

TENSAR® GEOSYNTHETICS IN CIVIL ENGINEERING

A GUIDE TO PRODUCTS, SYSTEMS
AND SERVICES



Tensar®



Tensorar® Technology – proven, practical products and systems and the know-how to get them built

Tensorar® Technology is widely adopted for Subgrade Stabilisation and Pavement Optimisation to improve the structural performance of paved roads and unbound roads and platforms. Tensorar Technology is also adopted for Earth Retaining Systems for cost effectiveness and versatility over other traditional methods. By delivering real savings in cost and time, Tensorar Technology can help you improve the bottom line on your project as well as preserving the invested capital.



For Over 30 Years, Tensorar has Provided Economical Solutions to Common Infrastructure and Site Development Needs

LEADING INTERNATIONALLY

Tensorar International Limited (Tensorar) is a worldwide leader in the manufacture and the provision of products and systems for subgrade stabilisation, pavement optimisation and soil reinforcement. Our expertise and experience has been accumulated over several decades of successful collaboration in projects internationally. Our service team, comprising many qualified civil engineers, provides practical and best value advice and design to support the use of Tensorar products and systems in your application.

INNOVATIVE, BEST VALUE SOLUTIONS IN THOUSANDS OF APPLICATIONS

Tensorar's high-performance range of innovative geogrids has been continuously developed since being introduced in the 1970s as the first geosynthetic products of their type. The outstanding performance of Tensorar® geogrids and geotextiles has benefited thousands of road, rail, runway, embankment and many other applications across the world. Tensorar products are available wherever subgrade stabilisation, pavement optimisation and soil reinforcement are required through Tensorar regional offices, or specialist distributor networks.

INDEPENDENTLY PROVEN PERFORMANCE

Our state-of-the-art geogrid and geotextile products have been rigorously and exhaustively tested by leading universities, independent laboratories and national authorities, under research and site conditions. Many Tensorar products and systems hold internationally recognised certification, and can provide cost-effective, timesaving and lasting solutions to widely encountered civil engineering problems.

PARTNERSHIP FOR SUCCESS

Tensorar's range of support services is an integral part of every project partnership. Our team of design and applications engineers can work with you from the outset to ensure that our products, systems and designs are tailored to your exact requirements, to help you achieve your project objectives on time and to budget.





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Subgrade Stabilisation

IMPROVING THE STRUCTURAL PERFORMANCE OF UNBOUND ROADS AND PLATFORMS WITH A TENSAR® MECHANICALLY STABILISED LAYER (MSL)

There are now unprecedented demands to design economic and environmentally sustainable roads, container ports, car parks, airfields and hardstandings sited over weak or variable ground. Tensar can provide high performance geogrid-based systems which meet these demands.

The structural contribution made by Tensar® TriAx® geogrids is to stabilise the unbound layers of roads and trafficked areas to create a mechanically stabilised layer. Aggregate particles interlock with the geogrid and are confined within the apertures, creating an enhanced composite material with improved performance characteristics.

TriAx geogrids have isotropic, radial stiffness producing a truly multi-directional product.

Independent trials have confirmed that the shape and form of the ribs and junctions of Tensar geogrids contribute to the performance of the mechanically stabilised layer.

Since 1980, several hundred million square metres of Tensar geogrids have been successfully incorporated into a wide range of sites under diverse working and climatic conditions.



Choosing the Subgrade Stabilisation Solution for your Project

Since Tensar introduced stiff polymer geogrids, more than 30 years ago, they have become a major component of civil engineering projects.

A project may require only one geogrid application or it may be necessary for a solution that involves a combination of applications.

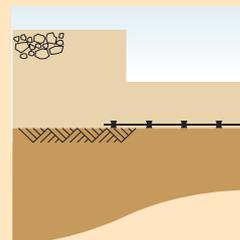
Our technical service levels range from a free Application Suggestion for your own project design to Design and Supply where Tensar can take over the responsibility for the design of mechanically stabilised layers based on agreed design parameters. Tensar can provide project specifications and certified calculations.

COST SAVINGS AND REDUCED EMISSIONS

Tensar TriAx geogrids combine major cost savings with considerable performance benefits in granular capping, sub-base and other aggregate layers. When compared with a non-stabilised aggregate layer, TriAx can:

- ▶ Give savings in granular thickness of up to 50% with no performance loss
- ▶ Provide a reduction of excavated soil together with conservation of natural aggregates
- ▶ Control differential settlement
- ▶ Reduce disturbance and weakening of sensitive subgrade formations
- ▶ Improve fill compaction
- ▶ Increase design life
- ▶ Increase bearing capacity
- ▶ Give savings of up to 50% on construction CO₂ emissions

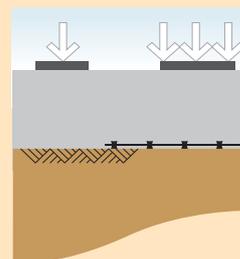
THE MAJOR SUBGRADE STABILISATION APPLICATIONS FOR TENSAR® TECHNOLOGY



REDUCING LAYER THICKNESS

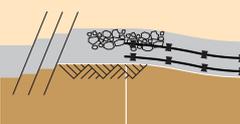
Numerous research programmes[†] over the years have consistently proven the high stabilisation factors attributed to Tensar geogrids. With the improved performance from Tensar® TriAx® geogrids, Tensar Technology now offers even greater reductions in aggregate.

[†] See Tensar Subgrade Stabilisation brochure



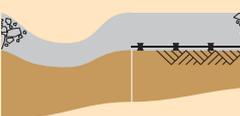
INCREASING BEARING CAPACITY

By applying Tensar Technology the load spreading capability of a Tensar TriAx stabilised layer can increase the bearing capacity of working platforms for heavy-duty plant, cranes and piling rigs.



CONTROLLING DIFFERENTIAL SETTLEMENT

Multiple layers of Tensar TriAx geogrids in an aggregate layer create a flexurally stiff platform. Through the use of Tensar Technology the effects of a variable quality of support from a foundation soil can be smoothed out.

