RAIL

RAILWAYS

MECHANICAL STABILISATION OF TRACK BALLAST AND SUB-BALLAST

Tensar®

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

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

Based on the characteristic properties of Tensar geogrids and geotextiles, 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.

# 2 Major Application Areas for the use of Tensar TriAx®

1. 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 and safe solution.

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

Ballast · Tensar TriAx® geogrid · Subgrade
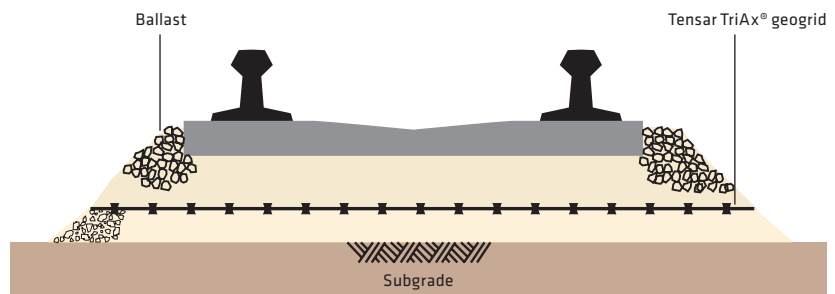
Mechanical stabilisation of the ballast layer to reduce the rate of track settlement and hence increase the period between maintenance operations with huge whole life benefits.

RESEARCH HAS DEMONSTRATED THAT TENSAR GEOGRIDS CAN:

▶ Reduce the rate of ballast settlement

▶ Maintain track geometry for longer

▶ Extend the maintenance cycle by a factor of approximately 3

▶ Function in ballast for more than 20 years

▶ Reduce traffic-induced ballast degradation

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

# Geogrids within the Track Substructure

2. Improving Track Foundation through the Mechanical Stabilisation of the 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.

Ballast

Tensar TriAx® geogrid

Subgrade

Granular sub-ballast
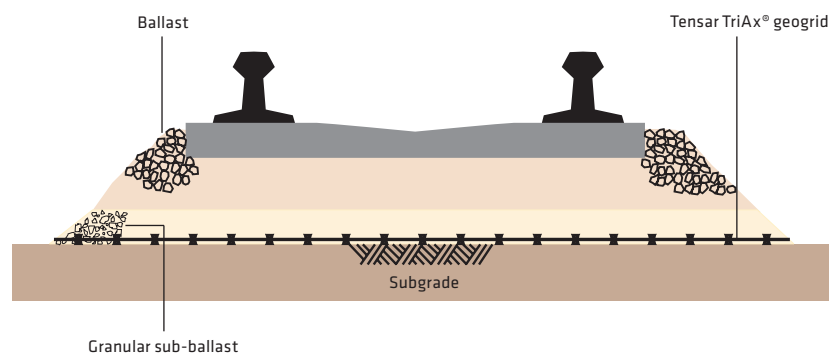
Stabilisation of the granular sub-ballast layer to increase the bearing capacity over soft subgrade results in significant thickness reductions and savings in both the capital and environmental costs.

3

How Tensar Stabilisation Geogrids Work

Tensar geogrids make a structural contribution to railway trackbed. When granular fill material, such as ballast or sub-ballast, is compacted over a Tensar geogrid, it partially penetrates and projects through the apertures to create a strong and positive interlock. This interlock enables the geogrid to confine the fill and restrain the granular material from lateral spread, which is a major cause of settlement of railway track. This mechanism is critical in helping to maintain the horizontal and vertical alignments of the rails.

