
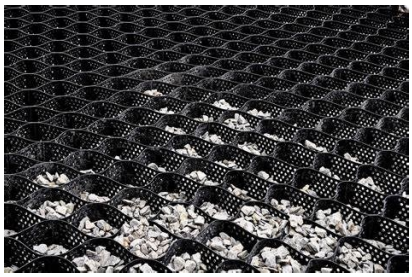


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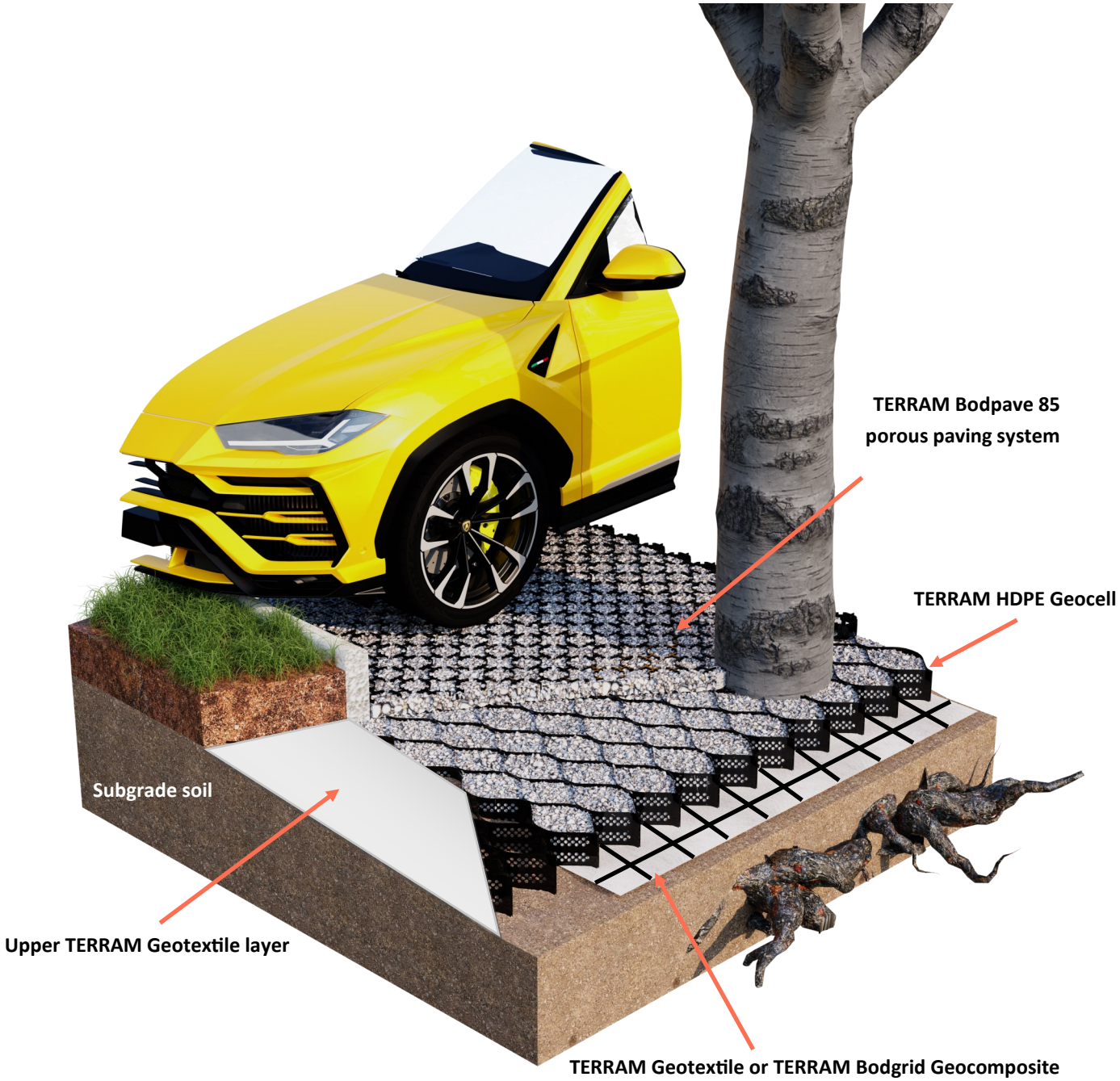

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INSTALLATION 1/4

1. Obtain the approval of the Local Planning Department and Arboricultural Officer for the method of construction proposed and any imposed limitations on the use of mechanical equipment.
2. Remove all debris and reduce surface levels to the allowable reduced dig whilst strictly avoiding soil compaction and tree root damage. Build-up directly on the existing surface levels may be necessary.
3. Ensure that the prepared surface is reasonably even and fill any localised depressions with sharp sand to achieve an even surface profile. Do not roll or consolidate the area.
4. Install tanalised timber edging boards or other approved edge retention to the perimeter of the construction zone as appropriate to the total layer profile thickness. Avoid damage to tree roots when placing fixing posts and pegs.
5. Install a layer of Terram T4000* geotextile across the site, over lapping adjacent rolls by a minimum of 150mm. Lightly pin the geotextile in place until the overlying layers are installed as required.
6. A layer of TERRAM BODGRID Geocomposite may be required depending upon the site soil strength, traffic loading intensity/frequency and any restrictions on build-up depth. Place TERRAM BODGRID with the black geogrid on the top and the white geotextile on the bottom and fix down using steel pins to hold flat. Overlap adjacent rolls by minimum 150mm. Avoid tree root damage and soil compaction.