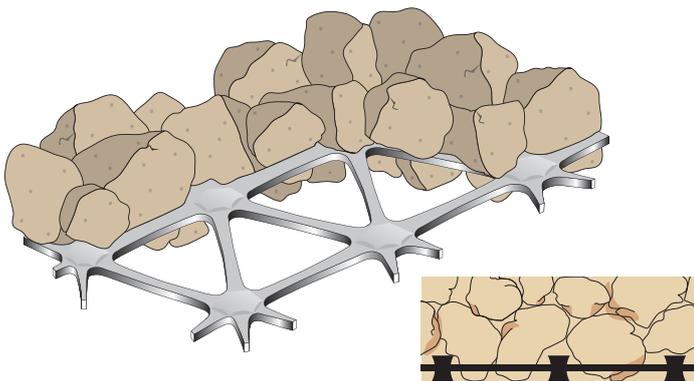


CAPPING WEAK DEPOSITS

Where the ground is exceptionally weak, Tensar TriAx Technology is available to enable a capping operation. Tensar TriAx geogrids enable safe placement and compaction of the fill when capping sludge lagoons and industrial waste deposits.



TriAx® gives improved aggregate confinement and interaction, leading to improved structural performance of the mechanically stabilised layer.



Particle interlock and the effect of confinement enhances compaction over weak ground and increases the stiffness of the aggregate layer above.



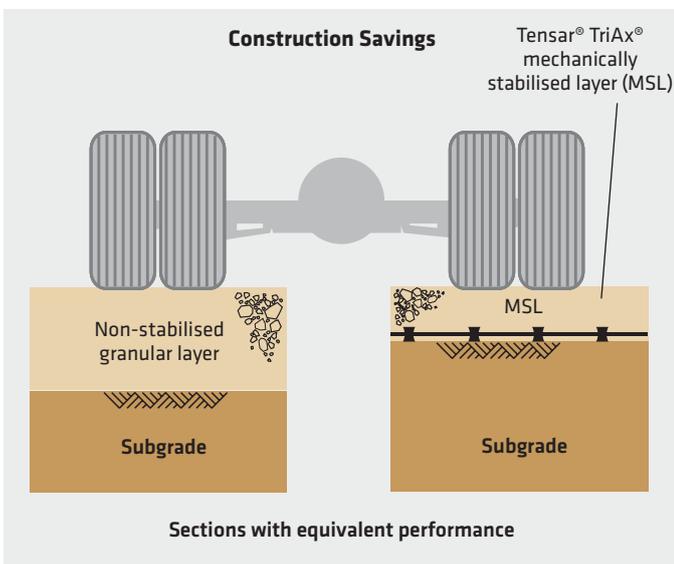
CAPPING WEAK DEPOSITS

Tensor has continued to develop and refine techniques for capping weak deposits and is seen by engineers as the preferred method for capping sludge lagoons and industrial waste deposits.



INCREASING BEARING CAPACITY

On weak subgrades, it is often necessary to construct access roads or working platforms that have to bear very heavy loads. Tensor has a proven design method for safe working platforms incorporating TriAx that delivers significant savings to contractors.



TriAx enables significant savings in granular thickness and consequent reduction in construction CO₂ emissions.



Pavement Optimisation

IMPROVING THE STRUCTURAL PERFORMANCE OF WHOLE PAVEMENTS WITH A TENSAR® MECHANICALLY STABILISED LAYER (MSL)

The Tensar® Spectra® Pavement Optimisation System provides you with the tools and confidence to optimise your whole pavement designs, allowing you to meet individual customer needs or project requirements whilst reducing construction and long-term maintenance costs. The Spectra Pavement Optimisation System gives you the proven performance of our Tensar's Mechanically Stabilised Layer (MSL), design tools and background experience to make sure your whole pavement life is preserved along with the invested capital.



Extend Pavement Life with the Spectra® Pavement Optimisation System

The Spectra Pavement Optimisation System exploits the proven performance of a mechanically stabilised layer of aggregate incorporating TriAx geogrids. The system comprises of the following components:

TENSAR MECHANICALLY STABILISED LAYER (MSL)

Granular layers stabilised with Tensar TriAx geogrids will perform as a composite due to the interlock mechanism that develops between the aggregate and the stiff geogrid structure. This geogrid/aggregate composite is known as a Tensar MSL.

DESIGN TOOLS

The performance properties of the Tensar mechanically stabilised layer can be included in pavement analysis allowing designers to benefit from:

- ▶ Proven pavement design methodology
- ▶ Life cycle cost analysis assessment (LCCA)
- ▶ Environmental assessment in terms of carbon footprint (CO₂)
- ▶ Performance based system specifications

STABILISATION

The European Organisation for Technical Assessment (EOTA®) www.eota.eu, define stabilisation as the beneficial consequence on the serviceability of an unbound granular layer via the inhibition of the movement of the particles of that layer under applied load. This is the result of the mechanical effect of confinement on an aggregate layer, resulting from the mechanism of interlock provided by a structure (see EOTA Technical Report TR 41, edition October 2012).

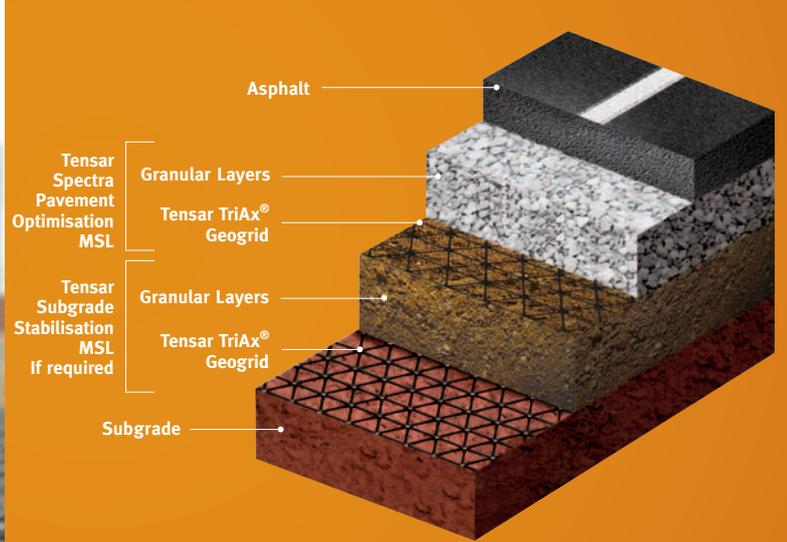
RESEARCH AND PERFORMANCE TESTING

The enhanced performance properties of stabilised layers incorporating Tensar geogrid have been the subject of extensive research including the use of full scale accelerated pavement facilities at the US Corps of Engineers and the University of Illinois in the USA. This research is in keeping with AASHTO's endorsement of quantifying the benefits of geosynthetics in pavements with full scale performance data (Ref: AASHTO R50-09).