Tensar stabiliation geogrids are produced with high tensile stiffness which allows load to be developed at very low strain. These polypropylene geogrids are manufactured with dimensionally stable apertures. Matching the appropriate geogrid aperture size with the particle sizes of the overlying fill material is important to the stabilisation performance. The essential features of Tensar geogrids, which are required to ensure effective interlock, include the strength of the junctions and the shape and stiffness of the ribs. The Tensar manufacturing process produces a monolithic geogrid structure with high junction strength and with ribs which present a square and thick leading edge to the aggregate for effective transfer of load.
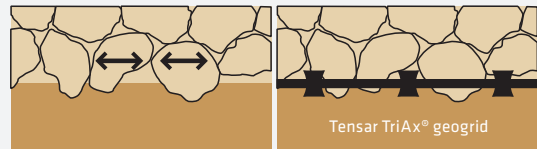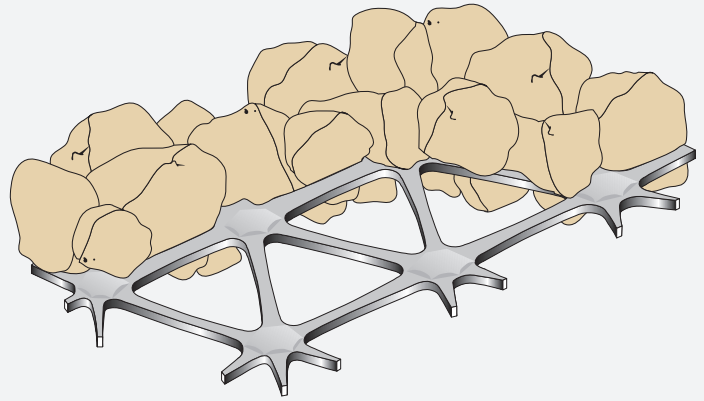
The interlock between the geogrid and the granular fill limits lateral movement of particles even when dynamic loading is applied. In practice this means that the settlement rate is reduced.
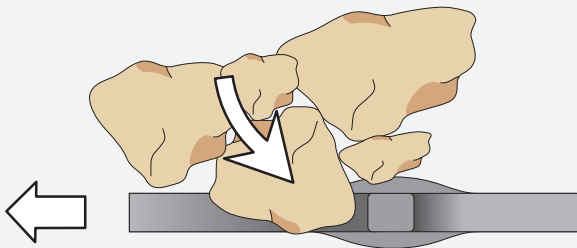

The characteristic cross-sectional shape of Tensar TriAx® ribs provides bearing points for fill particles. The forces can then be transferred through the rigid junctions.

The ribs present a thick, square, leading edge to create positive transfer of load from the ballast to the geogrid.

Tensar Geocomposites

Tensar geogrids are also available in a composite form where a non-woven geotextile is bonded to the geogrid. The composite products are particularly suitable when the function of separation is needed together with stabilisation.
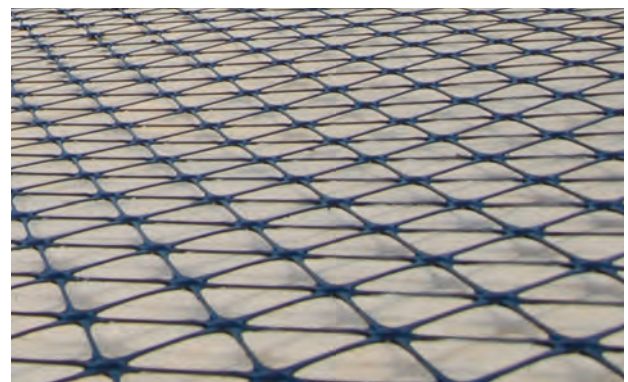
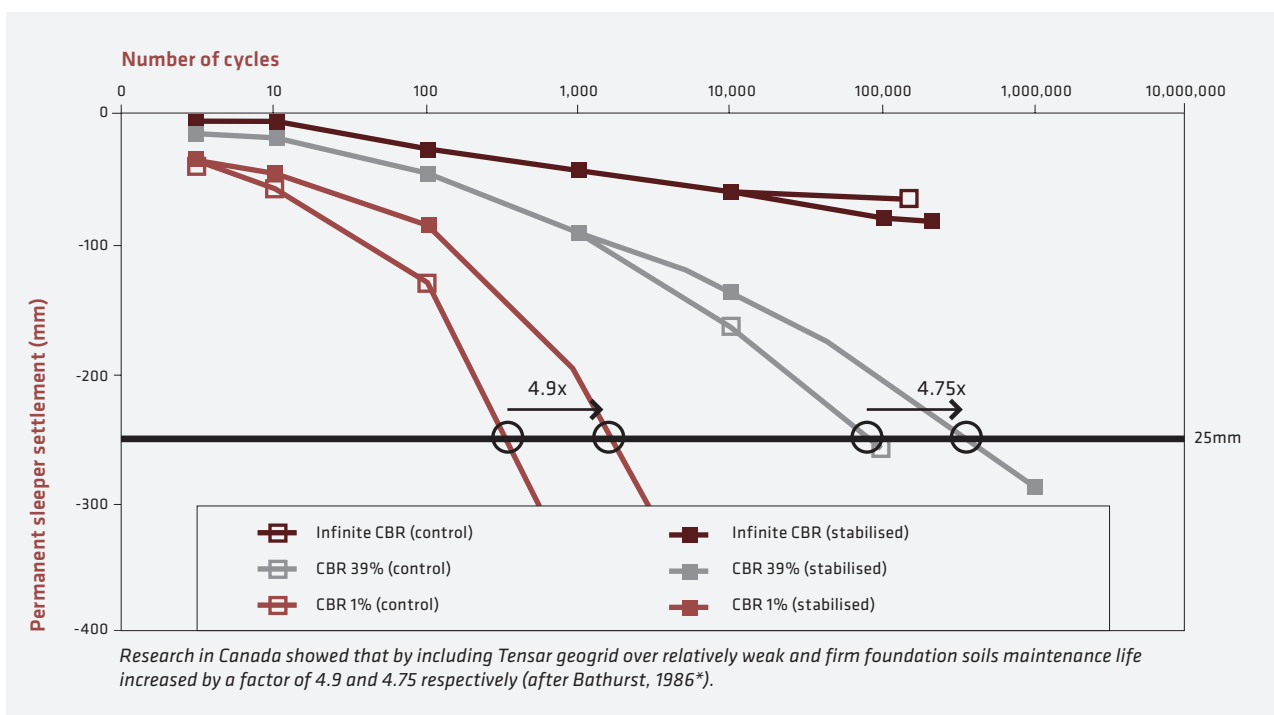*A composite version of TriAx® is available incorporating a geotextile separator.*