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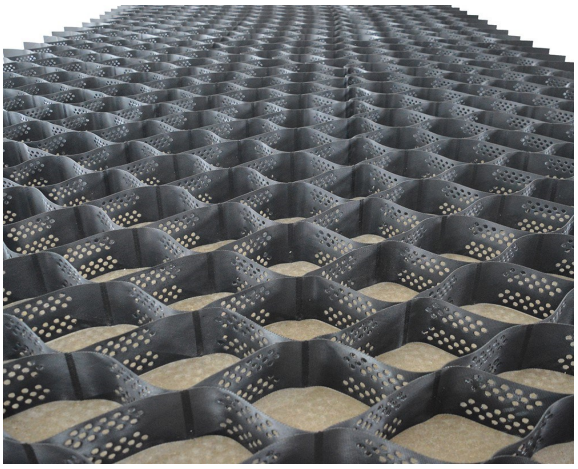
INSTALLATION 2/4

7. TERRAM Geocell panels are very flexible and can easily be installed around obstacles such as trees or structures. TERRAM HDPE Geocell panels can easily be cut by hand using safety cutting tools with a downward action close to the welded joints. Geocell panels can be joined together at every cell with galvanised staples installed with a pneumatic heavy duty stapling plier or UV stabilised nylon cable ties. Changes in gradient and curves can easily be accommodated by either allowing some variations in cell shapes and sizes (over or under expanding the cells) or cutting an entire panel at an angle and then joining to form a taper or L-shape.

8. Open out the TERRAM Geocell layer and pin in place using steel fixing pins or similar approved between the edging boards. The pins hold the cells in an open and fully expanded position during the filling process.

9. Pin spacing will vary according to the site conditions, generally 1m –2m centres on flat surfaces around the perimeter and where panels join. Drive the pins in so that they are just touching the top of the cells but do not compress the fabric and avoid tree root damage. Cut the TERRAM Geocell to suit using a sharp knife/scissors or alternatively fold up against the edgings.



Hooked Knife

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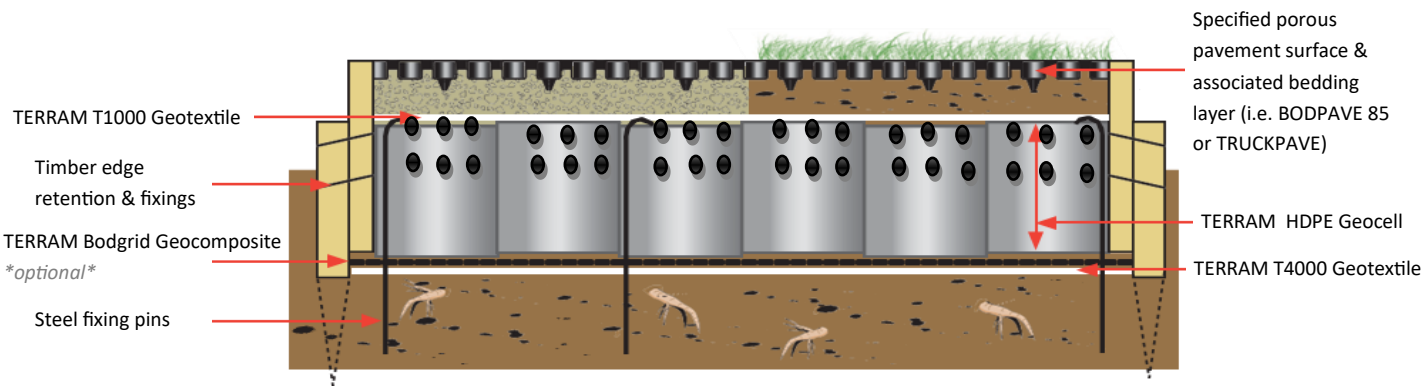
INSTALLATION 3/4

10. Fill the TERRAM HDPE Geocell with a clean, open graded angular aggregate like (4mm - 40mm)** working towards the tree from the furthest point away and using the filled TERRAM HDPE Geocell as a platform. (Single sized, rounded aggregate or DoT Type 1 should not be used). Do not roll the surface, a light vibratory compaction plate may be permitted to settle the stone into the cells; seek advice from the specifier or Arboricultural Officer. Do not contaminate the filled cells with site debris, soil or mud.

11. Install the permeable surface layer such as TERRAM BODPAVE 85, TERRAM TRUCKPAVE, permeable concrete block paving or a porous asphalt on top of the TERRAM HDPE Geocell according to the manufacturer's recommendations. The type of bedding layer will depend upon the specification of the porous surface, an additional layer of TERRAM T1000 (APN 12, 2020) geotextile may be required over the filled HDPE Geocell to prevent loss of the bedding layer material into the voids. Please refer to Specification, Design and Installation Guidance for BODPAVE 85 and TERRAM TRUCKPAVE, or refer to the specific manufacturer's guidance for other surfacing materials.



