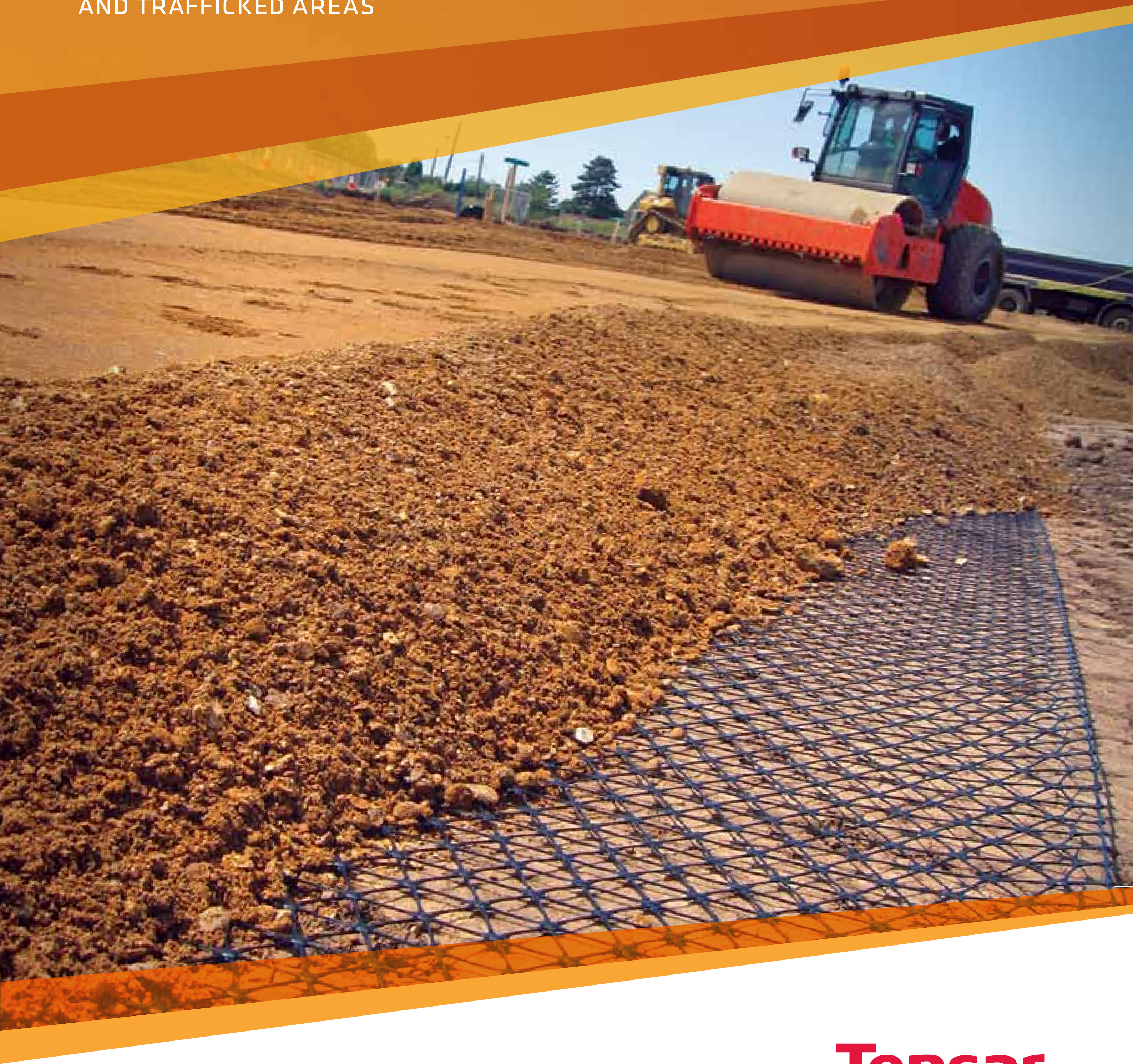
ROADS AND PLATFORMS

SUBGRADE STABILISATION

MECHANICALLY STABILISED LAYERS FOR ROADS AND TRAFFICKED AREAS



Tensar®

❯Tensar® TriAx® Geogrids have proven to be extremely efficient at confining and stabilising aggregate. TriAx has replaced Tensar biaxial geogrids in most stabilisation applications, delivering even greater cost savings.

