ROADS, RAILWAYS, LARGE AREAS

Man. Technology. Environment.

BASE REINFORCEMENT

The construction of works on large areas on soft ground requires a preliminary improvement of the characteristics of the ground itself in order to increase the load-bearing capacity, avoid the formation of holes and reduce differential settlements.
Tenax geogrids and geocomposites are specifically designed for the basic reinforcement of soft soils: they represent non-invasive and cost-effective solutions compared to other kind of interventions.

OUR HISTORY

TENAX was established in Viganò Brianza (Lecco) in 1960, following the advent of polypropylene and thanks to its technological ability to transform this new polymer into grid-like structures.
Technical skills and internationalization have allowed us a strong development, enabling us to create products and solutions in different sectors such as gardening, agriculture, industry, construction, and geotechnics.
Within the latter category, since the 80s, we've developed a diversified range of geosynthetic products: high-tech plastics materials, which represent an economical solution with less impact on the environment than works carried out in civil engineering and environmental projects with traditional solutions.

MADE IN ITALY

All TENAX products are developed in research and development laboratories before being entirely manufactured in our own plants, which are also designed and created independently.
A sophisticated monitoring system applied to all automated production plants, constantly collects data on each batch under production.
The so obtained data allows the entire process to be constantly monitored with a dual advantage both in terms of production planning and quality control.

TECHNICAL-SCIENTIFIC SUPPORT

"Technical Competence Centre" is a TENAX in-house structure made up of a team of technicians, problem-solving oriented, always close to the customer, which offers a wide range of specialized services such as:

- *On site inspection;*
- *Feasibility studies and executive projects;*
- *Technical data and costs analysis for tender specification;*
- *Installation guideline and instructions;*
- *On site staff training;*
- *Independent laboratory tests following the European and international standards;*
- *Organization of seminars, scientific workshops, and corporate training.*

"AD HOC" SOLUTIONS AND PRODUCTS

The wide range and ready availability of geosynthetics products allow TENAX to promptly satisfy most of the project requirements.
We have always been supporting our clients by offering technical expertise with "tailor made" solutions from the design phase up to the on-site implementation.
New products with on-request, specific characteristics, are manufactured in synergy with the internal TENAX laboratory where mechanical, hydraulic and durability tests necessary for the their development, are carried out.

OUR ECO-FRIENDLY COMMITMENT

Protecting who has always welcomed us is our goal. TENAX's commitment to protect the environment is realized thanks to the use of eco-friendly production technologies, performance optimization and energy saving, waste reduction and the use of 100% recyclable polymers. With a crucial purpose: economic, social, and environmental sustainability.

LIFEGATE *TENAX has started a process for defining the sustainable strategy in collaboration with LifeGate. (www.lifegate.it - Milano FM 105.1).*

TENAX products and systems are certified by the most accredited international bodies.
In order to develop, test and promote Geosynthetics we cooperate with qualified University and Research Institutes.

Certifications

ISO 9001 ISO 14001 0799-CPR-25

EPD Environmental Product Declaration

UK CA

Memberships

AGI igs uni AssINGeo

Active participation in Geosynthetics technical committees: UNI, CEN, ISO.

TENAX GEOSYNTHETICS FOR AN EFFECTIVE STABILIZATION WITHOUT ALTERING THE NATURAL BALANCE

Throughout history, man has developed several methods to improve the bearing capacity of soft soils.
One of the oldest and most effective systems consists in applying lateral confinement to the soil to increase its shear resistance.

In the past, this result was obtained by using bundles of intertwined branches or tree trunks placed perpendicularly to the direction of the road.

Another ancient method implies the creation of a separation layer between the base soil and the structure to be built through a drainage system to prevent water from rising into the backfill.
Traditionally, animal skins or natural textile fibers were used as a separating layer, while gravel and sand were used as drainage layers.

Luckly today, modern technologies allow the use of geosynthetic products to obtain the same lateral confinement effects and improve the bearing capacity and stability of the soils without compromising their natural balance.

The use of geosynthetics, beyond improving soil performance, allows for a reduction in environmental impact and costs compared to traditional systems.

Geosynthetics for base reinforcement, settlement reduction and load bearing capacity increase

Every time a road, railway, large area etc. is under design and construction, it is essential to evaluate the true nature of the ground and its mechanical properties, many times it is necessary to create load distribution systems to stiffen the structure and stabilize it with a cost-saving, environmental friendly and better performing approach.

Geosynthetics which are applied inside a base layer bring many benefits and advantages, such as:

1) Reduction of horizontal deformations with consequent maintenance of the thickness of the originally built layer;

2) Transmission of forces and distribution of vertical loads with consequent increase in bearing capacity.

The advantages of using geosynthetics are visible in both works where important loads are distributed over large areas, and in those cases where the loads are concentrated on “small footprints” (i.e. load transferred by a tire).

Another important factor to take into consideration is the stratigraphy of the soil, since in many cases the presence of aquifers, stagnations, underground waterways can compromise the stability of the soil itself, causing possible subsidence, cracks and/or actual collapses.

In these cases, in addition to the use of geosynthetics for base stabilization and reinforcement, it is appropriate to combine a draining geocomposite, to interrupt capillary rising damp and preserve the integrity and function of the overlying layers.

There are many solutions on the market to solve these problems, TENAX with its experience, has studied, designed and manufactured a wide range of products to fulfill each specific need at best.

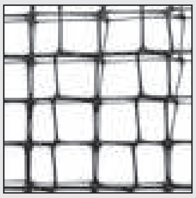
Advantages of using geosynthetics

- **Depth of earthworks excavations reduced by up to 45%.**
- **Fewer excavation materials to be sent to landfills.**
- **Reduced use of more “noble” filling materials (e.g. crushed quarry).**
- **Less number of road trains to be used for material handling.**

Geosynthetics by TENAX for base stabilization

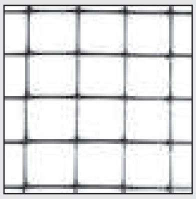
THREE DIMENSIONAL GEOGRIDS

The TENAX 3D GRIDs range of geogrids has been designed to ensure an improved interaction with the soil by increasing its lateral confinement and interlocking.