INSTALLATION 4/4

Installation of Geocell on Curved or irregular sufaces

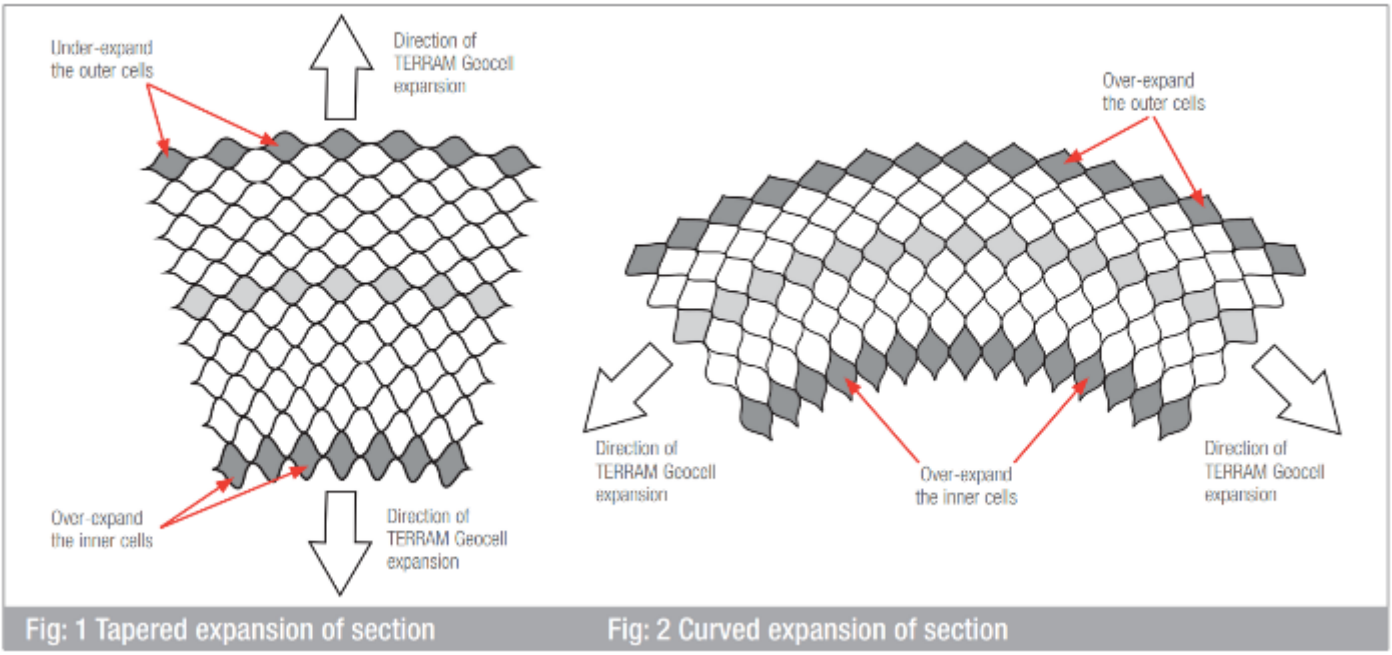


Fig: 1 Tapered expansion of section

Fig: 2 Curved expansion of section

Field cutting of TERRAM Geocell to form tapers and "L"-shapes

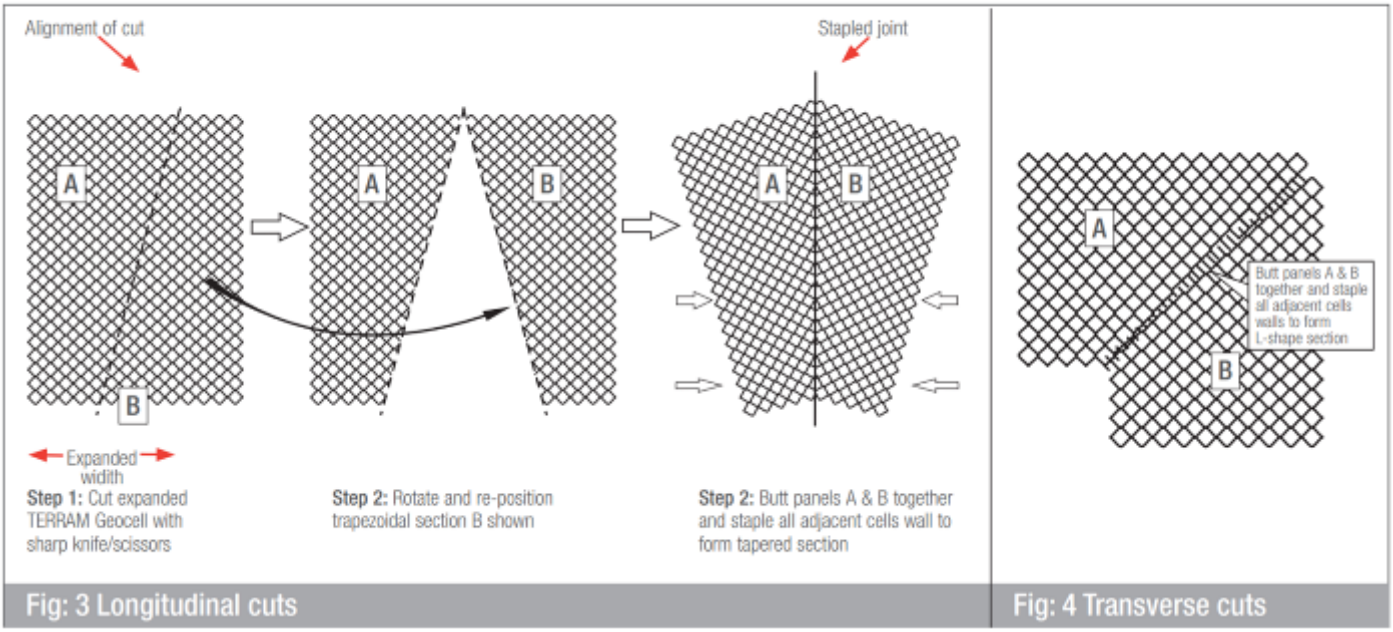


Fig: 3 Longitudinal cuts

Fig: 4 Transverse cuts

INSTALLATION METHOD FOR GEOCELLS FOR TEMPORARY HUAL ROADS

In some applications a TERRAM Geocell may be installed as a temporary haul road base and completely removed after use. Alternatively, a sacrificial stone layer may be installed on the filled Geocell which is removed and replaced with a permanent permeable pavement solution when use of the haul road is complete.