Installation of geogrid within the ballast (Belgium).

1. Mechanical Stabilisation of Ballast to Reduce Maintenance Costs

Early Laboratory Tests, Canada 1986

Full scale model laboratory tests were carried out to investigate the effect of Tensar geogrids in stabilising railway ballast and controlling the settlement of the sleeper. On both a weak and a firm subgrade, the geogrid reduced the rate of sleeper settlement such that the sleeper could sustain over 4 times the number of load cycles, across the practicable range of settlements. This indicated that there were great advantages to using geogrid stabilisation for all railway track in reducing settlement and reducing maintenance.

Research in Canada showed that by including Tensar geogrid over relatively weak and firm foundation soils maintenance life increased by a factor of 4.9 and 4.75 respectively (after Bathurst, 1986).*

Research by British Rail demonstrated the maintenance benefit of Tensar geogrids.

Research by British Rail, UK 1994

In the early 1990s British Rail Research investigated the use of a Tensar geogrid to limit the progressive lateral displacement of the ballast particles under repeated train loading. This investigated the settlement and the rate of deterioration of the vertical track geometry.

The full scale trial using a 40 tonne rolling load rig to simulate 2 million gross tonnes on the track, consisted of three tests over a soft subgrade (E=10MPa). In two of the tests, the geogrid was laid in the underlying ballast layer. The results of these tests were then compared with a similar non-stabilised test previously carried out over a very firm subgrade.

This work showed that the introduction of geogrid reinforcement into the ballast over a soft subgrade can provide a performance almost equal to a railway track placed on a firm foundation.