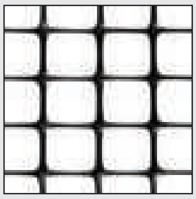
TENAX 3D GRID MS

Since they are produced with an exclusive co-extrusion and biaxial stretching system, the TENAX 3D GRID MS are specifically designed for the stabilization and reinforcement of fine and less thickened soils (silts, clays, sands), they consist of a multilayer structure to form a dense network of multiple joints cable to ensure a high interaction with soils of this type.



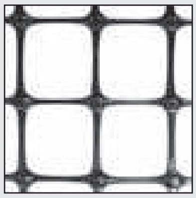
TENAX 3D GRID S

They have been developed to obtain a high section of the longitudinal threads and knots, particularly suitable for medium-small size soils.



TENAX 3D GRID T and HT

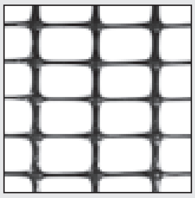
They are an evolution of the 3D GRID S, whose special "T" shape includes the advantages of the rigidity of the classic T-beam, resulting in a mesh with increased torsional stiffness and shear resistance. The "T" section also allows for a better interaction with the ground through lateral confinement but also on the floor.



TENAX 3D GRID XL

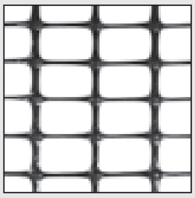
Its particularly thick ribs, in combination with the increased opening of the meshes, allow for optimal interaction with large-sized granular materials.

BI DIMENSIONAL GEOGRIDS AND GEOCOMPOSITES



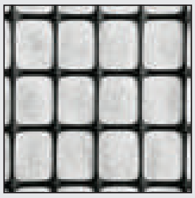
TENAX LBO SAMP

They are 100% PP structures designed to have isotropic tensile strength for soil stabilization and reinforcement.



TENAX LBO HM

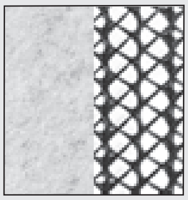
They are structures specifically designed for situations in which minimal deformations and high elastic modules are permissible, they guarantee high tensile performance at minimum deformations of 0.5% and 2%.



TENAX GT SAMP and HM

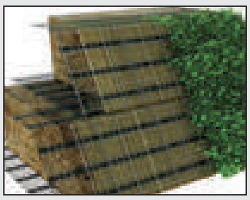
It is a Geocomposite employing a HM or SAMP geogrid combined with a non-woven geotextile. The shape of the grid allows a strong interaction with the ground while the geotextile allows a complete separation and filtering action.

GEOSYNTHETICS AND COMPLEMENTARY SYSTEMS



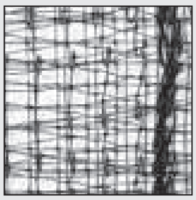
TENAX TENDRAIN

It is a triangular-shaped mesh structure made of 3 orders of overlapping and intersecting wires. The heavier and thicker internal threads allow a high transmissivity and compressive strength and the diagonal threads prevent the intrusion of the geotextile and the soil under vertical loading.



TENAX RIVEL SYSTEM

The TENAX RIVEL system makes it possible to create reinforced earth works with a greener facade which can be the proper solution for different fields.
The construction of reinforced earth is simple, fast and does not require manpower or special means.



TENAX MULTIMAT

The TENAX MULTIMAT geomat is laid on a slope made up of soil suitable for the growth of vegetation and performs, before the vegetation takes root, the function of limiting the speed of runoff water and protecting the underlying soil from erosion.

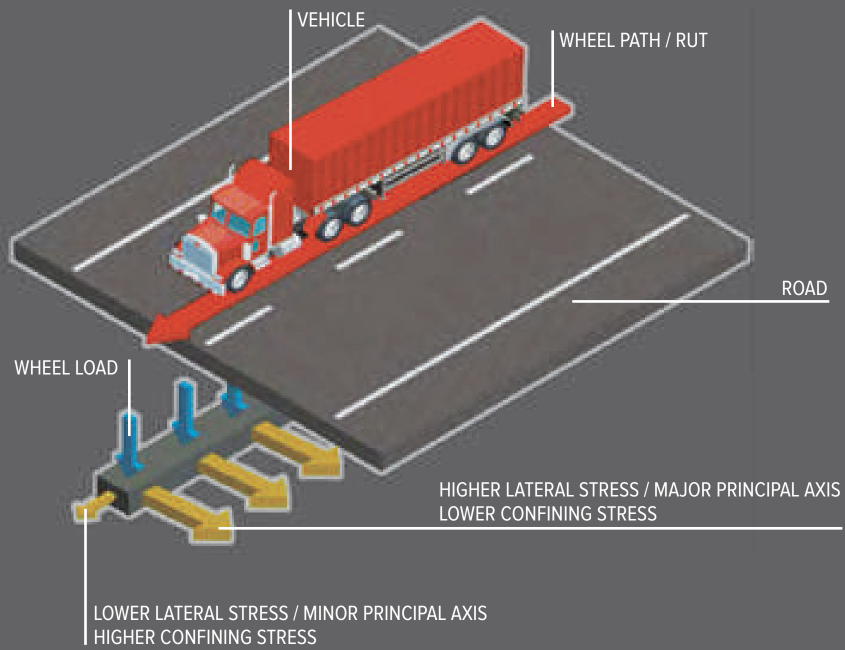
TENAX TENWEB

The TENAX TENWEB geocells are made using a continuous polyethylene extrusion process without subsequent welding or studding: the cells remain connected to each other through open joints from which liquids and fluids can flow so as not to stagnate and weigh down the cape.