1. Apply all construction detail as for items 1 to 10 above for 'Permanent Access Routes'.
2. Place a separation layer of TERRAM geotextile onto the TERRAM Geocell surface. The geotextile grade will be determined by the specific site design criteria and degree of haul road traffic proposed. E.g. TERRAM T1000 or TERRAM T2000.
3. Place a minimum 100mm thick layer of either clean graded stone or DoT Type 1 sub-base stone onto the TERRAM geotextile.
4. Routinely check for erosion of the surface and repair with additional stone as required to avoid exposure of the separation geotextile.
5. After the haul road use is completed, remove the sacrificial layer of stone and geotextile. Avoid contamination of the open-graded stone within the TERRAM Geocell during removal of the sacrificial stone layer. Alternatively remove the entire construction profile and return the site to its original status. At all times avoid damage to tree roots and soil compaction during removal and disposal of the construction layers.
6. Seek the specifiers' advice on renovation and restoration of the landscaped surfaces within the tree.

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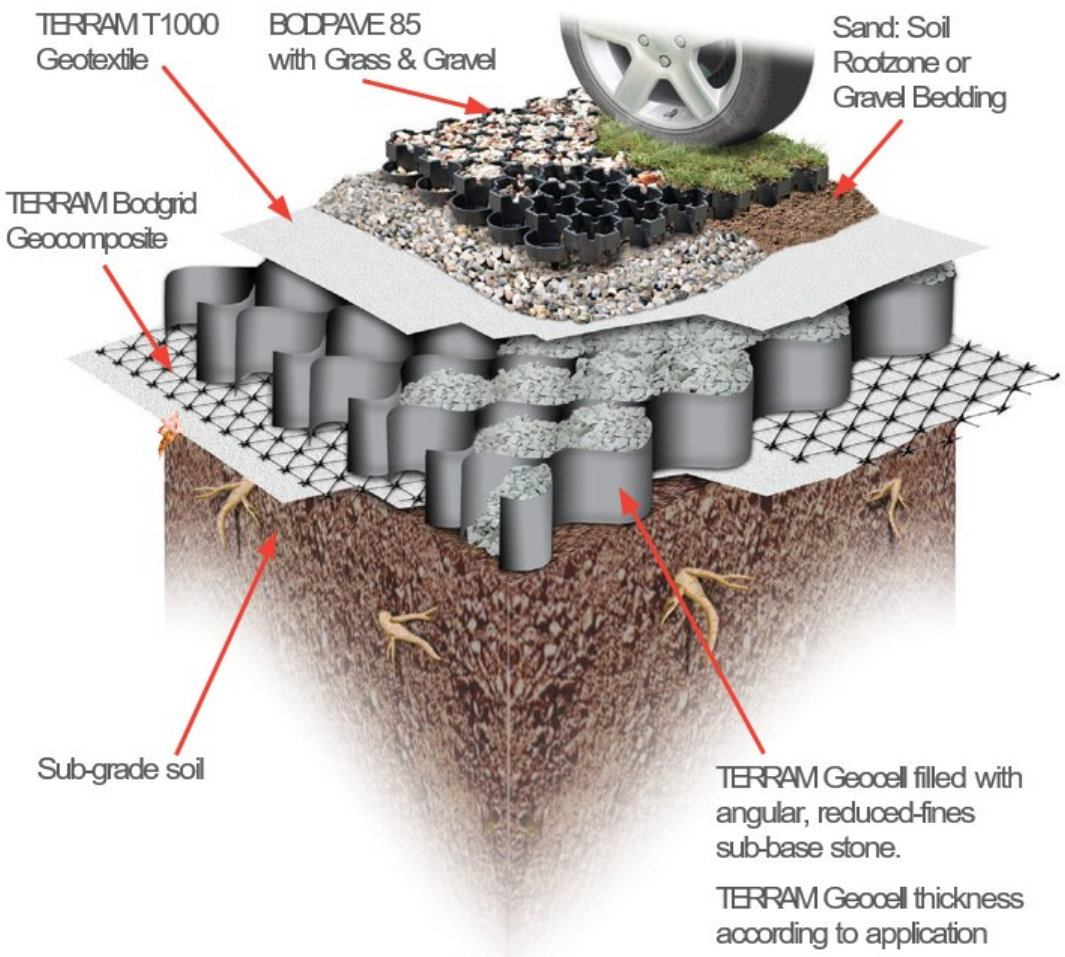
DESIGN NOTES - INTRODUCTION

TERRAM Geocell TRP is a three-dimensional geocellular sub-base confinement system designed for the protection of tree roots where the construction of roads, car parks and access routes are required in the vicinity of trees and where Tree Preservation Orders (TPO) may be enforced. The structure confines and stabilises the sub-base stone ensuring that vehicle loads are dissipated, rutting and soil compaction is prevented and damage to tree roots is avoided. When installed as advised, TERRAM Geocell will also allow the continued passage and circulation of air, water and nutrients to tree roots to sustain a healthy growing environment as recommended by the following 2 documents:

- British Standard BS5837: 'Trees in Relation to Construction' (2012).
- Arboricultural Advisory and Information Services APN12– Driveways Close to Trees.