This extensive investment in research has allowed the development of Tensar stabilisation factors that represent the influence on the whole pavement of Tensar TriAx geogrids in an aggregate layer.



Tensar has carried out years of laboratory research and numerous full scale tests to evaluate the stabilisation effect of Tensar geogrids in flexible pavements.



The Spectra® Pavement Optimisation System can Enhance Structural Performance of Whole Pavements

The Spectra® Pavement Optimisation System uses the improved performance properties of a Tensor mechanically stabilised layer (MSL) in whole pavement construction to give designers an innovative way of reducing both aggregate and asphalt costs and increasing value in road construction.

Reducing Construction Costs and Longer Term Maintenance Needs

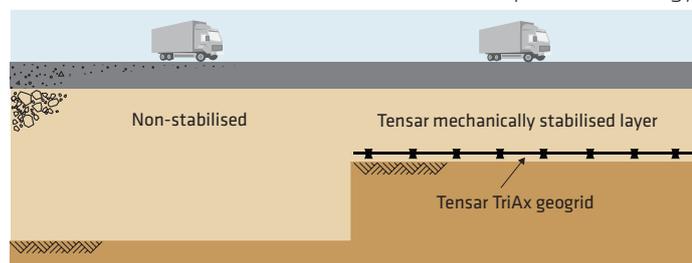
The Spectra Pavement Optimisation System provides the tools and confidence to pavement design engineers to optimise their pavement designs to suit individual customer or project requirements and demonstrate the increased value available with this proven technology.

REDUCED PAVEMENT THICKNESS

The Spectra Pavement Optimisation System has been shown to reduce overall pavement layer thickness by as much as 50% whilst maintaining performance targets.

By reducing the quantities of aggregate and/or asphalt required in the final pavement construction, benefits can be demonstrated in terms of:

- ▶ Cash savings in the delivery, placement and compaction of aggregate and/or asphalt materials
- ▶ Carbon savings in the extraction, delivery and installation of aggregate and asphalt materials

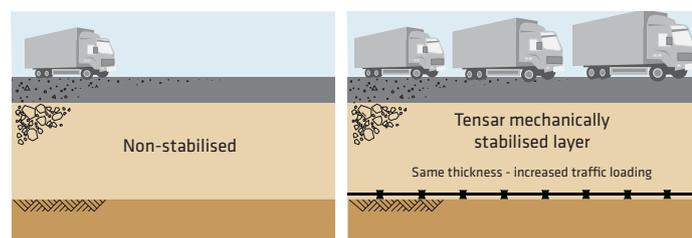


Large reductions in aggregate fill can be achieved (up to 50%) without compromising the road performance.

INCREASED PAVEMENT LIFE

The adoption of the Spectra Pavement Optimisation System can extend the service life of a road and offer benefits in terms of:

- ▶ Increased time between maintenance operations
- ▶ Ability to carry higher traffic load without increasing layer thickness



Increased traffic life without increasing pavement layer thickness.

REDUCED LIFE CYCLE COST

By applying the Spectra Pavement Optimisation System, life cycle costs can be reduced by:

- ▶ Reducing initial construction costs
- ▶ Increasing pavement performance to reduce maintenance and rehabilitation costs
- ▶ Increasing end of life salvage value



A pavement stabilised with Tensor TriAx geogrids can minimise structural deterioration and preserve the whole pavement.

TensarTech® Earth Retaining Systems permit the construction of steeper slopes with the benefits of speed and versatility



TensarTech Systems for Earth Retaining Slopes can shorten construction times and minimise traffic disruption.

TensarTech® Earth Retaining Systems for Slopes

VERSATILE AND PROVEN SYSTEMS TO SUIT YOUR SCHEMES

TensarTech® Earth Retaining Systems permit the construction of steeper slopes with the benefits of speed and versatility and offer huge cost savings of up to 75% over alternative methods.

With ever increasing building constraints, including environmental and rising land costs, Tensar provides a variety of systems for slopes of up to 70° offering a number of finishes to fit in with your construction schemes.

Crucially the variety of systems we offer can help with early planning approval at the beginning of a scheme or can allow for greater aesthetic flexibility than those offered by traditional earth retaining schemes.

TensarTech® GreenSlope System

PRACTICAL, ECONOMICAL AND ATTRACTIVE CONSTRUCTION UP TO 70°

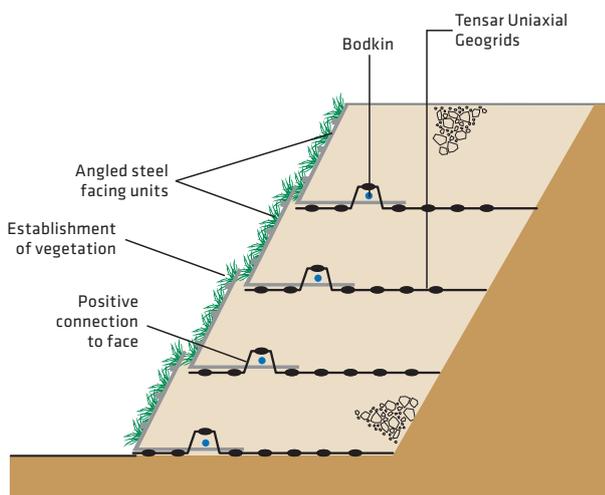
The TensarTech® GreenSlope System is designed for building soil structures with a sloped face of up to 70°.

The facing consists of durable steel units connected to the geogrids using Tensar's highly efficient bodkin connection. During installation these are lined with selected anti-erosion mats, allowing the chosen vegetation cover to establish itself upon the slope, whether these are climbing plants, grasses or simply ground cover.