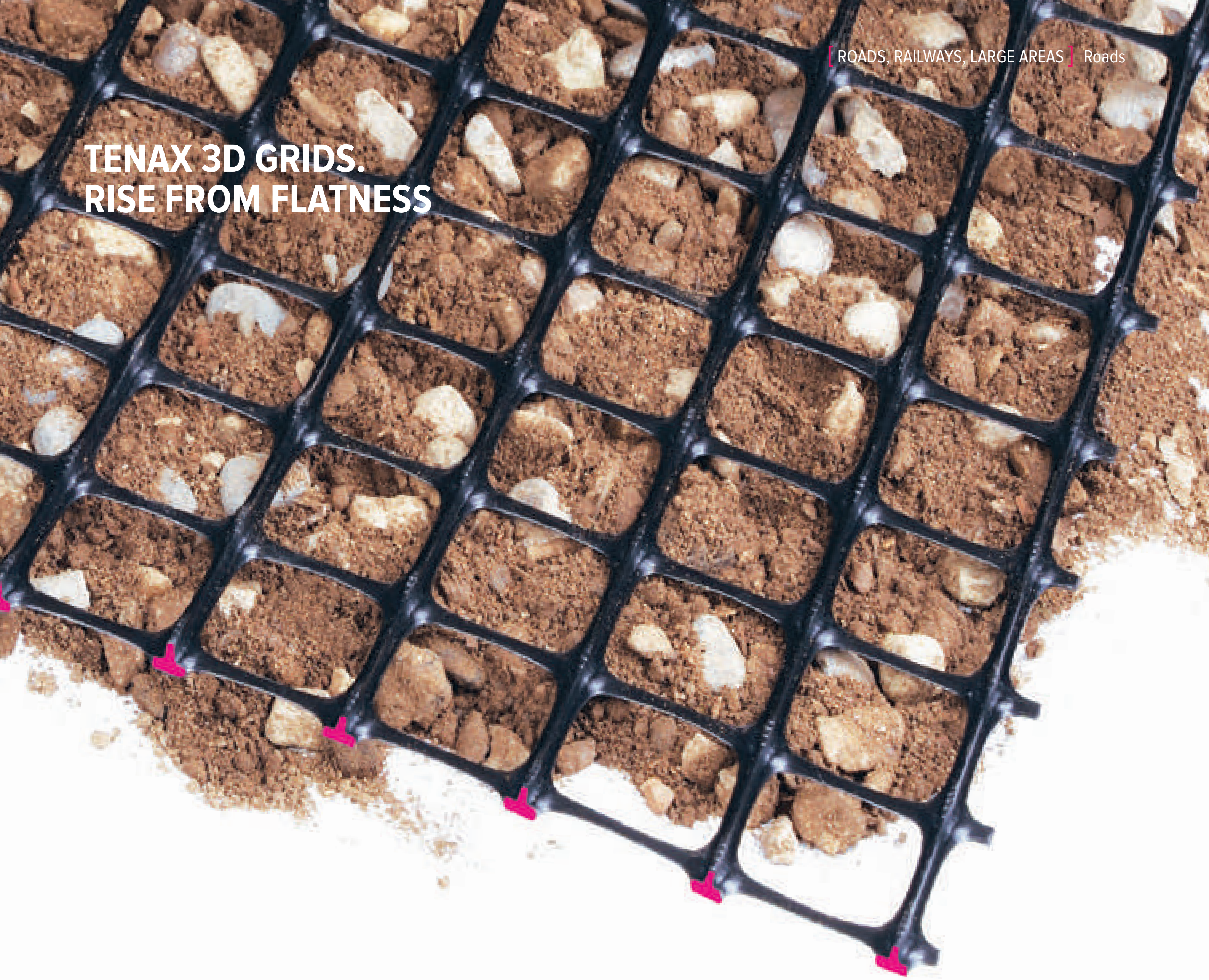
ROADS

Roads, since they are linear infrastructures, have a greater extension in their main direction, the longitudinal one.
This creates a plane strain state, where the strain along that main direction is almost at zero and the stress is limited. On the opposite, the stress is greatest along the transverse and vertical directions, which have a smaller extent. Given this characteristic, the occurrence of pointed/localized settlements along the direction of the vehicular passage is common, the so-called ruts.

The solution consists in improving the horizontal transmission of forces, perpendicular to the longitudinal development of the infrastructure. Therefore, it is necessary to obtain a high lateral confinement that interacts with a larger section of land.



TENAX 3D GRIDS.
RISE FROM FLATNESS



GREATER INTERLOCKING → **PERFORMANCE IMPROVEMENT** →

Reduction of infill material up to 45%

Reduction in effort transmission up to 30%

Geogrids by TENAX advanced performances for each specific stabilization

They are geogrids specifically developed to allow optimal base reinforcement, overpassing the excellent and traditional ones, the extruded geogrids with a TENAX planar structure: the thickness and geometry ensure a real and effective three-dimensional structure.
The uniqueness of the TENAX production technology ensures a very high level of lateral confinement by exploiting the high thicknesses of the longitudinal elements and integral joints.
The different mesh sizes make it possible to optimize the interlocking of the granules; the result is a unique product, specifically designed and developed to improve stress distribution, thus reducing rut formation and the thickness of granular material at the base of roads or railways.

Optimized interlocking

When the aggregates are spread and compacted on top of the reinforcing geogrids, part of the single soil grains penetrate the openings of the grid itself and remain “trapped” there, creating an effective and firm fit along the geogrid plane (interlocking). The interlocking mechanism is fundamental to characterize the effect of the geosynthetic reinforcement taken into consideration: this “constraint”, which is exclusive and characteristic of a geogrid reinforcement and not of a geotextile, allows to effectively contrast the lateral movements of the aggregate, considerably increasing the performance of the road pavement ensuring a high control of settlements and the consequent formation of holes and ruts.
Starting from this principle, the Research & Development staff of the TENAX Group has developed **an innovative range of extruded geogrids with three-dimensional integral junction that focus on optimizing interlocking**.