Tensar Technology – Proven Practical Solutions and the Know-How to Build Them

Based on the characteristic properties of Tensar geogrids, Tensar Technology is widely adopted for ground stabilisation and soil reinforcement problems, delivering real savings in cost and time. We can help you apply Tensar Technology to improve the bottom line on your project.

A GUIDE TO CHOOSING THE SUBGRADE STABILISATION SOLUTION FOR YOUR PROJECT

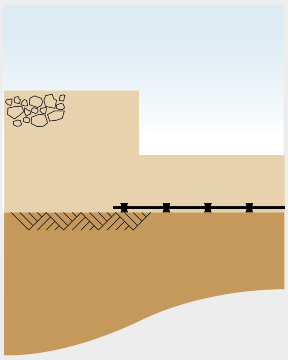
Since Tensar introduced stiff polymer geogrids, over 30 years ago, they have become a major component of civil engineering projects.

A project may require only one geogrid application or it may be necessary to devise solutions that involve a combination of applications.

There are six major subgrade stabilisation applications for geogrids.

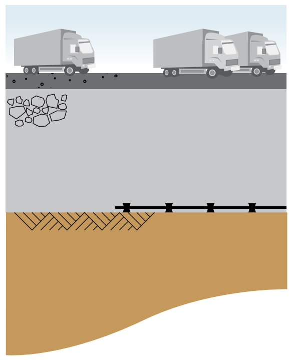
The Six Major Subgrade Stabilisation Applications for Tensar Technology

REDUCING LAYER THICKNESS



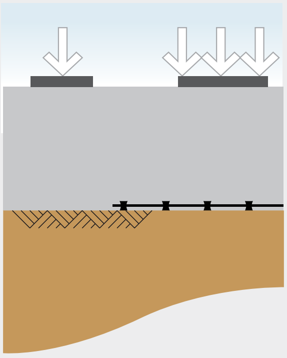
Numerous research programmes over the years have consistently proven the high stabilisation factors attributed to Tensar geogrids. With the improved performance from Tensar® TriAx® geogrids, Tensar Technology now offers even greater reductions in aggregate.

INCREASING LIFE



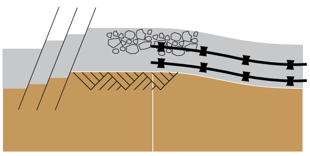
The use of Tensar TriAx geogrids in pavement layers can extend the service life of the road and therefore the use of Tensar Technology makes significant savings in maintenance budgets.

INCREASING BEARING CAPACITY



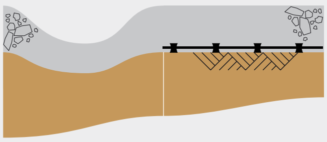
By applying Tensar Technology, the load spreading capability of a Tensar® TriAx® mechanically stabilised layer can increase the bearing capacity of working platforms for heavy-duty plant, cranes and piling rigs.

CONTROLLING DIFFERENTIAL SETTLEMENT



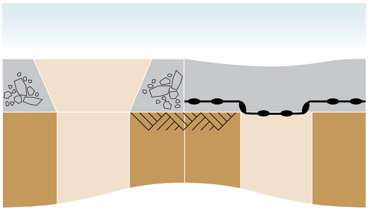
Multiple layers of Tensar TriAx geogrids in an aggregate layer create a flexurally stiff platform. Through the use of Tensar Technology the effects of a variable quality of support from a foundation soil can be smoothed out.

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.