The cost effectiveness of the TensarTech GreenSlope offers many advantages over traditional concrete structures and has a more attractive appearance than gabions or crib walling.

TENSARTECH EARTH RETAINING SYSTEMS FOR SLOPES CAN:

- ▶ Allow rapid and economical construction
- ▶ Maximise the plateau area on a sloping site
- ▶ Tolerate differential settlement
- ▶ Optimise the use of available space
- ▶ May allow use of site-won materials (including cohesive or contaminated), or recycled fill materials
- ▶ Provide high resistance to earthquake loading
- ▶ Often avoid expensive foundation treatment



A typical section through the TensarTech GreenSlope System shown with a stepped face to aid irrigation of the vegetation.



The TensarTech GreenSlope System can provide practical solutions to otherwise difficult building projects.



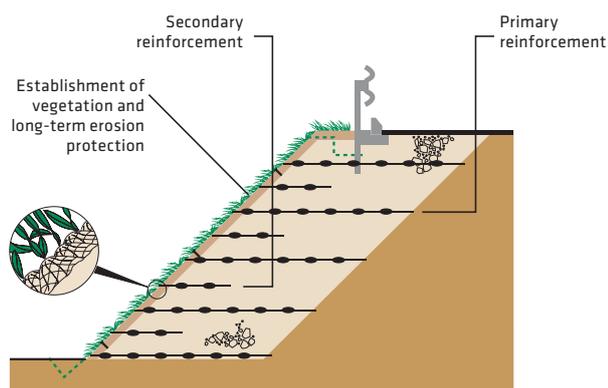
The TensorTech NaturalGreen System can provide a durable, cost-effective and attractive flood defence.

TensorTech® NaturalGreen System

TENSARTECH® NATURALGREEN IS AN ESTABLISHED AND PROVEN SYSTEM WHEN BUILDING SOIL SLOPES OF UP TO 45°

The system relies on Tensor's proven geogrids to reinforce the soil mass, providing the structure with long-term stability and a high quality composite erosion protection material at the slope face to help establish the chosen vegetation and stabilise the roots systems. This mesh composite provides all the root support and moisture retention necessary for productive and sustained growth for the slope covering.

In addition Tensor is able to offer advice on construction and vegetation selection ensuring optimum growth and cover.



Tensor's proven geogrids reinforce the soil mass providing long-term stability.

TensorTech® SlipRepair System

QUICK AND EFFICIENT REPAIR OF SOIL EMBANKMENTS OR CUTTINGS

Tensor® geogrids can be used to provide a quicker, cost-effective and more environmentally friendly alternative to the customary techniques for slip repair.

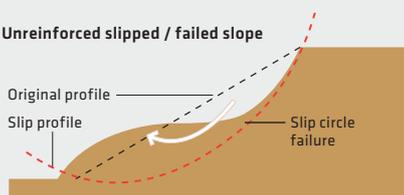
Traditionally these would involve the excavation and off-site transportation of failed fill material. Replacing these materials often with imported granular fill is not only time consuming and expensive but can incur landfill and aggregate taxation as well as being environmentally damaging.

Tensor provides a solution whereby the excavated soil can be returned and reinforced with geogrids, reducing the need for additional on-site imports. Construction activity on-site is significantly improved as off-site movements are kept to a minimum.

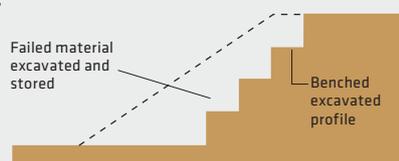
- ▶ Reduction in off-site tipping
- ▶ Reduction in imported fill
- ▶ Less transportation costs and pollution
- ▶ Minimising traffic disruption and lane closures
- ▶ More economic than traditional methods by up to 75%
- ▶ Meeting sustainable construction objectives

A TYPICAL SECTION THROUGH A TENSARTECH SLIPREPAIR

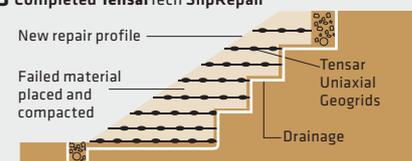
1 Unreinforced slipped / failed slope



2



3 Completed TensorTech SlipRepair





TensarTech® Wall Systems such as this TW1 modular block wall are suitable for the most demanding applications and are versatile enough to accommodate both technical and aesthetic requirements.

TensarTech® Earth Retaining Systems for Wall and Bridge Abutments

A Comprehensive Range of Solutions and Advice for Your Projects

TensarTech® Wall Systems have a proven worldwide reputation for quality in the construction of retaining walls and bridge abutments, with savings of up to 50% on traditional concrete structures.

TensarTech Wall Systems utilise uniaxial geogrids for soil reinforcement leading to rapid and cost-effective construction.

We offer free application suggestions to support your own designs or you can select a Design and Supply contract, based on a design brief, including specifications, drawings and certified designs.

The wide ranging options in facing materials will give the designer and builder the opportunity to meet the aesthetic demands as well as providing economic options on cost and finish.

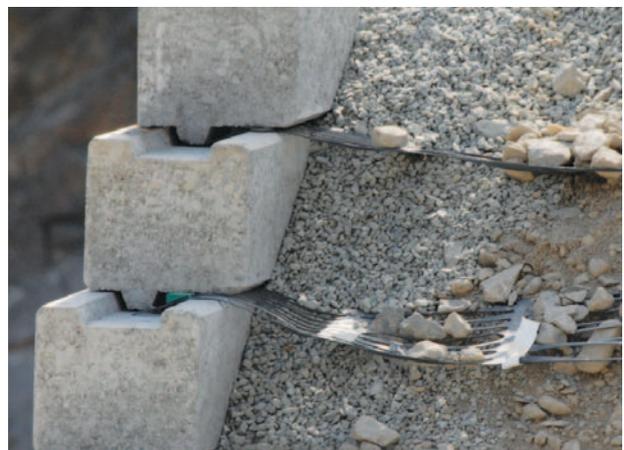
- ▶ Long-term design stability using proven, independently certified products and systems
- ▶ Simply constructed systems to reduce build times and resulting costs
- ▶ An aesthetically appealing end result
- ▶ Modular block systems are dry laid without using mortar
- ▶ Easily form complex or curved geometry
- ▶ Durability – 120 year design life
- ▶ Possibility of using site-won fill materials
- ▶ High resistance to dynamic and seismic shock loadings
- ▶ May avoid the need for piling or ground treatment

Tensar Offers a Range of TensarTech® Modular Block Wall Systems

TENSARTECH MODULAR BLOCK WALL SYSTEMS SAVE TIME AND PROVE MORE ECONOMIC

The TensarTech Wall System offers a combination of concrete modular facing blocks and reinforcing soil geogrids to create strong and durable retaining wall structures. A highly efficient connection is made between the facing block and geogrid creating a durable, strong retention system.