TENAX 3D GRIDS.
Research and development

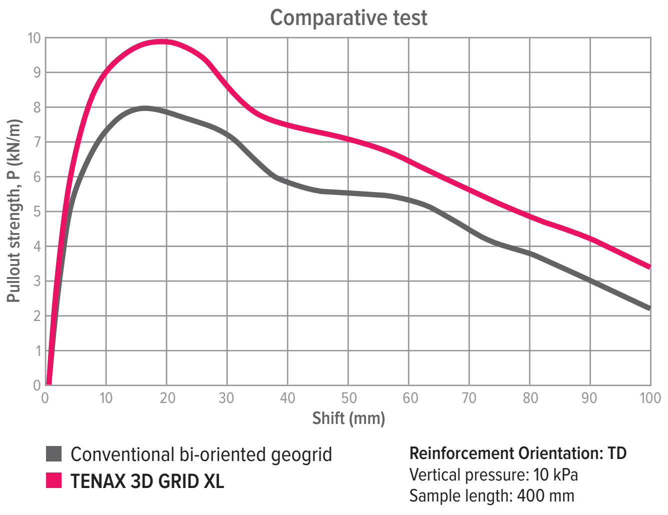
TENAX was able to develop its 3D GRIDS product range after a constant effort in researches conducted in collaboration with prestigious bodies and institutions in the field of design and certification, countless tests and trial campaigns which have been conducted to verify the performance of each of the grids.

As previously described, the mechanism through which the soil transmits stress to the geogrid is interlocking; the mechanism by which the geogrid transmits its resistance to the ground is the development of passive resistance wedges.

It is not possible in a simple way to measure the resistance developed, by simply imposing a movement on the ground to verify the capacity of the geogrid to hold it; however, it is possible to impose a displacement on the geogrid and verify the ability of the soil to prevent its movement. This can be done with a pullout test, through which a sample of geogrid inserted into soil is subjected to a normal stress and horizontal tensile force that attempts to pull the geogrid out of the soil.

This test is also apt to provide the value of the apparent friction coefficient (soil/geogrid interface) which is essential in the design phase.

Thanks to a series of tests carried out also in collaboration with the Mediterranean University of Reggio Calabria it was possible to evaluate the effect of the reinforcement structure and the difference in performance between traditional planar geogrids and 3D geogrids. The test results clearly show the effectiveness of the structure of TENAX 3D GRID S geogrids compared to conventional geogrids.



TENAX 3D GRIDS geogrids have been tested in collaboration with:

COMPARISON OF PASSIVE RESISTANCE WEDGES

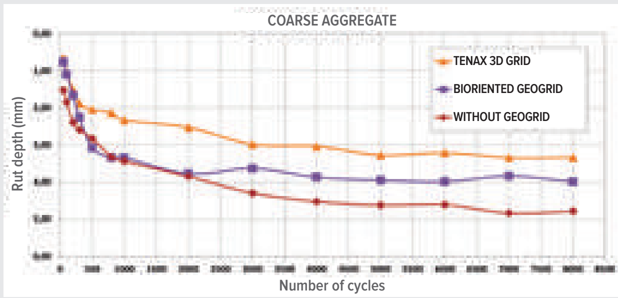
In order to validate and measure the behavior of 3D geogrids, an extensive test campaign was carried out at the University of Tennessee (USA) using a specific equipment to evaluate the performance of road pavements (APA, Asphalt Pavement Analyzer), adapted to allow testing of unbound granular substrates.
This equipment allows to verify the behavior of typical road packages by applying cyclic loads that simulate the passage of wheeled vehicles with a controllable contact pressure.
The depth of the ruts is measured on a regular basis after a pre-set number of load cycles: in this way it is possible to obtain graphs showing the depth of the ruts as a function of the number of cycles performed.

In agreement with what is stated in the document AASHTO Designation: R 50-09 “Standard Practice for Geosynthetic Reinforcement of the Aggregate Base Course of Flexible Pavement Structures”, to measure the effect of inserting a reinforcing geosynthetic in a flexible pavement it is necessary to carry out full-scale laboratory tests.
At the TRI-Environmental facility in Grenville (SC), USA, tests were carried out using the so-called APT (Accelerated Pavement Tester) equipment. The test envisages the construction of different full-sized road sections on which a load of 40 kN is applied cyclically, by means of a mobile semi-axle with twin wheel.
During the test, the ruts are measured as the number of cycles increases (passages of the car).

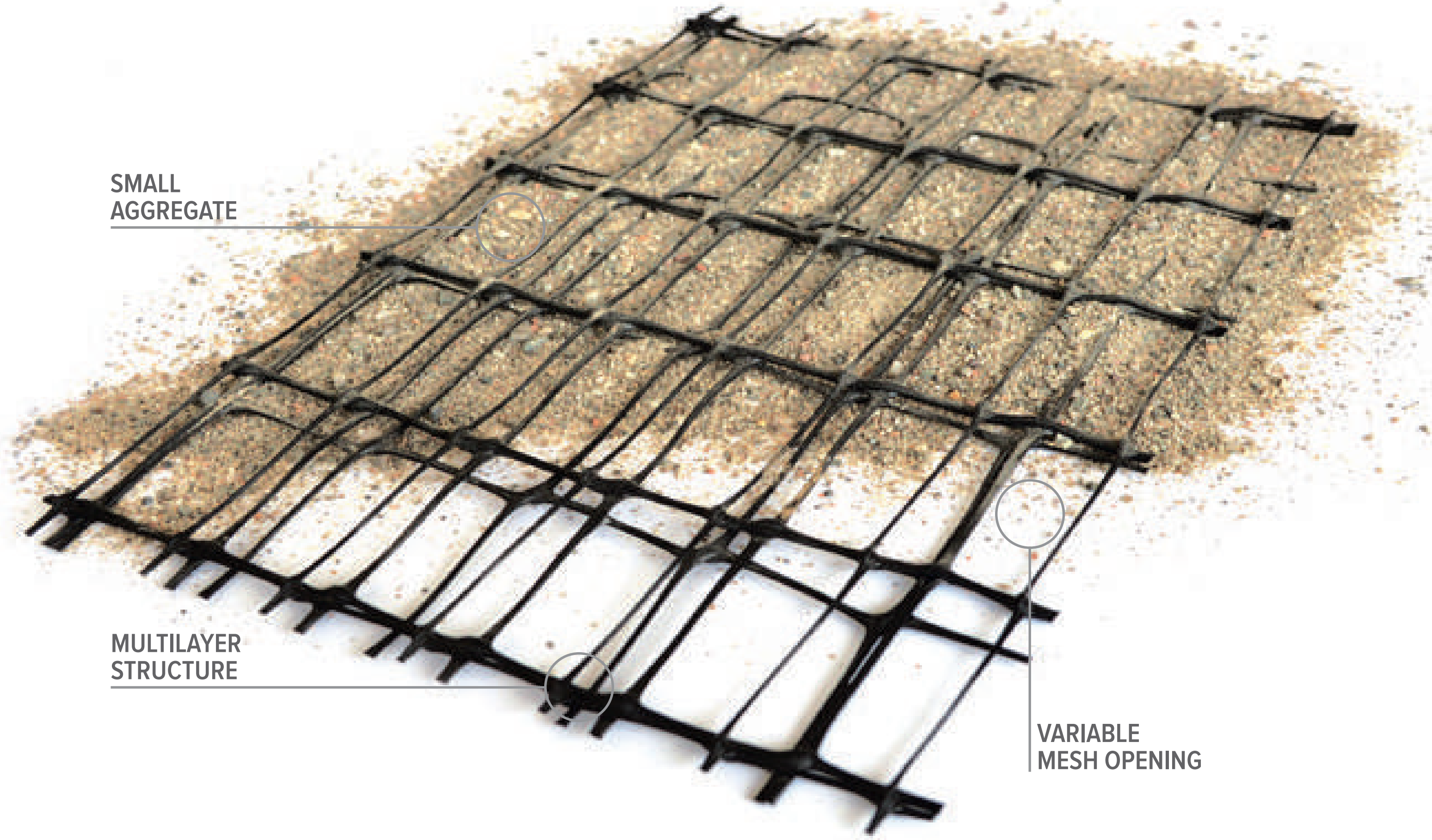
The ratio between the depth of the ruts, with equal passages, between a section of land stabilized with geogrids and a non-reinforced one, is indicated as “Rut Reduction Ratio (R.R.R.)”; the ratio between the number of cycles needed to reach a given rut depth in the two cases (unreinforced and reinforced land), is called the “Traffic Benefit Ratio (T.B.R.)”; the latter value indicates the possible increase in lifetime in a given reinforced road section.