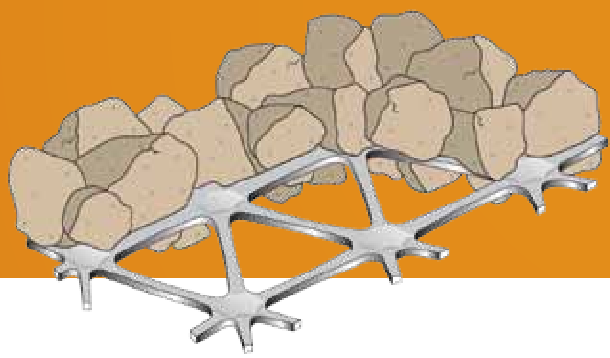
SPANNING VOIDS



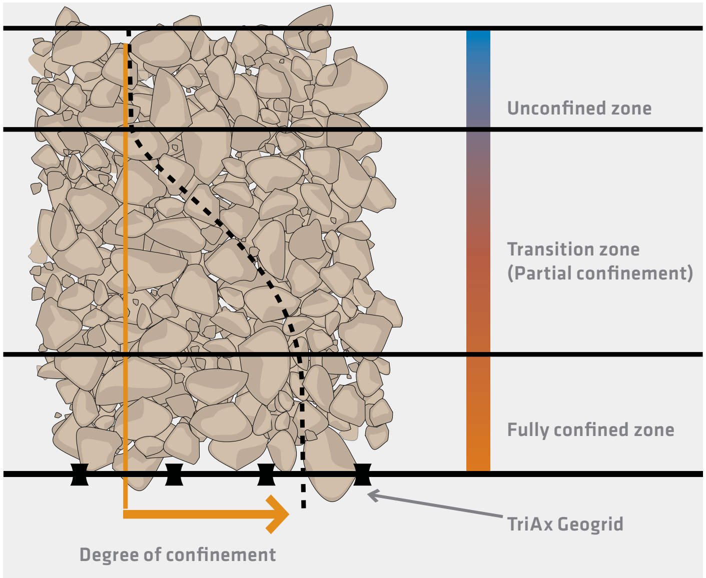
In areas where subgrade soils are prone to erosion, dissolution or collapse, Tensar biaxial geogrids along with Tensar Technology provide a support function to maintain safety pending response and a more permanent repair. This is not a true stabilisation application as the geogrid is required to perform more of a reinforcement function.

Tensar® TriAx® Geogrids Work by Confining Aggregate Particles

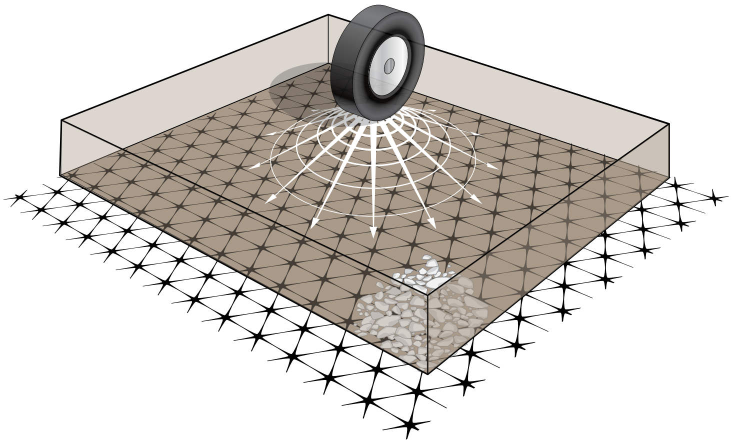
Tensar® TriAx® geogrids can solve stabilisation problems because they interlock very efficiently with granular materials. When granular particles are compacted over these geogrids, they partially penetrate and project through the apertures and abut against the ribs. Interlock is the mechanism by which the geogrid and aggregate interact under an applied load. This mechanism results in confinement and lateral restraint of the granular particles.



The Interlock Mechanism



Aggregate confinement within a mechanically stabilised layer. An efficient stabilisation material such as Tensar TriAx geogrid creates a high degree of internal confinement.



For a stabilised layer to be effective it must have the ability to distribute load through 360 degrees. To ensure optimum performance, the geogrid in a mechanically stabilised layer should have a high radial stiffness throughout the full 360 degrees.