The distinctive and aesthetic quality of the facing blocks permit internal and external curves, corners and stairs to be easily detailed allowing for easier and quicker installation. With a wide range of finishes and colours combined with special attention to the detail such as corners and copings, it is possible to create strong architectural results easily and cost effectively.



A feature common to all TensarTech Wall Systems is the high efficiency of the connection between geogrid and the chosen facing, in this case the TW1 Wall System.

Significant Savings on Time, Budget and Design

Costs can be kept to a minimum with the TensarTech® TW Wall System which can be built without the need for cranes or propping. Facing units are simple to install and connection to the face is easy yet secure. Proven benefits include significant time savings and up to 50% on traditional build costs, combined with durability and a wide choice of finishes.



TensarTech Wall System – a combination of coloured facing blocks is used for dramatic effect on this bridge wingwall.

Tensar – Making the Right Choice for Your Building Projects

Tensar offers a broad variety of cost-effective and attractive solutions for retaining walls. Whether they are to provide long term permanent solutions or for temporary works, we have a variety of systems available.

TENSARTECH PANEL SYSTEM

Pre-cast full height or incremental facing panels are connected to the geogrid reinforcement creating a wall clear of horizontal joints. The installation is quick and a variety of finishes can be added to the fascias.

TENSARTECH ROCKWALL SYSTEM

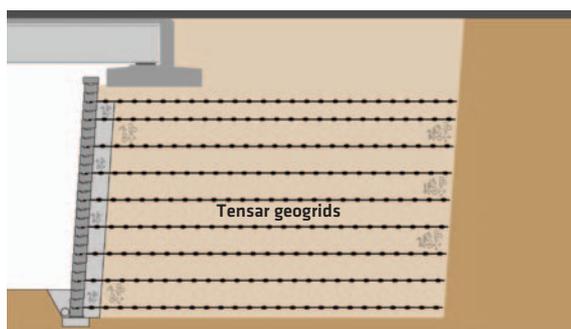
This method replaces the traditional mass gabion gravity structure with a single rock filled steel facing unit, securely connected to the geogrid reinforcement. Reductions can be made in both the cost and time of placing rockfill.

TENSARTECH MARINE SYSTEM

Suited to aggressive marine conditions, these large sized stable blocks are designed so that no propping is required through construction.

TENSARTECH TR2 SYSTEM

This system is aimed mainly at temporary structures where practicality and economy are more important than aesthetics. Designed principally for contractors' temporary works situations, these simple to build, low cost structures have also been successfully adapted as thrust-relief structures.



A typical section through a Tensar load bearing bridge abutment detailed here with a modular block facing.

TENSARTECH ECOCRIB SYSTEM

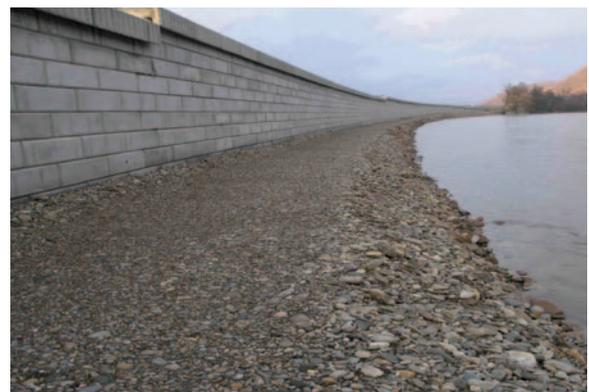
This system provides an aesthetically pleasing alternative to a timber or concrete finish. The crib facing is manufactured from 100% UK waste mixed polymer.

TENSARTECH SLOPELOC SYSTEM

An aesthetically pleasing concrete finish, TensarTech SlopeLoc is designed for the construction of reinforced soil walls with a 68° face angle and a concrete ribbed face in a variety of colours.



A variety of panels and finishes can be applied with either pre-cast or cast on-site panels.



A TensarTech Marine System is well suited to aggressive coastal or tidal conditions such as harbour and river locations.

Whatever the particular circumstances and problems, we can offer advanced, cost-effective and proven solutions.



Tensar® Basetex™ geotextile installation at Oran airport in Algeria providing cost-effective installation and offering permanent high strength reinforcement below the fill layer.

Embankments Over Weak Ground

PROVEN RELIABLE GROUND REINFORCEMENT SOLUTIONS THAT ARE BOTH RAPID AND INEXPENSIVE

When faced with building embankments over soft ground, it may not be economical or environmentally viable to excavate and dispose of the poor soil and replace it with granular fill. In such cases, Tensar can help with the best option from a range of possible techniques. Whatever the particular circumstances and problems, we can offer advanced, cost-effective and proven solutions.

When stability rather than settlement is the problem, the use of Tensar® geogrids will allow initial access over a soft formation and permit embankment construction to take place in a controlled and safe manner.

Tensar geogrids and Tensar® Basetex™ geotextiles can be placed as a single layer, or as multi-layer reinforcement, at the base of the embankment to intersect potential failure surfaces extending into the foundation.

The use of Tensar Basetex geotextiles can avoid staged construction delays and, if vertical drains are used, will allow greater surcharges to be applied safely to the weak foundation to accelerate settlement. Tensar Basetex can also be used as a tensioned membrane between piles.



TensarTech® Stratum Foundation Mattress System is used here to control differential settlement over variable ground.