Tensar geogrids were also shown to reduce the elastic deflection by up to 40%. This benefit can be of considerable value in reducing maintenance costs and disruptive delays in replacing damaged track components such as insulated block joints (IBJs) which are vulnerable to damage caused by rail deformation.
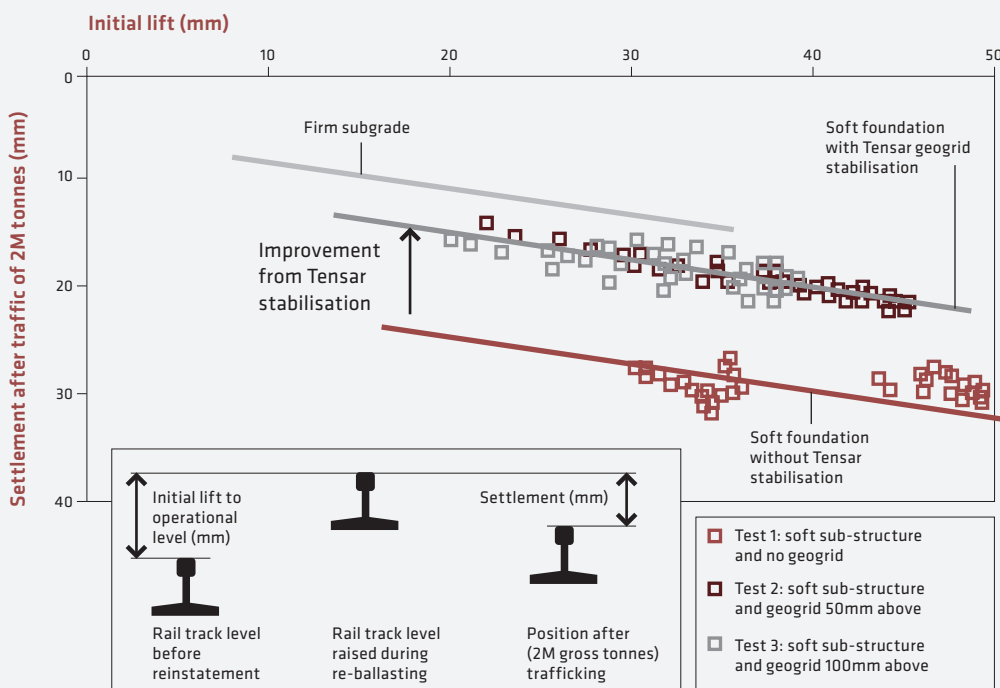
Installation of Tensar geogrids into the ballast over soft subgrade significantly reduces settlement, making it comparable with track on firm foundations (after Matharu, 1994*).

Research at The University of Nottingham, UK 2006

A major UK research and development project led by the University of Nottingham quantified the permanent settlement of track and investigated the use of Tensar geogrids to control the settlement of track ballast and increase the periods between maintenance. The three-year project concluded in 2006 and was part funded by a £250,000 innovation award grant from the Royal Society.

The project involved experimental work and theoretical modelling together with a major field trial and the development of design guidance. The research was conducted at the University with three commercial partners; Tensar International, leading railway consultant Scott Wilson Pavement Engineering Ltd and leading railway contractor Carillion Rail. Network Rail (who own and operate Britain's rail infrastructure) was represented on the project Steering Group.

Initial work on a small element of railway track tested a variety of geogrids to examine the influence on settlement of grid stiffness, aperture size and geogrid rib profile. The results identified the optimum rib pitch for interlock with standard ballast stone grading. The performance was found to be relatively insensitive to the geogrid depth within the ballast.

RESULTS DEMONSTRATED THAT THE FOLLOWING GEOGRID PROPERTIES ARE ALSO IMPORTANT:

► Strong junction strength (>95% efficiency)

► High tensile stiffness at low strain levels

► Rib thickness

► Square edged rib profile

Tensar Geogrid Reduces Maintenance

The Nottingham Rail Test Facility (RTF) allows a full-scale section of rail track, three sleepers in length, to be tested. Dynamic loading is provided by three hydraulic actuators to simulate the passing of a rolling stock axle. Three separate installations, one control and two geogrid stabilised, were tested to a million cycles. In one stabilised installation the geogrid was placed at the base of the ballast and in the other the geogrid was raised slightly above the base.

