can have a powerful effect on steep slopes, river banks, spillways and other exposed areas. It takes an effective engineered solution to prevent the movement of soils caused by static, dynamic, hydro-dynamic and gravitational forces.

The Terram Cellular Confinement System utilises a three dimensional geotextile ‘honeycomb’ structure to provide soil stabilisation across a wide variety of applications.

The system confines the fill material within its strong and flexible geotextile cell structure. This restricts down-slope migration in slope applications, provides an even load distribution on paved and unpaved areas and also provides a stable base when used over soft subgrades.

Whilst the strong, permeable geotextile material restricts the movement of fill material, it allows the free movement of water and nutrients to create a healthy soil environment.

The system can be used with a variety of infill materials including soil, aggregates and concrete and because native infill materials may also be acceptable, it can be a very cost-effective solution.

The Terram Cellular Confinement System is easy to handle and install, is low maintenance, economical and strong; providing a cost effective solution for many soil stabilisation applications.

The Terram Cellular Confinement System offers the following advantages over ‘traditional’ construction methods.

- Flexible and easy to install
- Strong and light
- Developed and tested to rigorous independent standards
- Economical with low maintenance requirements
- Can eliminate the need for more expensive construction techniques
- Helps encourage vegetation for a natural green environment

Typical applications include:

- Access roads and parking areas
- Pavement bases and sub-bases
- Road widening schemes
- Embankment slopes
- Containment dykes and levees
- Landfill lining and covers
- Dam faces and spillways
- Noise abatement walls.
Terram Geocell can be used in many slope protection applications often eliminating complicated and expensive construction techniques. Its three dimensional structure provides a blanket of 'cells' on the slope surface which can contain a variety of infill materials depending on the application; either topsoil, aggregates, from sands and gravels to larger stones and cobbles, and concrete of various strengths and surface finishes. This greatly improves resistance to erosive forces such as rainwater run-off on steep or unstable slopes, or slopes exposed to severe hydraulic or mechanical stresses.

Terram Geocell can provide a means of fully vegetating slope surfaces where this would not otherwise be possible. Each discrete cell contains soil infill to facilitate the growth of vegetation. The exposed edge of the cell panels also disrupts and reduces the velocity of any surface run-off from the slope; further reducing erosion of the topsoil.

Precipitation percolating into Terram Geocell must be able to drain, either vertically into the slope substrate or parallel to the slope surface through the cell structures. As many slopes that require such a system have poor drainage, this parallel drainage is of vital importance and Terram Geocell, with its unique material characteristics, offers this without requiring wall weakening perforations.

Terram Geocell is anchored to slope surfaces using Terram Fixing Pins; these combined with the weight of the infilled system prevent the system from slipping down the slope. This allows the Terram Geocell to perform the important function of reinforcing the root zone of the vegetation; in the long-term it is the successful establishment of a consolidated vegetation layer that will provide the required protection to the slope surface.

Many variables affect the installation and performance of Terram Geocell, including slope grade, subsurface stability, infill material, rainfall and artificial watering conditions, hydraulic characteristics of ground water flow and sub-base anchoring quality. It is important therefore that due consideration is given to all relevant design criteria on a project specific basis.

**Design Considerations**
- Slope angle
- Slope drainage
- Slope length
- Slope substrate
- Hydrology
- Required finish on slope.

**SLOPE PROTECTION**

**Typical Applications Include:**
- Cut or fill embankments
- Dams or spillways
- Shoreline revetments
- Abutment protection
- Geomembrane protection
- Landfill lining, covers and drainage
- Steep slopes
- Soil nailing cover.

**SLOPE WITHOUT GEOCELLS**
- Strength of forces acting to cause slope failure
- Forces causing slope failure
- Resistance failure due to weight of fluid
- Material from failing face of slope
- Soil movement
- Failure subbase
- Failure resistance due to weight of fluid ...

**SLOPE WITH GEOCELLS**
- Strength of forces acting to cause slope failure
- Forces within Geocell in equilibrium
- Soil protected from erosion
- Failure resistance due to weight of fluid Geocell
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 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.
Terram Geocell system can solve many load support problems as it provides both a stable base for paved surfaces and surface stabilisation for unpaved areas. When filled with sands or granular fills, the cellular structure performs as a semi-rigid ‘slab’ distributing loads laterally, stabilising base materials, reducing subgrade contact pressures and minimising surface rutting. It also prevents the lateral displacement of infill and reduces vertical deflections even on low-strength sub grades.

The system is delivered to site as flat panels and once opened and pinned can be infilled with either aggregate or sand and compacted to form a stable traffickable surface. The use of cohesive infill materials is not recommended due to the problems with placing and compacting such materials within the cell structure.

When installed the Geocell structures confine the infill materials within the hoops formed by the cell walls. As load, either static or dynamic, is applied to the confined infill materials its expansion perpendicular to the applied load is restricted by a combination of the tensile strength within the cell walls (hoop strength) and by the passive resistance from the infilled cells surrounding the loaded cell. This increases the strength of the fill through creation of confining stresses within the infill materials.