TENAX has therefore developed a specific software (Tenax 3D) for the project of a road section or the verification of an existing section starting from the results of the real-scale tests described above.

The software allows engineers and designers to visualize, process and understand the parameters and requirements of the projects before the construction of the work. Its use allows to reduce design times while providing useful information for feasibility studies, cost-saving and LCA.

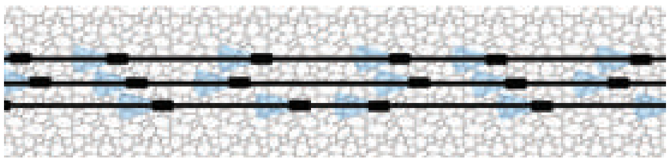


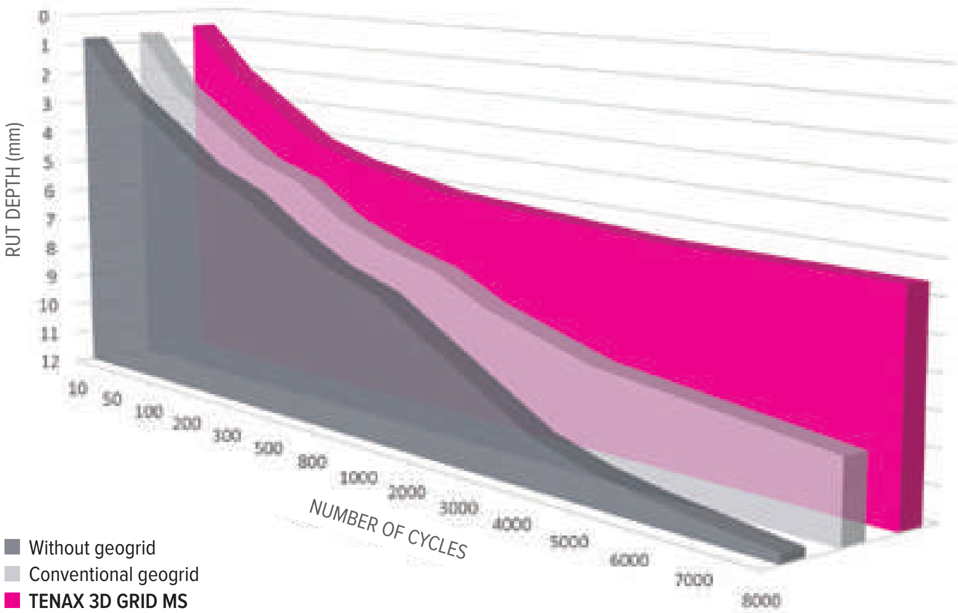
TENAX 3D GRID MS



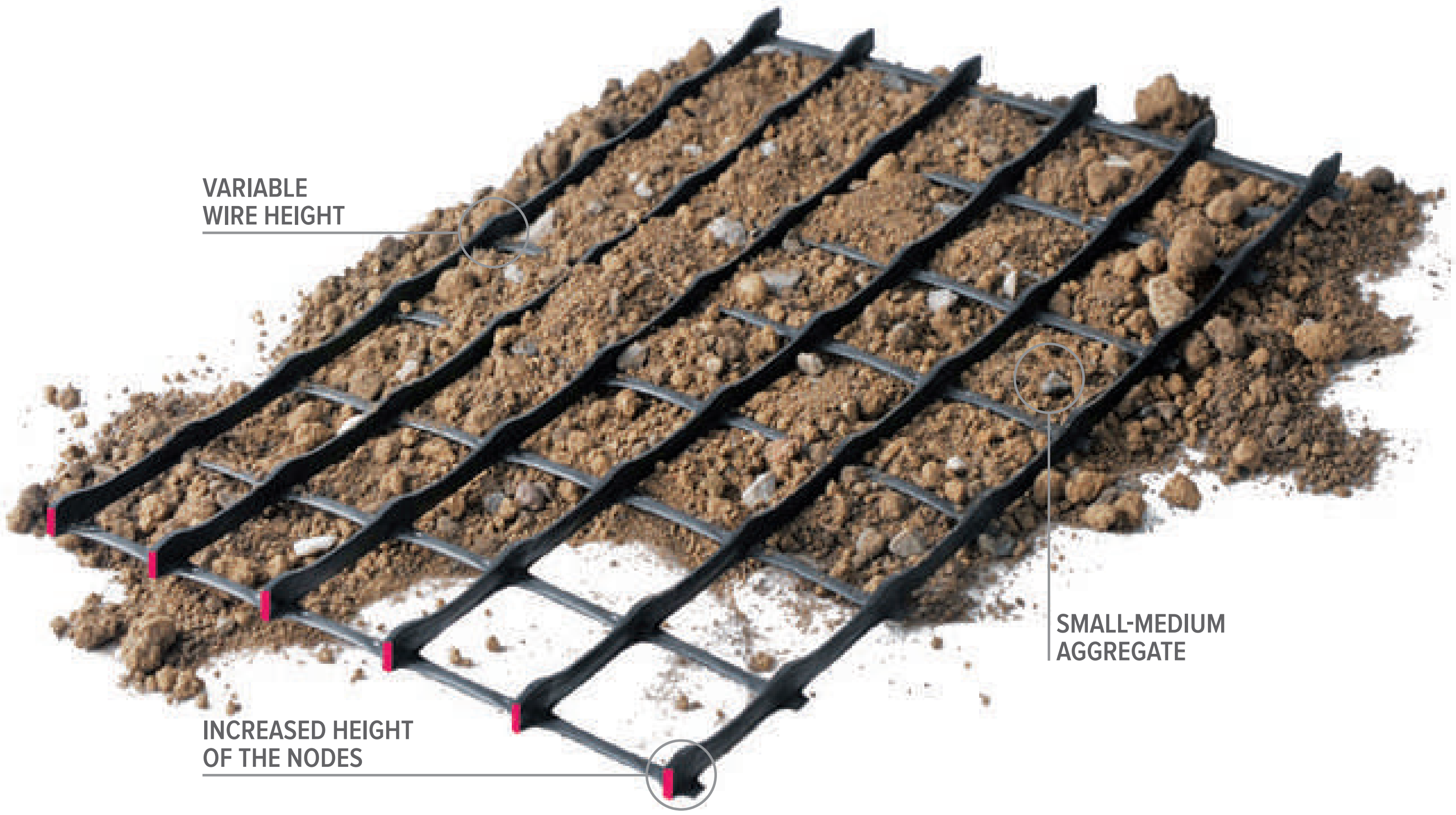
The 3D GRID MS are designed to ensure high interaction with fine, silty and sandy soils.