Settlement was measured and the results confirmed the findings from smaller scale composite element tests (CET). The results showed that use of Tensar large aperture geogrid could increase the intervals between maintenance interventions by a factor of at least 2.5.
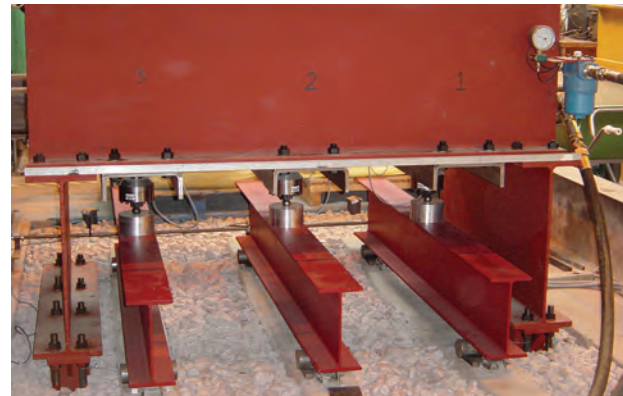
Simulated train loading at The Nottingham University RTF.
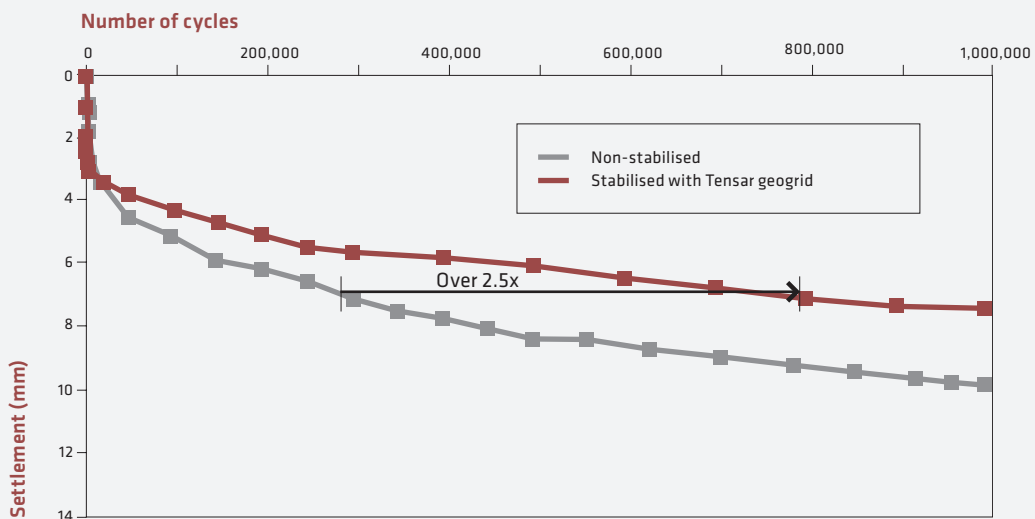
Results from the Nottingham University Railway Test Facility (RTF) show that Tensar geogrids provide approximately 2.5 times increase in number of axle passes for same settlement (after Brown et al, 2006).*

Monitored Field Demonstrations, Network Rail, UK

A demonstration project organised by Network Rail on the busy West Coast Main Line (WCML) between London and Scotland has confirmed the findings from the Nottingham laboratory research. An 800m section of track at Coppull Moor had a history of poor geometry and high maintenance. Network Rail decided to reconstruct this length of track with new ballast and sleepers. The demonstration was split into four sections; two control sections and two with Tensar geogrid ballast stabilisation.

Network Rail has regularly monitored standard deviation (SD) of the vertical deformation of the track using their high speed track recording coach (HSTRC). There was much historical data with which to compare the performance of the stabilised and non-stabilised sections of the latest renewal.

Network Rail has found that the performance of the Tensar stabilised sections shows a significant improvement. Analysis of the data indicates that Tensar is extending the maintenance life compared with the conventional solution by between 2 and 4 times.

The detailed record from the HSTRC monitoring (shown below) demonstrates dramatically how, for more than 10 years, this section of track had required almost continuous speed restrictions despite maintenance typically twice a year. However after the renewal in late 2004, using geogrid to stabilise the ballast, both the reduction in the magnitude of SD as well as the rate of deterioration are likely to result in at least three years with neither maintenance nor speed restriction.
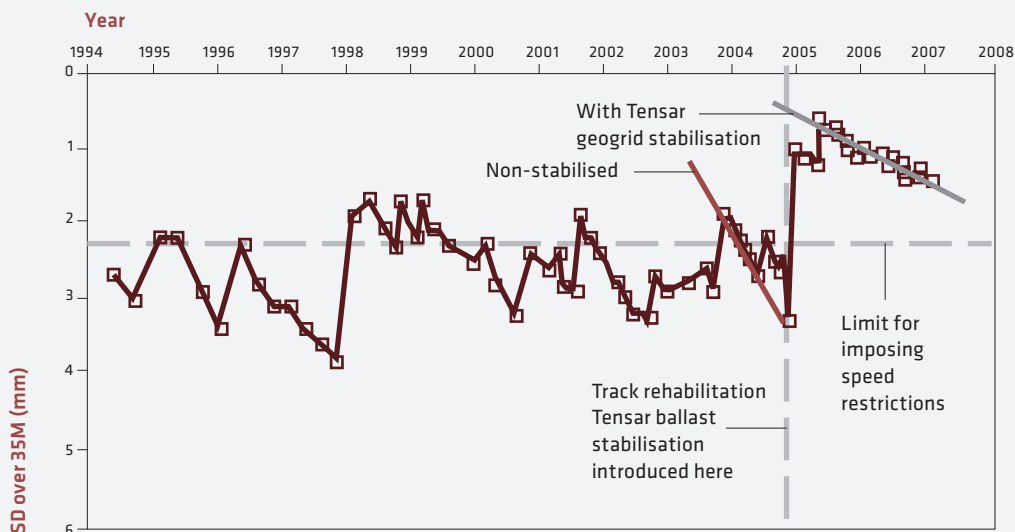
WCML trial showing reduced rate of track quality deterioration following geogrid installation (after Sharpe et al, 2006*).