The Versatility of Tensar® Geogrids

Since the early 1980s several hundred million square metres of Tensar geogrids have been used in tens of thousands of projects. In 2007, Tensar TriAx geogrids were introduced to provide a significant advancement in geogrid technology.

Tensar geogrids have been used in many countries in the world, under a wide variety of climates and soil conditions, and frequently Tensar Technology has been used to solve difficult design or construction problems. The Tensar TriAx manufacturing process produces a hexagonal geogrid structure consisting of high strength junctions and stiff ribs forming equilateral triangular apertures. The ribs present a thick square leading edge to the aggregate which allows the geogrid ribs to get a good "grip" on the aggregate particles, and results in effective mechanical interlock. Efficient interlock helps control lateral movement and dilation of aggregate particles, so that a very high effective angle of shearing resistance is mobilised. This effect is also referred to as "confinement," because interlock efficiently confines and restrains the aggregate particles.

The combination of these features ensures that, in Tensar TriAx geogrid stabilised granular layers:

- Tensile load in the geogrid is generated at very small deflections in supporting an applied vertical load
- The strain in the geogrid is very small at working loads
- Stabilisation benefit is localised and can be generated within the loaded area
- The Tensar geogrid and granular material together form a composite – a Tensar mechanically stabilised layer (msl)

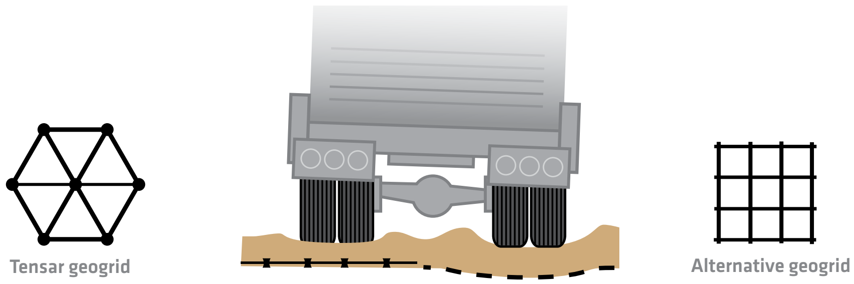
The essential features of TriAx are the strength and rigidity of junctions and thick ribs.

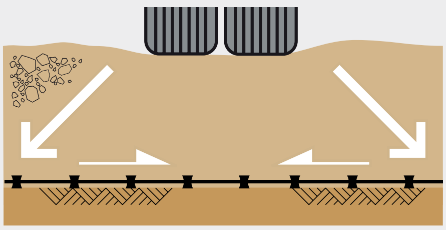
TriAx rib structure directly influences the efficiency of the stabilised layer.

Do All Geogrids Work in the Same Way?

This is a common question when considering the benefits of using geogrids – particularly in a road pavement. The answer is, **'No, geogrids perform differently and a good indicator of the reinforcing effect is the method of manufacture.'** The quality of the mechanical interlock is not the same when comparing the Tensar® manufacturing process with other methods of forming geogrids such as extruding, weaving and welding.

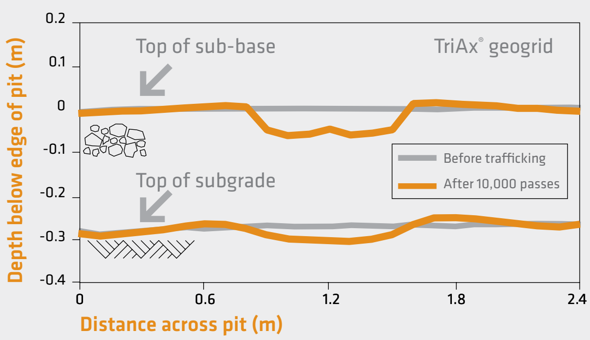
Tensar designs are based on the proven mechanism of interlock and the lateral confinement of the aggregate. Most geogrids produced by other methods of manufacture that create different ribs, junctions and apertures, perform as 'tensioned membranes.' The tensioned membrane performance requires large deformations along the fixed alignment of the wheel paths. See the evidence for this below.