When there is a danger of collapse into underlying voids such as in areas of shallow mine workings or dissolution features, a reinforced layer may be constructed by using either Tensar geogrids with granular fill to form a stiffened raft, or Tensar Basetex, as a tensioned membrane, to provide short term support should a void appear prior to a permanent repair.

TensarTech® Stratum™ Cellular Foundation Mattress System

When the need is to reduce differential settlement or maximise the bearing capacity from a relatively thin soft formation, a TensarTech® Stratum™ Cellular Foundation Mattress System can provide the base strengthening.

The TensarTech Stratum System is a 1 m deep, open top, continuous cellular structure formed from geogrids and strong connectors. It is placed on the subsoil and filled with granular material. This creates a stiff foundation for the embankment as well as safely allowing initial construction access over the soft site.

Use of the TensarTech Stratum Cellular Foundation Mattress System results in rapid construction with no need for excavation and removal of subsoil.

TENSAR CAN OFFER DESIGN IN EMBANKMENT FOUNDATIONS

Tensar has a range of proven and economical solutions for construction over soft or variable ground that can:

- ▶ Allow rapid construction
- ▶ Allow safe access for operatives and machinery
- ▶ Avoid excavation and replacement
- ▶ Reduce loss of fill into weak foundations
- ▶ Reduce differential settlement
- ▶ Enable safe spanning of voids



TensarTech® Plateau™ Load Transfer Platform System

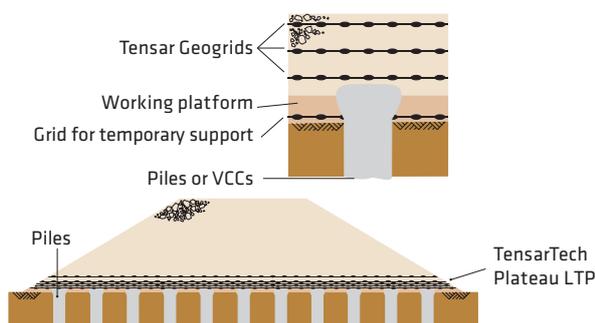
Project programme constraints can mean that there is insufficient time to allow for consolidation settlement to occur after placing embankment fill over soft compressible soils. In this situation, a deep foundation solution may be the only way to resolve such a problem.

The TensarTech® Plateau™ Load Transfer Platform (LTP) can distribute embankment load efficiently onto a series of piles or vibro concrete columns (VCCs) which bear on firmer strata below. This avoids the cost of using a concrete raft. Depending on ground conditions, the most economic solution could be to form the LTP from good quality granular fill reinforced with multiple layers of Tensar® grids. Alternatively a design using Tensar® Basetex™ can be employed to accommodate poorer quality fill. Tensar LTPs have also been successfully used below concrete ground floor slabs in order to avoid designing the slabs to span between piles.

Controlling Differential Settlement

When settlement restrictions dictate that a deep foundation solution is required to support an embankment or ground-bearing slab, an TensarTech Plateau LTP can:

- ▶ Avoid the need for concrete rafts
- ▶ Mean simple and rapid construction
- ▶ Be used under ground-bearing slabs to provide a uniform quality of support



Second Severn Crossing Bridge Toll Plaza supported on Tensar geogrid LTP (UK).



LTP to support a concrete ground floor slab beneath a steel portal frame building (UK).



Road construction using an LTP over peat (Indonesia).

Tensor asphalt reinforcement products have been proven by up to 30 years of success in many countries and in a range of climates.



Asphalt Pavements

HELPING YOU DELIVER INCREASED VALUE FROM YOUR ROADS MAINTENANCE BUDGET

Tensor asphalt reinforcement applications have been demonstrated to increase the service life of roads and thereby save significant maintenance costs and traffic disruption.

Tensor asphalt reinforcement products have been proven by up to 30 years of success in many countries and in a range of climates.

Tensor offers you a solution to suit the conditions and requirements of your project. Tensor asphalt reinforcement applications have been designed to address structural pavement issues; fatigue cracking, reflective cracking and to provide resistance to asphalt rutting and mitigation of cracking due to differential settlement during road widening projects.

BENEFITS THROUGH EXPERIENCE

By selecting the appropriate Tensor solutions, proven benefits can include:

- ▶ Significantly reduced reflective and fatigue cracking
- ▶ Reduced rutting
- ▶ Extended pavement structural life
- ▶ Quick installation
- ▶ Long-term cost savings compared with traditional rehabilitation methods
- ▶ Durable and efficient solution
- ▶ Technology proven over more than 25 years of experience
- ▶ Delivery through Tensor or through our network of specialist installers and distributors



Common structural pavement problems, rutting, fatigue and reflective cracking.



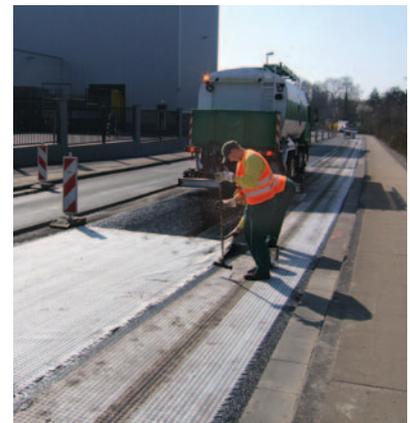
Mechanical installation of Tensar® Glasstex™ is fast and efficient; an experienced crew can install up to 12,000m² per day, per tanker.



AR-GN bonds well into the underlying surface.



Glasstex®Patch™ 880 can be applied to most sound substrates utilising the adhesive coating.



A simple overlap joint for Tensar Glasstex.



Paving takes place directly over the Tensar AR-GN.



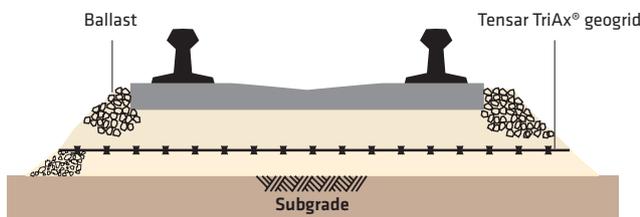
Stabilisation of the ballast layer using **Tensar® TriAx®** geogrids can substantially delay track settlement, increasing periods between maintenance operations.