They are produced with an exclusive biaxial co-extrusion and stretching system, which allows for the creation of a multilayer structure with a dense network of multiple joints capable of ensuring interaction with a larger section of terrain.

GRAPH OF THE WEDGES OF PASSIVE RESISTANCE IN CORRESPONDENCE WITH THE RIBS



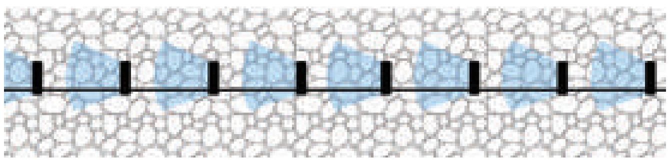


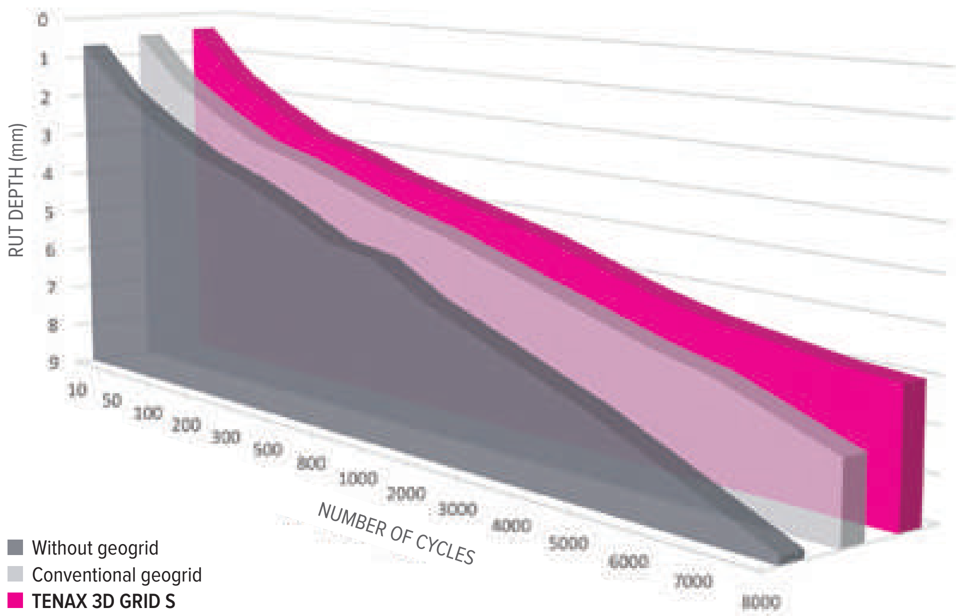
TENAX 3D GRID S



The 3D GRID S are designed to obtain a high section of the longitudinal wires and nodes.
Nodes dimensions 6 mm, thickness of the longitudinal wire 4 mm.
In particular, they are suitable for medium-small size soils.