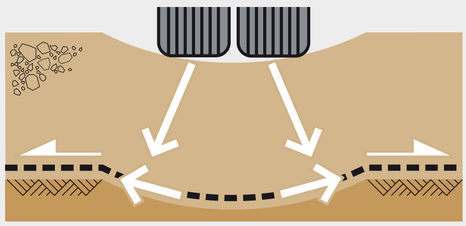


TENSAR GEOGRID STABILISED LAYER – INTERLOCK AND CONFINEMENT MECHANISM

- Interlock and confinement stiffens the aggregate layer
- Load spread is increased
- Vertical stress is reduced
- Performance is improved

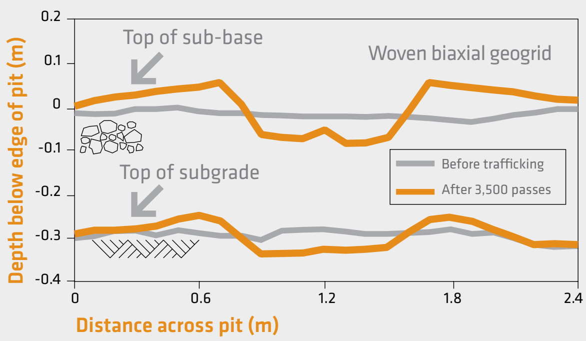


Tensar TriAx manufactured using punched and drawn process.



ALTERNATIVE GEOGRID REINFORCED LAYER – TENSIONED MEMBRANE MECHANISM

- Alternative geogrid tensioned membrane needs anchorage at edges
- Load is directed to geogrid membrane
- Geogrid and subgrade deform
- Performance gain only after extensive trafficking
- Wheel path must be maintained within rut line to maintain the effect



Alternative geogrid manufactured using alternative process.

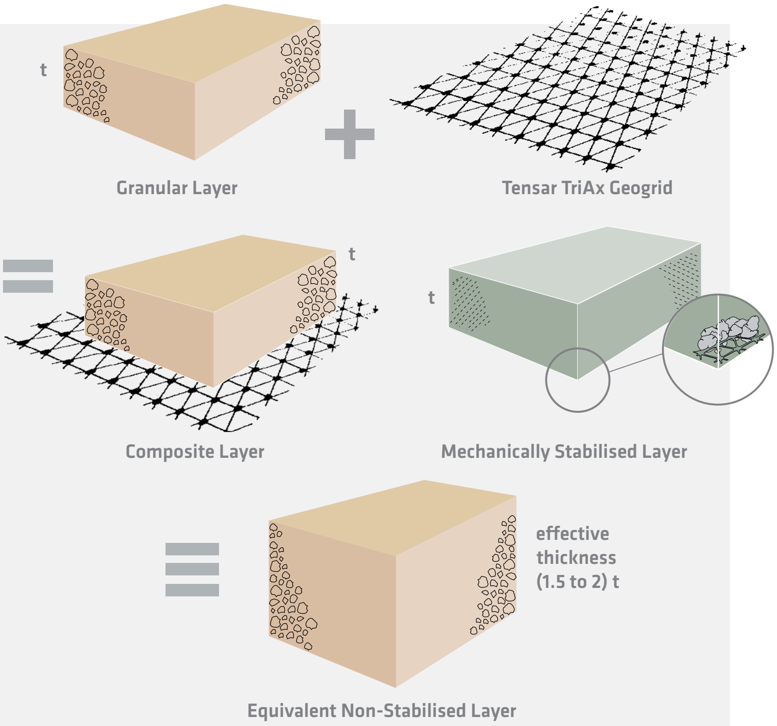
The confinement effect and physical properties of Tensar TriAx punched and drawn geogrid result in reduced rutting compared with other forms of geogrids. This difference in performance is emphasised by the rut profiles, shown above, measured as part of a detailed pavement trial carried out by TRL (Transport Research Laboratory, UK). These are cross-sections of the trial pavement, showing both the top of the sub-base (300 mm thick) and the top of the subgrade (CBR = 1.5%), before and after completion of trafficking. After 3,500 passes a deep rut has formed in the surface of the alternative geogrid (tensioned membrane) reinforced sub-base with a considerable amount of deformation. A similar rut has developed at the top of the subgrade. This results in remoulding and softening of the subgrade. For the Tensar section (interlock and confinement), after 10,000 passes the rut in the sub-base is much smaller with little deformation, and the rut in the subgrade is negligible. The performance of Tensar geogrid is clearly and significantly different to geogrids manufactured by other methods (welded, woven, etc.).