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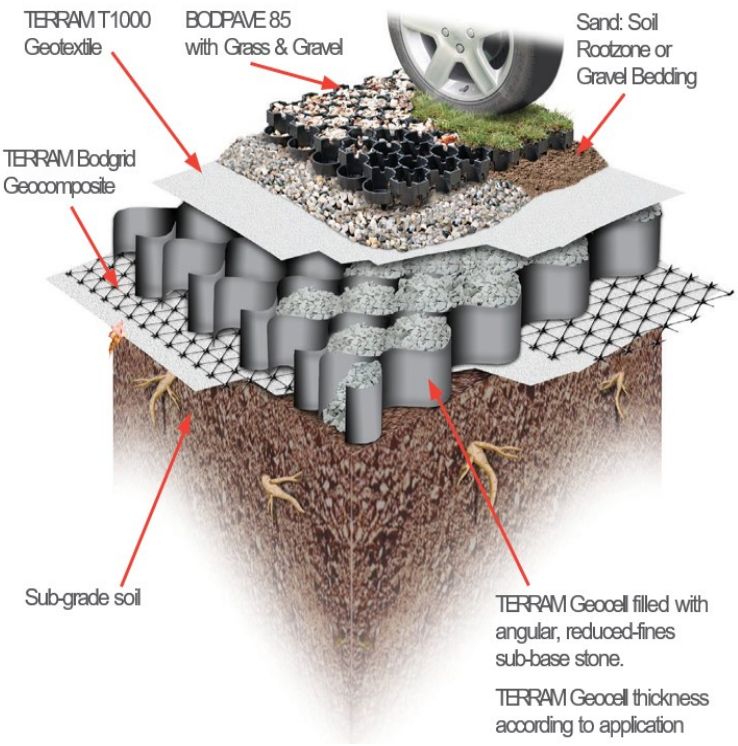
DESIGN NOTES - STANDARDS & COMPLIANCE

1. BS5837 advises that any new permanent hard surfacing should not exceed 20% of any existing unsurfaced ground within the TRP area.
2. HDPE Geocells could be filled with clean, open graded angular aggregate, normally in the particle size range between 4mm-45mm. Clean 4/20 or 4/40 stone. MOT Type 3, Type 1 or single sized aggregate should not be used for tree root protection applications because they contain fine particles. (APN 12, 2020)
3. TERRAM HDPE Geocell layer thickness and inclusion of a geogrid will depend upon subgrade soil strength and proposed traffic loadings. See table 1-6 for further guidance.



4. Specific advice on CBR% strengths, ground conditions and construction over weak ground with a CBR less than 1% is available from TERRAM. CBR% = California Bearing Ratio, a measurement of subgrade soil strength.
5. Soil compaction will severely affect the trees ability to take up water and oxygen; similarly, raising soil levels around trees will deprive roots of oxygen and cause stress and dieback.
6. In most cases 80% - 90% of a tree's root system are in the upper 1m of soil and the small fibrous tree roots are the most important to a tree's health. The fine roots enable transport of oxygen, water and nutrients to the tree via the larger roots which also anchor the tree and provide stability. Severing only a small proportion of the fine surface root structure can severely affect the tree, causing stress, die back and loss of stability.

DESIGN NOTES - CONCEPT

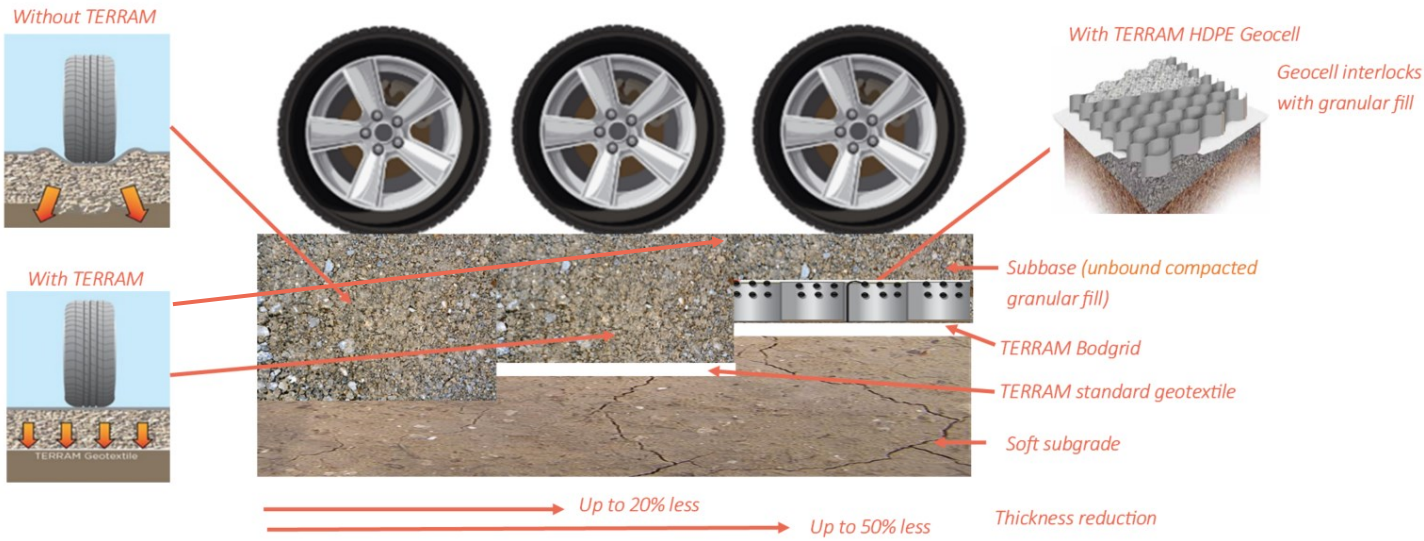
Terram geotextiles have been used in civil engineering projects worldwide for over 50 years to separate subgrade and subbase layers, significantly extending the lifespan of pavements by preserving the integrity of the unbound granular fill layer. Terram HDPE Geocells, in combination with Bodgrid geocomposite and nonwoven geotextile, provide reinforcement, confinement, separation, filtration, and other functions that reduce subbase thickness and enhance the longevity of the pavement foundation.