Tensar® TriAx® geogrids installed under the granular sub-ballast layer to increase bearing capacity (Belgium).

Railway Trackbed Stabilisation

Two Major Applications for the use of **Tensar TriAx®** Geogrids within the Track Substructure



Mechanical stabilisation of the ballast layer to reduce the rate of track settlement.

REDUCING BALLAST DEFORMATION THROUGH THE MECHANICAL STABILISATION OF THE BALLAST LAYER

Poor track geometry and a loss of vertical and horizontal alignment of the rails is a major reason for line speed restrictions and track maintenance work. These can significantly affect schedules and are expensive and disruptive to the public and the train operators.

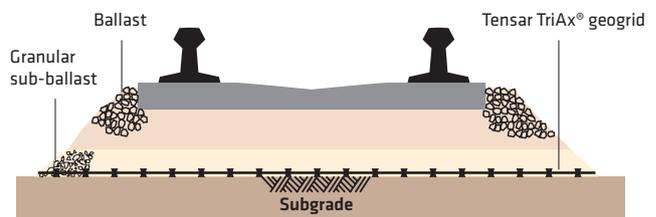
Track maintenance, involving ballast tamping or full ballast replacement, arises not only on weak subgrades but also on firmer supporting soils.

Mechanical stabilisation of ballast, using **Tensar** geogrids, gives the railway engineer a rapid solution as well as increasing the period between maintenance operations with huge whole life benefits.

Tensar geogrids have been used to stabilise track ballast since the early 1980s to decrease maintenance costs and maintain ride quality.



*Track reconstruction over low bearing capacity subgrade soils using **Tensar® TriAx®** mechanically stabilised sub-ballast. (Bratislava, Slovakia).*



Stabilisation of the granular sub-ballast layer to increase the bearing capacity over soft subgrade.

IMPROVING TRACK FOUNDATION THROUGH THE MECHANICAL STABILISATION OF SUB-BALLAST LAYER

When constructing track over soft subgrade soils having a low bearing capacity, it is necessary to improve the foundation to support the ballast effectively. This can involve a time consuming chemical stabilisation of the subgrade or deep excavation followed by importation and placement of a thick and expensive granular sub-ballast layer.

Introducing a **Tensar** mechanically stabilised layer using **TriAx®** geogrids, enables a significant reduction of sub-ballast layer thickness for the same bearing capacity.

This results in reduction of subgrade excavation and spoil disposal and much less imported sub-ballast fill, while still achieving the target stiffness value required for the support of the ballast.

Tensar has extensive experience in mechanically stabilising sub-ballast layers, especially in the upgrading of European railway corridors, that has resulted in many successful cost-effective installations.

RESEARCH SHOWS THAT TENSAR GEOGRIDS CAN:

- ▶ Reduce the rate of ballast settlement
- ▶ Maintain track geometry for longer
- ▶ Extend the maintenance cycle by a factor of about 3
- ▶ Function in ballast for more than 20 years
- ▶ Reduce traffic-induced ballast degradation



Tensor® erosion products provide a high-performance and economical solution for the control of erosion.

A green and cost-effective bioengineering solution that improves the visual landscape.

Tensor Erosion Control

EROSION CONTROL MATTERS

Very often, construction can mean removing vegetation, altering the landscape and/or covering previously vegetated areas with roads, driveways or buildings. These changes often cause soil erosion and sediment deposits.

THE BENEFITS

Erosion control, sediment control and vegetation establishment are essential to almost every construction project. A well-planned solution tailored to your site can:

- ▶ Eliminate costly reconstruction of degraded slopes and shorelines
- ▶ Prevent damage to landscapes, water sources and wildlife
- ▶ Keep you in compliance with local regulations

HOLD YOUR GROUND

Tensor has top quality solutions for almost every erosion control need. Our products are rigorously tested and are proven to be effective in a wide range of real-world applications including:

- ▶ Slopes and embankments
- ▶ Landfills
- ▶ Shorelines
- ▶ Ditches and culvert outfalls
- ▶ Levees and earthen dams
- ▶ Channels and spillways
- ▶ Bioengineering



Application of HydraMax erosion control on the M25 Motorway, UK.

ROLLMAX™ ROLLED EROSION CONTROL

Every site has unique challenges created by soil characteristics, topography, climate and other environmental conditions. Tensor can cover them all, with our family of RollMax™ Rolled Erosion Control Products (RECPs). Whether you need temporary or permanent protection, short-term or long-term durability, biodegradable or photodegradable solutions.

Permanent Turf Reinforcement Mats (TRMs) are ideal for high-flow channels, shorelines and stream banks while Erosion Control Blankets (ECBs) will help to prevent erosion whilst establishing vegetation.

HYDRAMAX™ HYDRAULIC EROSION CONTROL

Hydraulic Erosion Control Products (HECPs) prevent erosion and aid vegetation establishment on slopes. Tensor's HydraMax™ Systems apply seed, soil amendments and hydraulic mulch in one step, offering a low-cost, low-labour solution. Standard or high performance products are available to suit all gradients of slopes.

REVETMAX™ FLEXIBLE REVETMENT

Flexible revetment mats provide cost-effective erosion protection from turbulent water flow and moderate wave attack. Tensor's patent-pending RevetMax™ System when combined with a Tensor® Turf Reinforcement Mat (TRM) or other underlayment offers a unique armouring solution and dramatically elevates permissible shear stress and velocity protection.

SEDIMAX™ SEDIMENT RETENTION

Unprotected topsoil, particularly on slopes and construction sites, is vulnerable to erosion and runoff problems. Tensor's SediMax™ Systems can prevent much of the damage and save millions spent on restoring slopes, rebuilding drainage channels and dredging ponds and streams.

TRITON® COASTAL AND WATERWAYS SYSTEMS

For heavier-duty, non-vegetative scour protection applications our Triton® composite marine systems are perfect used in conjunction with or alternatively to RevetMax™ Systems. Durable, non-corrosive Triton mattresses, marine cells, gabions and gabion mats are less expensive and more scour resistant than rigid systems.