Tensar® Mechanically Stabilised Layers

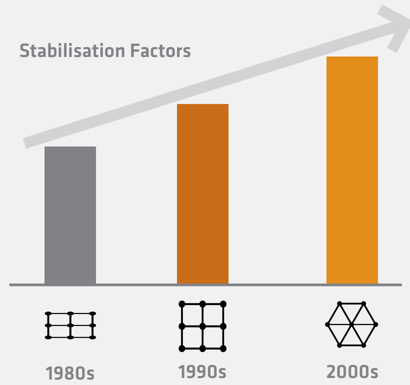
Granular layers stabilised with Tensar® TriAx® geogrids perform as a composite due to the interlock mechanism. The geogrid/aggregate composite can then be regarded as a Tensar® Mechanically Stabilised Layer (MSL).

Designers and specifiers can choose to specify a Tensar Mechanically Stabilised Layer and be confident in the knowledge that the properties and performance of the composite are known and definable.

The 'equivalent non-stabilised layer' can be thought of in different ways and therefore it can be introduced into existing design methods according to how the concept would fit best. The following ranges would normally apply in most designs.



Design parameters	Tensar range of effective increases	Units
Thickness 't'	1.5<t<2.5	mm
Modulus 'E'	1.5<E<3.0	kN/m²
Traffic load 'TIF'	3<TIF<15	Standard axles



Tensar Stabilisation Factors – Improvements in geogrid technology were achieved based on knowledge gained over the last 30 years.

Quantifying the Performance Benefit

Starting with small-scale laboratory work and moving to full-scale trafficking

In order to define the effective thickness of Tensar Mechanically Stabilised Layers, common performance data has been accumulated from numerous monitored trials on full-scale trafficking demonstrations over many years; initially with Tensar biaxial geogrids and more recently with TriAx geogrid.

__A) 1981 –__ Testing of Tensar geogrids for subgrade stabilisation commenced in 1981 with some very simple bearing tests that demonstrated the benefit of the interlock mechanism.

__B) 1985 –__ Tensar has shown complete commitment to full-scale testing over a period of more than 20 years.

***1992 –** Laboratory testing is repeatedly confirmed by on-site trials*

***1996 –** The lateral confinement function of Tensar geogrids leads to significant reductions in rut depth*

***2000 –** Full-scale laboratory tests at the UK Transport Research Laboratory comparing Tensar geogrid with alternative forms of geogrid*

These pictures display the types of research in which Tensar® International has been involved over the years. The data in these tests have provided the factors to employ in empirical design methods. Now the trend in pavement design is moving towards more analytical design methods where the pavement response to traffic loads can be seen in numerical models. Tensar International is at the forefront of this development by modelling the effect of mechanical stabilisation from geogrids.