The thickness and type of granular material used to form the subbase will depend on a number of factors including the following:

1. Strength of the underlying ground (subgrade) generally measured in CBR* %
2. Type of underlying ground (subgrade) E.g. clay/silt/sand/gravel/rock
3. Frequency and intensity of the construction traffic converted to ESA (Equivalent Standard Axles)
4. Water permeability of the underlying ground (subgrade) k measured in m/s
5. Presence of ground water and depth of water table below formation level
6. Finished surface; paved/unpaved and/or permeable/impermeable

*California Bearing Ratio test

A comprehensive ground investigation survey with suitable testing is highly recommended to ensure the subbase is suitably strong and sufficiently durable for the anticipated use. **This design guide can be used for estimating ground conditions and assist with producing preliminary pavement foundation designs, but it is not a substitute for site specific ground investigation works and a detailed pavement design by a suitably qualified civil engineer.**



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DESIGN NOTES - SUBBASE THICKNESS

1. Minimum subbase thickness (Tx) can be selected from tables 1-4 with ground strength and permeability estimated from tables 5 and 6 in the absence of any site-specific ground investigation report.
2. Minimum subbase thickness (Tx) is shown for preliminary pavement foundation designs and estimating purposes only, a detailed site specific design should be undertaken for construction.
3. Minimum subbase thickness (Tx) is based upon a maximum rut depth at the surface of 100mm, aggregate delivered by trucks with rubber road tyres with an overall weight of 20Tn, a maximum axle load of 10Tn and up to 1,000 ESA's of construction traffic required to build the subbase/pavement foundation only.
4. Minimum subbase thickness (Tx) is based upon a well graded compactable angular granular aggregate such as DoT type 1 SHW (Specification for Highways Works) clause 803. To ensure efficient granular interlock with the apertures of Terram Bodgrid, the aggregate fill should have 50% less than 40mm maximum stone size and no more than 15% greater than 80mm. Other granular fill materials may be used (see table 8) but subbase thickness must be increased to allow for a reduction in shear strength.
5. If construction traffic axle load exceeds 100kN (10 Tonnes) an additional static bearing capacity check will be required to confirm if the subbase thickness is sufficient. The nomogram shown below can be used to check initial layer thickness of the subbase (unbound layer) for both unsurfaced and paved roads for axle loads up to 30 tonnes when using a Terram standard geotextile separation layer. For CBR values less than 3% this thickness can be reduced by up to 40% by specifying a layer of Terram Bodgrid. Contact Terram for further advice on subbase layer thickness if construction traffic exceeds 1,000 ESA and axle loads over 100kN (10 Tonnes).
6. The total subbase layer thickness (Tx) must be increased if the Terram Bodgrid or standard geotextile layer is omitted.
7. A Terram standard geotextile separation layer should be specified in accordance with BS8661:2019 with lower subgrade strength (CBR value) requiring a more robust grade.

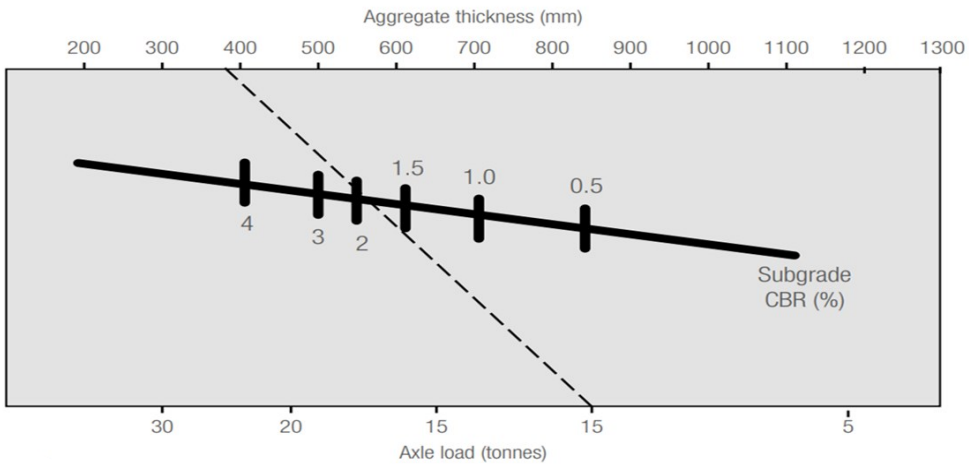

Fig. 1
Example: Subgrade CBR = 2%,
Axle load = 10 tonnes,
Stone thickness required = 350mm