# Network Rail's Approach to Mechanical Stabilisation of Ballast in the UK

Based on the above evidence, Network Rail is extensively using Tensar geogrid to extend the maintenance life for track renewals over problem formations. Tensar geogrids are also being used at transition zones between widely different support stiffness formations, to mitigate the effect of differential settlement. This can occur for example at the run-on and run-off at under bridges.

Network Rail's current Code of Practice on Formation Treatments, R/SP/TRK/9039, acknowledges the structural contribution from an approved geogrid. This code, coupled with a product acceptance certificate allows significantly lower dynamic sleeper support stiffness values for track on geogrid stabilised ballast compared with conventional unstabilised ballast. In effect, the presence of the geogrid allows thickness reductions to the trackbed depth under the sleeper.

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

Network Rail has granted Tensar geogrids full product acceptance in accordance with The Code of Practice.
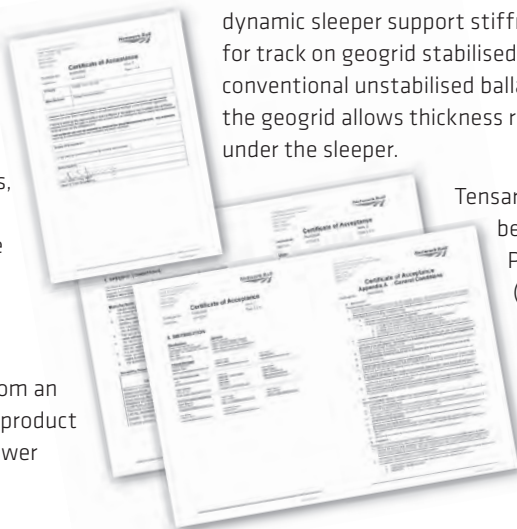
Durability in Ballast

Tensar geogrids have been used to stabilise ballast for almost 30 years and some monitoring of their condition, in the field, has been possible.

At a site known as Shirland in the UK, the geogrid was installed in 1988 and in collaboration with the track operator Network Rail, geogrid samples were retrieved in 1997 and 2006. Since installation the railway had been trafficked by some 200 million gross tons of both freight and passenger trains. An assessment of abrasion was made by examining the tensile strength properties of a geogrid that was placed approximately 225mm below sleeper bottom. The diagram shows that the tensile strength properties have been maintained and the geogrid remains stronger and stiffer than the quality control standard for the Tensar geogrid that was supplied to the project. Abrasion effects are negligible.

This is evidence that in the harsh environment of railway ballast, Tensar has proved that the service life will extend well beyond twenty years.

For the project itself, it is a problem solved. Before the maintenance work, the line needed maintenance several times per year. The records show that maintenance has been reduced to a fraction of the former level. The cost benefit to railway operators speaks for itself.