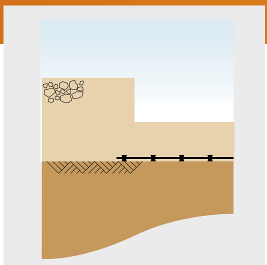
***2004 –** Testing is not confined to one region but has involved independent laboratories and research across the globe*

***2004 –** One of the longest monitored and severely trafficked trials took place in the Feiring Bruck Quarry, Norway*

***2007 Tensar Technology Centre –** In-house trafficking facility enables geogrids, fills and subgrades to be investigated*

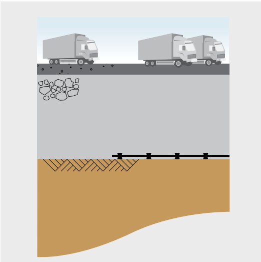
***2008/2011 –** Controlled environment conditions ensure comparable trafficking test results*

Each of the Six Major Applications Brings Major Benefits and These Can Often be Converted to a Cost Advantage



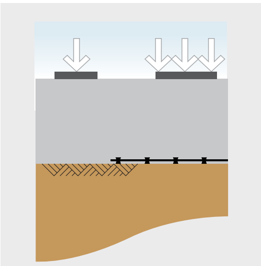
REDUCING LAYER THICKNESS

By reducing the capping layer thickness by up to 50% with no performance loss compared with a standard non-stabilised design, the contractor can save significant money on the costs of the ground improvement work as well as achieving savings of up to 50% in construction CO_2 emissions.



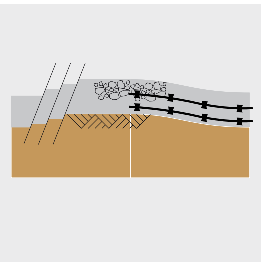
INCREASING LIFE

Road rehabilitation, especially if it involves full depth reconstruction, is an expensive item for any road owner. A value engineering exercise can show that the inclusion of a mechanically stabilised layer will increase a road pavement life by a factor of three or more and therefore reduce an annual maintenance budget, for asphalt course replacement, by over 50%.



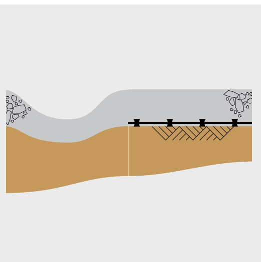
INCREASING BEARING CAPACITY

On weak subgrades, such as peat, it is sometimes necessary to construct access roads that have to bear very heavy loads. Crane access to wind farm installations are a prime example where the bearing capacity has to be increased and designed for safe site operations.



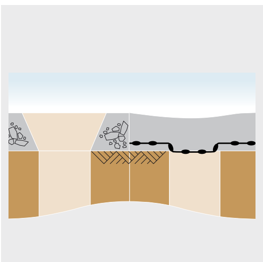
CONTROLLING DIFFERENTIAL SETTLEMENT

Many construction sites are taking place on 'brownfield' development areas where the subgrade will have variable qualities of support and the pavement layers are prone to differential settlement. Establishing Tensar's track record, projects have been visited after many years of service, confirming that the surface profile has been preserved. Cost savings of over 75% have been made on conventional solutions, such as working platforms, in providing a supporting substructure to a road pavement.



CAPPING WEAK DEPOSITS

Tensar® has developed techniques for the capping of weak deposits. The Tensar Technology has been refined over the years to 'make possible the impossible' and now becomes the preferred method for capping sludge lagoons and industrial waste deposits.



SPANNING VOIDS

Areas of abandoned mine workings frequently need some form of protection against the dangers of a sudden collapse and the opening up of a deep 'crown hole.' Tensar Technology has been put to the test in this critical application and, as intended, provided warning and sufficient time for the authorities to react and secure public safety.

Practical Examples of the Major Applications

TriAx installation, Stoke

- Reducing layer thickness
- Increasing life
- Controlling differential settlement

Stabilising weak soil in Ashbourne, Derbyshire

- Capping weak deposits
- Increasing bearing capacity

Improving and strengthening the A66 in Melsonby

- Reducing layer thickness
- Increasing life

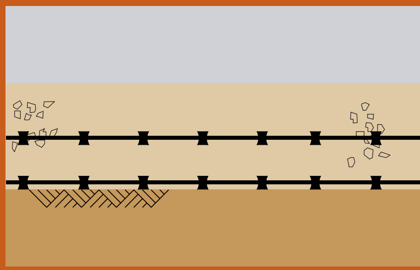
Stabilising ground to facilitate off-road parking at Lanarkshire

- Reducing layer thickness
- Increasing bearing capacity
- Controlling differential settlement

Specialist Pavement Designs

If heavy axles loading or highly concentrated wheel loads define the traffic loading, rather than repetitions of more moderate highway traffic, then specialist design methods for geogrids have been developed by Tensar® International.