DESIGN NOTES - SUBBASE THICKNESS

TABLE 1 MINIMUM SUBBASE THICKNESS (Tx) WITH HDPE GEOCELL < 60kN (6Tn) AXLE*

SUBGRADE CBR* %	Thickness (mm) #	HDPE GEOCELL	Terram Below Geocell	Terram Above Geocell	Overlap (mm)
1	200	TG356/200mm	GC30	T1000	600
2	200	TG356/200mm	T4000	T1000	500
2	150	TG356/150mm	GC30	T1000	500
3	150	TG356/150mm	T4000	T1000	300
4	100	TG356/100mm	GC30	T1000	300
5+	100	TG356/100mm	T4000	T1000	300

* For CBR values more that 2% and pedestrian loading only 100mm deep Geocell (TG356) should be sufficient, for more info contact TERRAM.

TABLE 2 MINIMUM SUBBASE THICKNESS (Tx) WITHOUT HDPE GEOCELL < 60kN (6Tn) AXLE

SUBGRADE CBR* %	Thickness (mm) #	Standard geotex-tile	Overlap (mm)
1	400	T2000	1000
2	200	T1500	800
3	175	T1000	600
4	175	T1000	450
5+	150	T1000	300

*California Bearing Ratio test

If construction traffic axle load exceeds 60kN (6 Tonnes) and/or the pavement is used as a site access haul road the minimum subbase thickness over TERRAM should be 200mm.

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DESIGN NOTES - SUBBASE THICKNESS

TABLE 3 MINIMUM SUBBASE THICKNESS (Tx) WITH HDPE GEOCELL UP TO 100kN (10Tn) AXLE

SUBGRADE CBR* %	Thickness (mm) #	HDPE GEOCELL	TERRAM Below Geocell	TERRAM Above Geocell	Overlap (mm)
1	300	TG356/150mm (2 layers)	Bodgrid GC30	T1000	600
2	200	TG356/200mm	Bodgrid GC30	T1000	500
3	200	TG356/200mm	T4000	T1000	400
4	150	TG356/150mm	Bodgrid GC30	T1000	300
5+	150	TG356/150mm	T4000	T1000	200

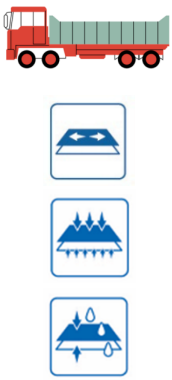
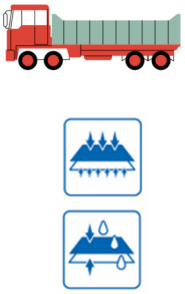


TABLE 4 MINIMUM SUBBASE THICKNESS (Tx) WITHOUT HDPE GEOCELL UP TO 100kN (10Tn) AXLE

SUBGRADE CBR* %	Thickness (mm) #	Standard geotextile	Overlap (mm)
1	600	T2000	1000
2	350	T1500	800
3	300	T1000	600
4	200	T1000	450
5+	200	T1000	300



* California Bearing Ratio test

If construction traffic axle load exceeds 100kN (10 Tonnes) and/or the pavement is used as a site access haul road the minimum subbase thickness should be re-calculated

DESIGN NOTES

TABLE 5 FIELD GUIDANCE FOR ESTIMATING SUBGRADE SOIL STRENGTH

Consistency	Indicator		Strength		
	Tactile (feel)	Visual (observation)	Mechanical (test) SPT	CBR %	Cu Kn/SQM
Very Soft	Hand sample squeezes through fingers	Person standing will sink >75mm	<2	<1	<25
Soft	Easily moulded by finger pressure	Person walking sinks 50-70mm	2-4	~1	~25
Medium	Moulded by moderate finger pressure	Person walking sinks 25mm	4-8	1-2	25-40
Firm	Moulded by strong finger pressure	Utility truck ruts 10-25mm	8-15	2-4	40-75
Stiff	Cannot be moulded but can be indented by thumb	Loaded construction vehicle ruts by 25mm	15-30	4-6	75-150

TABLE 6 TYPICAL SOIL TYPES AND PROPERTIES

Soil Type	Plasticity Index %	CBR% Depth of water table below formation level		Typical soil shear friction angle (°)	Typical undrained shear strength (Cu Kn/SQM)
		>600mm	<600mm		
Heavy clay	70 60 50 40	2 2 2.5 3	1 1.5 2 2		25-65
Silty clay	30	5	3		75-125
Sandy clay	20 10	6 7	4 5		75-200
Silt	Non-plastic	2	1		25-40
Poorly graded sand	Non-plastic	20	10	30	
Well graded sand	Non-plastic	40	15	35	
Well graded sandy gravel	Non-plastic	60	20	38	

CLAY

SILT

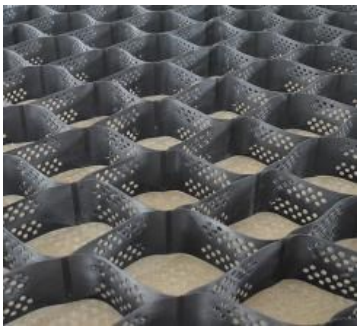
SANDY GRAVEL

This field guide is provided as an aid to assessing the mechanical stabilisation requirements in commonly encountered site conditions. TERRAM accepts no responsibility for any loss or damage resulting from the use of this guide.