GRAPH OF THE WEDGES OF PASSIVE RESISTANCE IN CORRESPONDENCE WITH THE RIBS

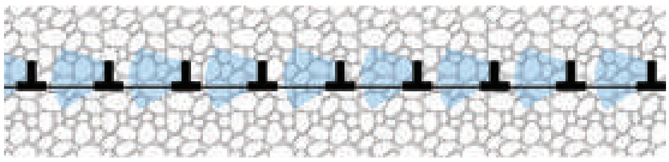


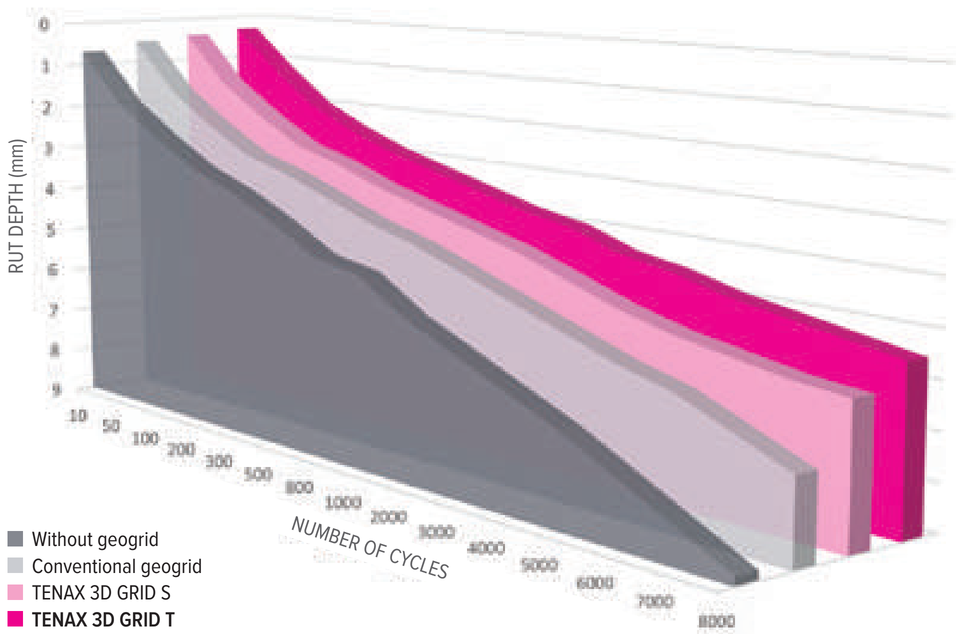


TENAX 3D GRID T e HT

The 3D GRID T and HT are an evolution of the 3D GRID S, whose special "T" shape incorporates the advantages of the rigidity of the classic T-beam, resulting in a mesh with increased torsional stiffness and shear resistance. The "T" section also allows to obtain a better interaction with the ground through lateral confinement but also on the floor.

GRAPH OF THE WEDGES OF PASSIVE RESISTANCE IN CORRESPONDENCE WITH THE RIBS

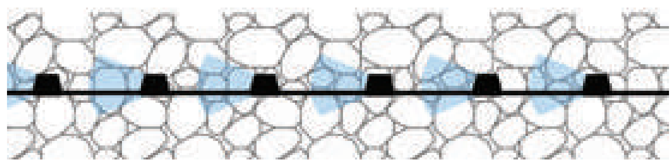


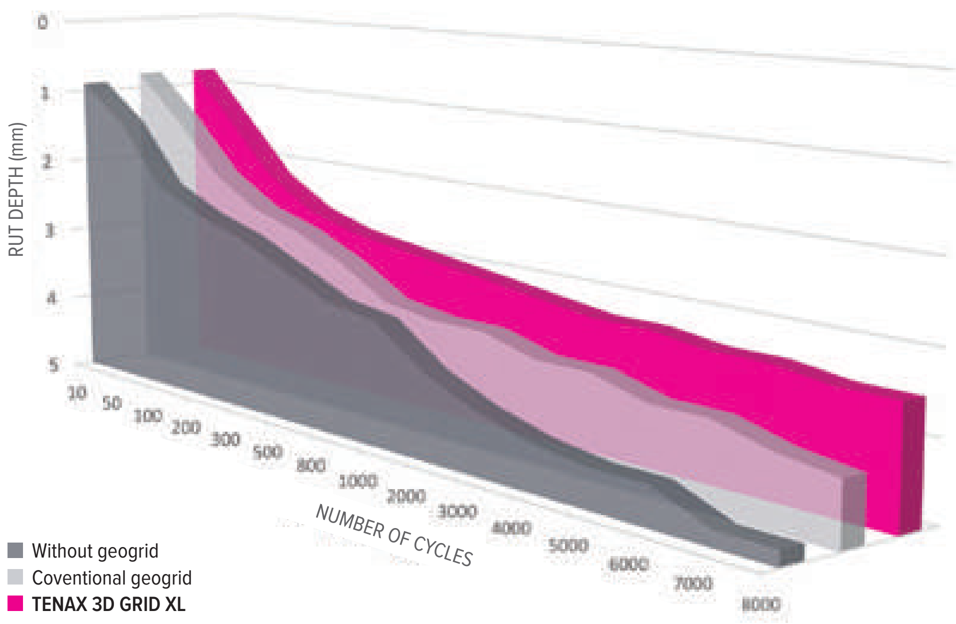


TENAX 3D GRID XL

TENAX 3D GRID XL with its particularly thick ribs, combined with the increased opening of the meshes (60x55 mm), allow for optimal interaction with large-sized granular materials.

GRAPH OF THE WEDGES OF PASSIVE RESISTANCE IN CORRESPONDENCE WITH THE RIBS





EXAMPLES OF APPLICATION

Ukraine, application of TENAX 3D GRID XL geogrid to stabilize a road.

Rome, St. Peter's Basilica. Stabilization of the floor adjacent to the basilica using the TENAX 3D GRID XL product.

Abraham Darby Academy, Telford, Shropshire. Application of 10,000 m^2 of TENAX 3D GRID MS geogrid for soil stabilization before the construction of a primary school.

RAILWAYS

The frequent passage of trains in very short intervals of time applies dynamic loads to the ground with consequent very intense compression and decompression cycles.

Therefore, railway foundations are subject to continuous fatigue stress which lead to frequent and costly maintenance.

Although these maintenance costs are high, by far the most impacting cost factor is the revenue reduction caused by disrupted services.