After 18 years, Tensar geogrid retains its quality control strength.
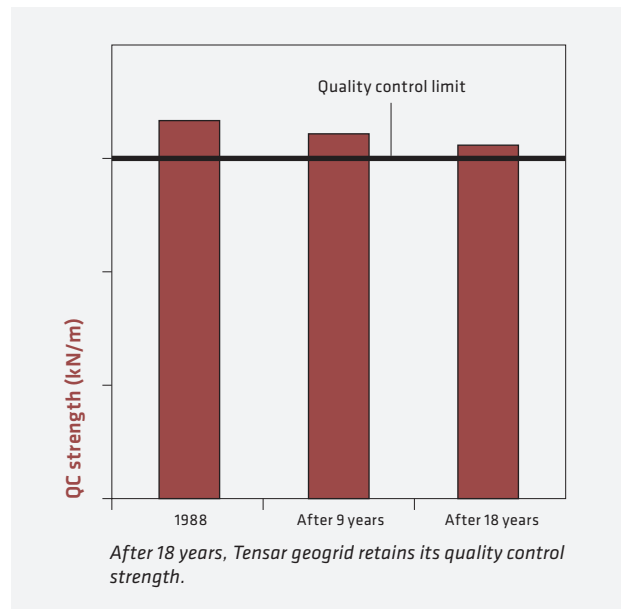
Tensar TriAx™ geogrids installed under the granular sub-ballast layer to increase bearing capacity (Belgium).

2. Mechanical Stabilisation of Sub-Ballast to Reduce Maintenance Costs

Almost 30 Years Experience in Mechanically Stabilising Granular Fill

Tensar International has developed the mechanical stabilisation of both sub-base and railway sub-ballast. A proven performance has been demonstrated in numerous trials, demonstrations and research projects.

The resulting sub-ballast layer will provide significant savings in construction costs.

The thickness and structural performance of sub-ballast, over weak subgrades, also ensures that the ballast layer has a sustained quality of support and maintenance needs can reduce significantly.
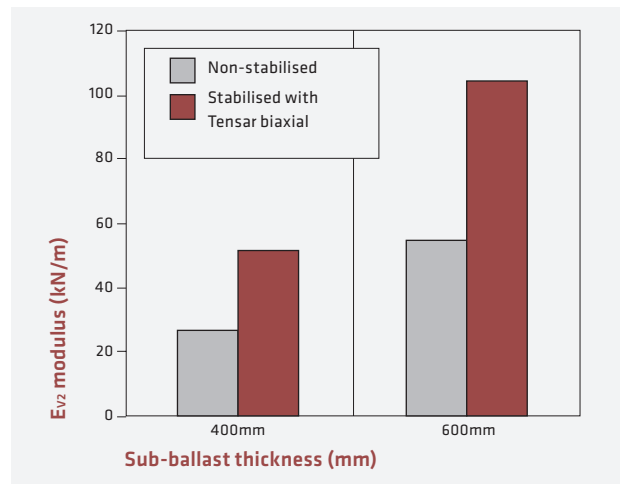
Demonstration Projects in Europe

DEUTSCHE BAHN, BERLIN-MUNICH LINE

The German Rail Authorities Deutsche Bahn (DB) carried out a monitored trial during the widening of the Berlin-Munich line between Hochstadt and Probstzella where the subgrade was very soft, with a modulus Eu of 7-15 MPa.

Trial sections of 400mm and 600mm sub-ballast thickness were constructed. Half of each section included Tensar geogrid stabilisation.

PLATE BEARING TESTS ON TOP OF THE SUB-BALLAST SHOWED:

▶ Tensar geogrid stabilisation doubled the modulus of a sub-ballast layer

▶ Tensar allowed a 33% reduction in sub-ballast thickness, ie the modulus of a 400mm layer with Tensar was equivalent to a 600mm non-stabilised thickness
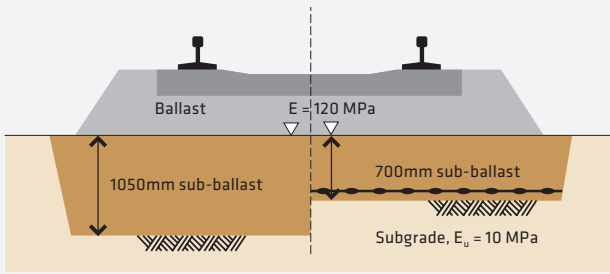
Non-stabilised and stabilised designs