MATERIAL SPECIFICATIONS

TABLE 7 HDPE GEOCELL GRADES & DIMENSIONS

TERRAM HDPE GEOCELLS					
Grades	TG330	TG356	TG445	TG660	TG712
Depths (mm)	75, 100, 125, 150, 200				
Cell Width (mm)	244	259	320	488	508
Cell Length (mm)	210	224	287	436	475
Panel width (m)	2.4	2.5	2.5	2.4	2.5
Panel length (m)	6.1	6.5	8.3	12.6	13.7
TERRAM nonwoven standard geotextile					
Grades	T1000	T1500	T2000	T3000	T4000
Tensile strength kN/m	8.5	12.5	14.5	18	22
CBR Puncture resistance kN	1.5	2.2	2.7	3.2	4.3
Standard roll dimensions (m)	4.5 x 100	4.5 x 100	4.5 x 100	4.5 x 100	4.5 x 50
TERRAM steel U-pins					
Type of steel	Mild				
Diameter mm	8				
Length mm	550				
Width mm	100				
Shape	U				
TERRAM BODGRID Geocomposite					
Tensile Strength (Tult)	EN ISO 10319	30 kN/m			
Tensile Elongation (Tult)	EN ISO 10319	7 %			
Roll Dimensions	50m X 4.8m	96kg			



HDPE Geocells

Standard geotextile

Steel U-pins

BODGRID Geocomposite

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MATERIAL SPECIFICATIONS

TABLE 8 TYPICAL GRANULAR FILLS (for subbase construction)

Description	Well graded granular DoT **Type 1**
Aggregate size range	0 to 63mm (<9% fines)
Grading to BS EN 13242	Gc 75/32 1/31.5 (**SHW Clause 803**)
Typical aggregate sources	Crushed quarried rock E.g. Limestone, Granite and Sandstone. Crushed concrete, slag, recycled aggregates.
Description	Well graded granular DoT **Type 2**
Aggregate size range	0 to 63mm (<9% fines)
Grading to BS EN 13242	Gc 75/35 1/31.5 (**SHW Clause 804**)
Typical aggregate sources	Crushed rock, concrete, slag, recycled aggregates, naturalsand and crushed gravel
Description	**Permeable** open graded granular DoT **Type 3** (Type 1x)
Aggregate size range	0 to 80mm (<5% fines)
Grading to BS EN 13242	Gc 80/26 1/40 (**SHW Clause 805**)
Typical aggregate sources	Crushed rock, blast furnace slag and concrete
Description	Asphalt Arisings DoT **Type 4**
Aggregate size range	0 to 63mm (<9% fines)
Grading to BS EN 13242	Gc 75/32 1/31.5 (**SHW Clause 807**)
Typical aggregate sources	Recycled aggregates; asphalt arisings (road planings), crushed rock, crushed slag, crushed concrete
Description	**Clean drainage stone**, course graded aggregate type 4/20
Aggregate size range	0 to 40 mm (<5% fines)
Grading to BS EN 13242	Gc 90/15 4/20
Typical aggregate sources	Hard crushed rock

UNCOMPACTED *COMPACTED*

Type 1

Type 2

Type 3 (1x) - permeable

Type 4 - Asphalt arisings

CGA type 4/20 (Clean stone) - permeable

MATERIAL SPECIFICATIONS

TABLE 9 SUPPLEMENTARY INFORMATION

DESCRIPTION	DATA
Geocell fill material	4mm to 45mm coarse graded aggregate (BS EN 13242 & 7533-13:2009
Geotextile separator layer (Bottom layer)	TERRAM T4000 - see APN 12, 2020
Geogrid reinforcement layer	TERRAM Bodgrid Geocomposite
Upper Geotextile layer	TERRAM T1000 or T2000 Nonwoven Geotextile

Further Reading

- British Standard: BS5837 (2012) – Trees in Relation to Construction - Recommendations.
- Arboricultural Advisory and Information Services APN12 (2020)– Driveways Close to Trees.
- 'Tree Root Systems'. (M. Dobson 1995) – Arboricultural Research Information Note 130/ARB/95.
- 'Driveways Close to Trees' (M. Dobson / D. Patch 1996). Arboricultural Practice Note 1.
- 'Guidance for Trees: Conflict or Compliment?'. (R. Nicholson 2001). Arboricultural Journal No. 25.

This field guide is provided as an aid to assessing the mechanical stabilisation requirements in commonly encountered site conditions. TERRAM accepts no responsibility for any loss or damage resulting from the use of this guide.

***It is recommended that the base geotextile is made of polypropylene or polyester (min. 300g/m2) with a CBR puncture resistance of 4000N. (APN 12, 2020)**

**** When geocells are used for tree protection, MOT Type 1, Type 2 and Type 3 are not suitable for use as infill because they contain fines. For cellular confinement systems above tree root zones, given the size of the geocells and the interlock required, the infill should ideally be crushed 20/40 stone (this means stones that are between 20mm and 40mm in diameter). However, where this is not available 4/20 stone can be used. In all situations the infill material should be washed or graded so that it contains no fine particles (fines). (APN12, 2020)**

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