It is for this application that Geocells were originally developed by the US Army Corps and Engineers to create a method of quickly building access roads for military vehicles over impassable terrain. Since entering the public arena, many thousands of miles of permanent and temporary access roads and hard standing areas have been reinforced using cellular structures.

**Typical Applications Include:**
- Site compounds
- Pile cap reinforcement
- Stabilised drainage layer
- No dig tree root protection
- Permeable load supporting surfaces
- Permanent Way ballast stabilisation
- Sub-base stabilisation for block paved areas
- Green access roads and temporary green occasional carparks
- Permanent and temporary access roads, footpaths and cycle paths.

**Design Considerations**
- Infill quality/properties
- Subgrade strengths
- Traffic conditions.
**TREE ROOT PROTECTION**

**BS 5837: 2005 for trees in relation to construction and APN12**

In recognition of the fact that trees are sensitive to disturbance the British Standards Institution has published recommendations on how to protect trees during development. In line with the earlier British Standard (BS 5837: 1991) the most recent guide, published in September 2005 (see further reading), recommends that there should be a ‘root protection area’ in which development should not be permitted.

In 2007 the Arboricultural Advisory and Information Service published Arboricultural Practice Note 12: Driveways Close to Trees (APN12) which suggested that driveways could be installed within the root protection area subject to roots and the soil not being damaged.

APN12 advised that driveways could be installed within the root protection zone provided that an above-ground, no-dig construction was used. This advice was incorporated into the recent British Standard which recommended that the most effective means of achieving this was through the use of a three-dimensional cellular confinement system, such as the Terram Geocell System.

**CHANNEL PROTECTION**

Terram Cellular Confinement Systems can be used to protect channels exposed to severe erosion conditions or continuous flow. It offers improvements over conventional materials such as concrete and aggregate by confining the infill within the cellular structure and assuring effective subgrade drainage and subsoil protection.

The system also allows for vegetated systems which provide increased strength through the root structure (as with the slope protection application) and result in a more natural finished appearance, compatible with the local environment and ecology.

Using the Terram Cellular Confinement Systems for channel lining is an extension of the slope applications, described previously, with the consideration of the additional forces generated through saturation of the fill and the flow of water within the channel.

**Design Considerations**

- Embankment slope angle
- Length
- Hydrology
- Drainage
- Substrate conditions
- Flow.

**Typical Applications Include:**

- Private drives
- Estate roads
- Car parks.

**Typical Applications Include:**

- Swales and drainage ditches
- Stormwater containment lagoons
- Process water channels
- Culvert outfalls
- Intermittent drainage channels.
**FURTHER READING**

Bathurst, R.J. and Jarrett, P.M. 1981.  
"Largescale model tests of geocomposite mattresses over peat subgrades." Transportation Research Record 1188. Transportation Research Board, Washington, D.C.


Koerner, R.M. 1996.  
Designing with Geosynthetics. Prentice Hall, Engelwood.


Patch, D and Holding, B. 2007.  
"Through the Trees to Development, APN12", Arboricultural Advisory and Information Service, Farnham, UK.


**TECHNICAL SUPPORT**

A full range of product data sheets, case studies and project information request forms are available from Terram technical support or as downloads from the Terram website. www.terram.com.

**IMPORTANT NOTICE**

The information contained herein has been prepared in good faith and is, to the best of our knowledge, accurate in all material respects. However, it does not purport to be comprehensive and since the circumstances and conditions in which such information and the products discussed herein can be used may vary and are beyond our control, no representation or warranty, express or implied, whether of merchantability, fitness for purpose or against patent infringement or otherwise, is or will be made and no responsibility or liability is or will be accepted by Terram Limited, any of its affiliates or its or their respective directors, officers, employees or agents in relation to the accuracy or completeness or use of the information contained herein or any such products and any such liability is expressly disclaimed. The information contained herein is offered free of charge and we give no undertaking to provide any additional, updated or corrected information.

**TECHNICAL SUPPORT**

A full range of product data sheets, case studies and project information request forms are available from Terram technical support or as downloads from the Terram website. www.terram.com.

**IMPORTANT NOTICE**

The information contained herein has been prepared in good faith and is, to the best of our knowledge, accurate in all material respects. However, it does not purport to be comprehensive and since the circumstances and conditions in which such information and the products discussed herein can be used may vary and are beyond our control, no representation or warranty, express or implied, whether of merchantability, fitness for purpose or against patent infringement or otherwise, is or will be made and no responsibility or liability is or will be accepted by Terram Limited, any of its affiliates or its or their respective directors, officers, employees or agents in relation to the accuracy or completeness or use of the information contained herein or any such products and any such liability is expressly disclaimed. The information contained herein is offered free of charge and we give no undertaking to provide any additional, updated or corrected information.