DEUTSCHE BAHN, COLOGNE

On a monitored project in Cologne in 2003, the inclusion of a Tensar geocomposite over a soft formation permitted a reduction in sub-ballast thickness from 1050mm to 700mm, while maintaining the target modulus of 120MPa as the ballast support value.
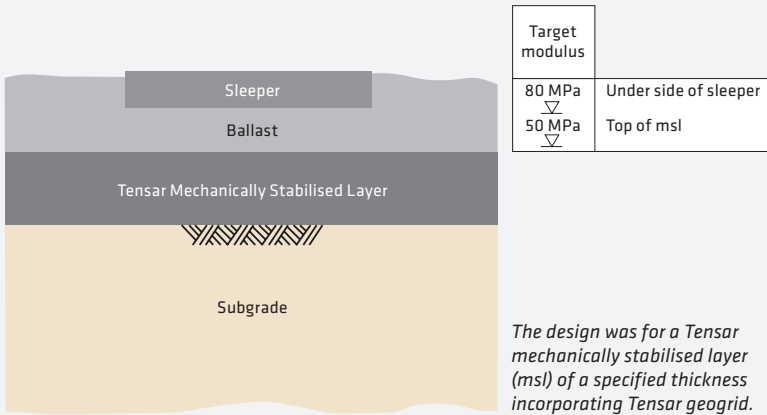
The design was for a Tensar mechanically stabilised layer (msl) of a specified thickness incorporating Tensar geogrid.

SLOVAKIA, BRATISLAVA-TRNAVA LINE

On the Bratislava to Trnava line in Slovakia, the client used a Tensar mechanically stabilised layer to achieve the UIC standard minimum support modulus of 50MPa on top of the sub-ballast.

Plate loading tests were conducted on site to examine the validity of the design. The following results were obtained:
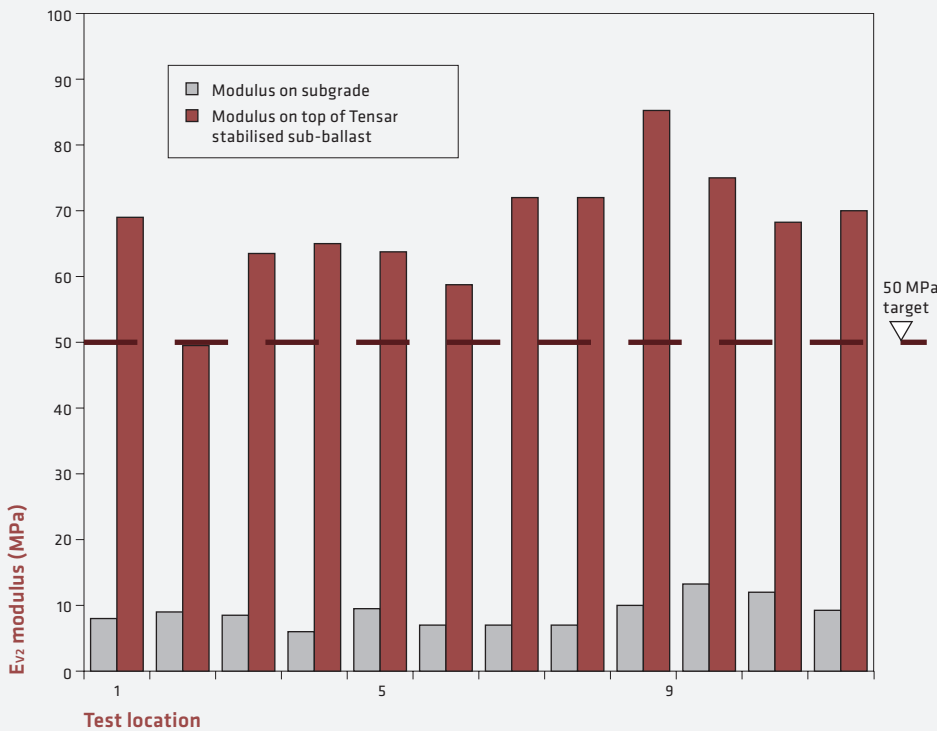
The Tensar solution achieved and exceeded the target.

Tensar geogrids for soil reinforcement have Network Rail Product Acceptance Certification (Number PA05/175 & 177) for railway embankments, slope repairs and reinforced soil applications.

*All technical references can be obtained from Tensar.

Your local distributor is:

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**
Mechanically stabilised layers for 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

▶ **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

Tensar®

Q 05288
ISO 9001:2008

EMS 86463
ISO 14001:2004