Tensar Support Services

We Offer Experience and Reliability for Unsurpassed Product Support

LEADERS IN VALUE-ENGINEERED SYSTEMS

We offer the services of a team of professionals who can assist in developing concepts to support the use of Tensar Products and Systems in your design (we call these Applications Suggestions) or undertake full construction design for your project. We also provide advice and initial training on site to assist you to effectively install our products and systems in your project.

Our range of innovative products is combined with our global experience of thousands of projects in a wide variety of climatic conditions and soil types. This means that we provide you with a unique specialist civil engineering viewpoint on how to use our products and systems and proven, best value solutions in your application.

We are committed to providing the highest levels of technical assistance in the field to support the use of our products and systems such as technical training seminars and on-site support to provide you with cost-effective and lasting solutions. Our own dedicated and trained teams of civil engineers or those of Tensar local distributors work in partnerships with you to ensure the success of your project.

TENSARPAVE™ AND TENSARSOIL™ DESIGN SOFTWARE

By using the design programs offered by Tensar, the design engineer can save valuable time by generating designs in-house. To assist the design engineer with this process, the Tensar Design and Technical Support team is available to give advice and offer a design checking service.

SPECTRAPAVE4-PRO™ SOFTWARE

The SpectraPave4-Pro™ software will enable the generation of designed pavement structures with options available to engineers in terms of layer thickness and pavement life to yield optimised cost and carbon savings.

TENSAR CAN TAILOR OUR SERVICES TO SUPPORT YOUR DESIGN NEEDS

- 1 SUPPLY ONLY**
- 2 APPLICATION SUGGESTION & SUPPLY**
Conceptual drawing, calculation and advice to support your decision to use Tensar products and systems in your application
- 3 DESIGN & SUPPLY**
Detailed design and construction drawings for using Tensar products and systems on your project

Our service range includes project specific advice on concepts, design, construction and installation, as well as general training on Tensar applications and your use of Tensar's proprietary software.

By engaging our team at the earliest stages of your project, we can help you save time and money during the initial feasibility phases by developing concepts and assessing the design feasibility of using Tensar products or systems, and by providing indicative budget costs.

TECHNICAL SUPPORT

We can also support your projects with construction and installation guidelines, with independent certification documentation and with specification notes to assist in the production of contract documents and installation procedures. These are backed by an extensive range of case studies, product specifications and in-depth technical papers.

TRAINING

- ▶ Comprehensive hands-on technical workshops
- ▶ Personal training or seminars tailored to your requirements



TensorTech® Systems are versatile and meet the environmental and economic demands of any project, as demonstrated on this earth retaining wall supporting a ten lane road that will navigate through the mountainous landscape between Fuhairah and Dubai (UAE).



DESIGN SUPPORT

- ▶ Application advice to assist you with your design concept
- ▶ Design advice to assist you in incorporating Tensor product and systems in your project
- ▶ Application suggestion providing our design concept for further consideration and design by you
- ▶ Detailed costing to enable you to competitively price Tensor in your project or bid
- ▶ Design review of your design which incorporates our products or systems
- ▶ Detailed design and construction drawings for using Tensor products and systems on your project

CONSTRUCTION SUPPORT

- ▶ Initial installation advice on how to install Tensor on your project
- ▶ Initial installation training to demonstrate installation of our product
- ▶ Construction advice to answer practical questions on Tensor installation while construction progresses

TENSOR TRIAX CARBON CALCULATOR

The Tensor Carbon Calculator estimates the percentage CO₂ saving by using Tensor TriAx geogrid in a mechanically stabilised layer when compared with the construction of an unstabilised road foundation.

Taking into consideration the carbon cost of manufacturing Tensor TriAx geogrids and delivering the geogrids to site, the Tensor Carbon Calculator works out potential savings in materials and transport when using TriAx geogrids. Savings in construction CO₂ emissions of up to 50% can be achieved when compared with an unstabilised road foundation.



www.tensorcarboncalculator.com



Independent Certification

Tensar® geogrids have been given accreditation by a number of independent government and other certifying agencies around the world. No other soil reinforcement material has such a wide range of certification.

- ▶ The British Board of Agrément has awarded HAPAS (Highway Authorities Product Approval Scheme) certificates both for retaining walls and abutments, and for steep slopes.



TENSAR RE AND RES00 GEOGRIDS FOR REINFORCED SOIL RETAINING WALL AND BRIDGE ABUTMENTS.



TENSAR RE AND RES00 GEOGRIDS FOR REINFORCED SOIL EMBANKMENTS.

- ▶ Tensar TriAx® TX190L geogrids have been granted Network Rail Product Acceptance Certification (Number PA05 157/100470) for the Structural Stabilisation of Ballasted Trackbed.



- ▶ In Hong Kong, the Geotechnical Engineering Office has awarded Certificate RF 2/2013 for the use of Tensar RE500 geogrids in reinforced fill structures.



Reinforced Fill Product Certificate No RF2/2013 for Tensar RE500 Geogrids

- ▶ The Roads & Maritime Services (RMS) Sydney, Australia has certified Tensar uniaxial geogrids under Specification R57 "Design of Reinforced Soil Walls".

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Contact Tensar or your local distributor to receive further literature covering Tensar products and applications.

Also available on request are product specifications, installation guides and specification notes.

The complete range of Tensar literature consists of:

- ▶ **Tensar® Geosynthetics in Civil Engineering**

A guide to products, systems and services

- ▶ **Subgrade Stabilisation**

Stabilising unbound layers in roads and trafficked areas with a Tensar MSL

- ▶ **Spectra® Pavement Optimisation System**

Improving the structural performance of whole pavements with a Tensar MSL

- ▶ **Asphalt Pavements**

Reinforcing asphalt layers in roads and trafficked areas

- ▶ **TensarTech® Earth Retaining Systems**

Bridge abutments, retaining walls and steep slopes

- ▶ **Railways**

Mechanical stabilisation of track ballast and sub-ballast

- ▶ **TensarTech® Plateau™**

Load transfer platform system over piled foundations

- ▶ **Basal Reinforcement**

Using Basetex high-strength geotextiles

- ▶ **TensarTech® Stratum™**

Cellular foundation mattress system for foundations with controlled settlement

- ▶ **Tensar Erosion Control**

A guide to products and systems