The granular layer may then require multi-layer geogrid stabilisation. Commonly used design methods for heavy-duty pavements have been adopted and modified to include the geogrid stabilisation benefits.



TYPICAL HEAVY-DUTY PAVEMENT

Heavy-duty pavements may require multi-layer geogrid stabilisation.

New taxiway at Adelaide Airport (Australia)

AIRPORT PAVEMENTS

As the weight of newer generations of aircraft increases, the intense wheel loads need special consideration in providing a robust base to runways and taxiways.

Tensar geogrids are perfect for dockside paving (Latvia)

DOCK PAVEMENTS

Container handling and stacking areas, bulk cargo handling and fabrication sites commonly impose highly concentrated wheel or truck loads.

Heavyweight crane on Tensar ground stabilised working platform

SAFE WORKING PLATFORMS

Cranes and piling rigs require a working platform to operate safely and with controlled accuracy. Frequently, these operations have to take place over very weak subgrades.

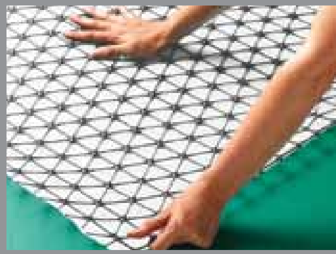
Benefits of Tensar ground stabilisation on railway tracks

RAILWAY TRACKBED

Both the ballast layer and the sub-ballast bearing layer benefit from geogrid stabilisation – particularly over weak subgrades. A stabilised bearing layer introduces an increased modulus in support of the ballast. A stabilised ballast layer laterally confines the ballast and prolongs the effective support of the sleepers and rails.

Tensar® TriAx® large aperture geogrid - TXL

Tensar TriAx standard aperture geogrid - TX



Tensar TriAx geocomposite - TXG

Tensar® International Support Services

Use Our Experience and Reliability for Unsurpassed Product Support

PROFESSIONAL SOLUTIONS

We offer the services of a team of professionals who can assist in developing concepts to support your design or undertake full construction design. We also provide advice and 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. 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™ DESIGN SOFTWARE

TensarPave is a software package developed by Tensar International, incorporating TriAx® design parameters for the most economical ground stabilisation and pavement design solutions. TensarPave software is available free of charge with specific user training from Tensar International.

INSTALLATION 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.

RANGE OF DESIGN SCHEMES IN 3 CORE STREAMS

1 **SUPPLY ONLY**

2 **APPLICATION SUGGESTION & SUPPLY**
Conceptual drawing and advice

3 **DESIGN & SUPPLY**
Certified detailed design and construction drawings covered by Tensar's Professional Indemnity (PI) insurance cover

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 design phases by developing concepts and assessing the design feasibility of using Tensar products or systems, and by providing indicative budget costs.

CONSTRUCTION SUPPORT

- Installation advice on how to install Tensar on your project
- Installation training demonstrating installation of our product
- Construction advice to answer practical questions on Tensar installation while construction progresses

TRAINING

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

DESIGN

- Design advice to assist you in incorporating Tensar products and systems in your project
- Detailed costing to enable you to competitively price Tensar in your project or bid
- Detailed design and construction drawings for using Tensar products and systems on your project

DESIGN SUPPORT

- Application advice to assist you with your design concept
- Application suggestion providing our design concept for further consideration and design by you
- Design review of your design which incorporates our products or systems

Contact Tensar® International 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
- **TriAx®: A Revolution in Geogrid Technology**
  The properties and performance advantages of Tensar TriAx geogrids
- **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
- **Foundations Over Piles**
  Constructing over weak ground without settlement
- **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

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