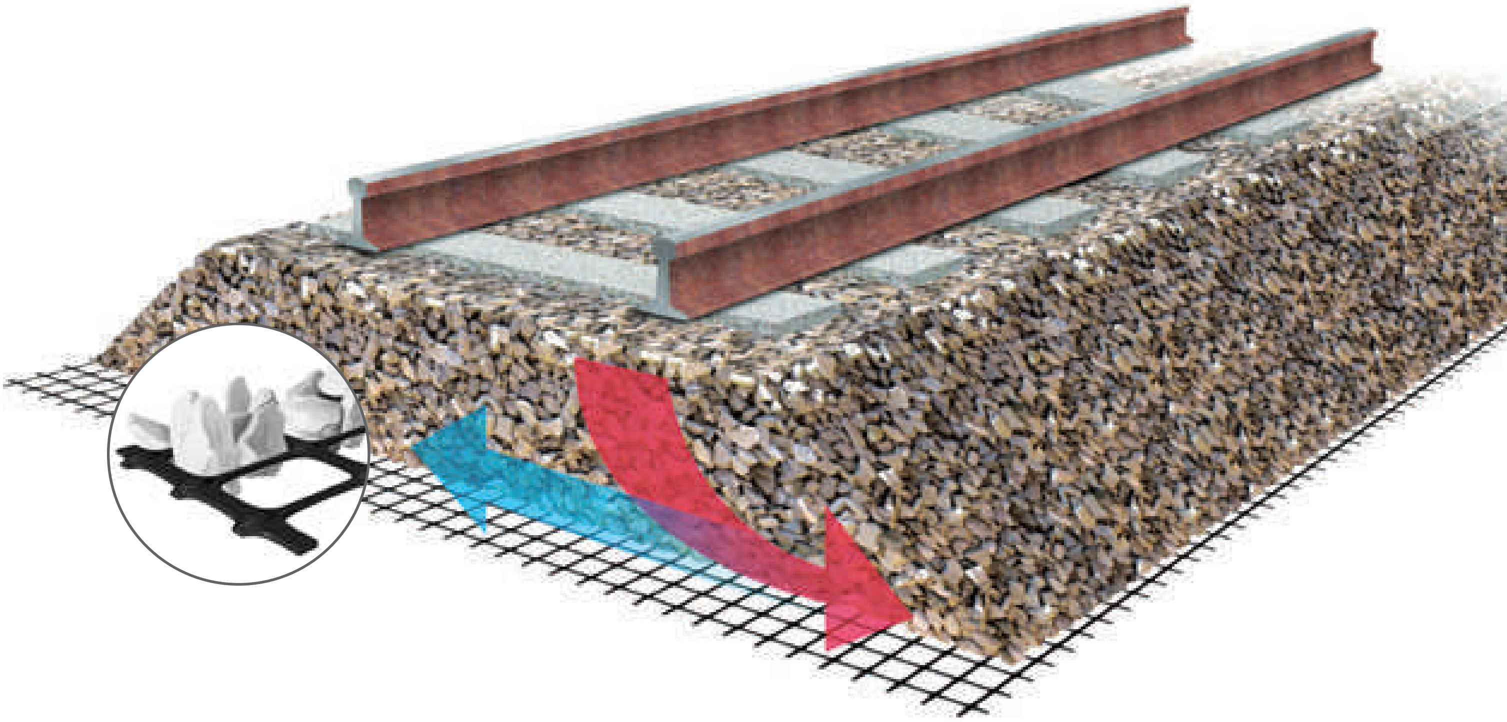
By incorporating TENAX geogrids within the railway construction layers, it is possible to combine important cost savings with significant performance advantages both in terms of ballast and sub-ballast levels.

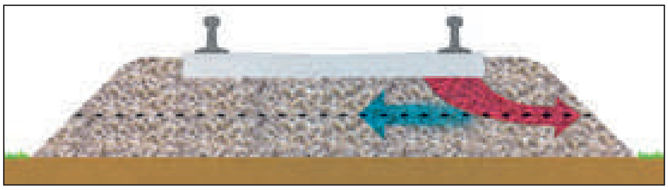
When granular ballast or sub-ballast material is compacted onto TENAX geogrids, the stone fill partially enters the grid openings and is eventually clamped down to create a strong, positive fit along the plane of the geogrid.

This locking mechanism allows the grid to resist the horizontal movement of the stones which improves ballast performance and reduces settling of the railway ballast.

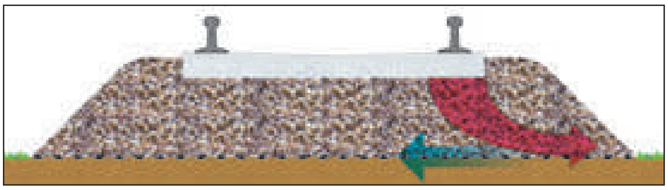
Celje, Slovenia.
TENAX geogrids installed in the underlay to increase the stiffness of the embankment and reduce the loss of aggregate into the substrate.

TENAX REINFORCEMENT SOLUTIONS





BALLAST REINFORCEMENT
TENAX geogrid improves ballast stiffness and provides lateral confinement of coarse aggregate.



REINFORCEMENT UNDER-BALLAST
The TENAX geogrid limits the deformation of the overlying ballast layer and distributes the stresses along the plane of the geogrid.

ALREADY EXISTING RAILWAY LINES

Over time, the constant movement of trains on the railways causes damage to the structure of the railway embankment, creating gaps inside it. It is common to observe, along the tracks, the sleepers that rise and fall during the passage of the train wheels. This excessive movement represents a hazard, so these gaps need to be filled and compacted to ensure a solid foundation for each sleeper. In some areas, loose and crushed stone chips accumulate in the gaps, compromising the drainage properties of the railroad construction layers.

To maintain track stability and levels, operations called “ballast tamping” are performed. These operations implies the use of specially designed tamping machines, which make the crushed stones vibrate and move them under the sleeper. This combination of actions allows the ballast to efficiently support the track, restoring its optimal conditions.

However, repeated pressing operations can cause further damage to the crushed stone particles, eventually depleting it and requiring its replacement. It is therefore desirable to increase the lifetime of the crushed stone, in order to reduce the need for repeated pressing operations, resulting in less maintenance, less disruption to railway operations and greater savings for the railway service operator.

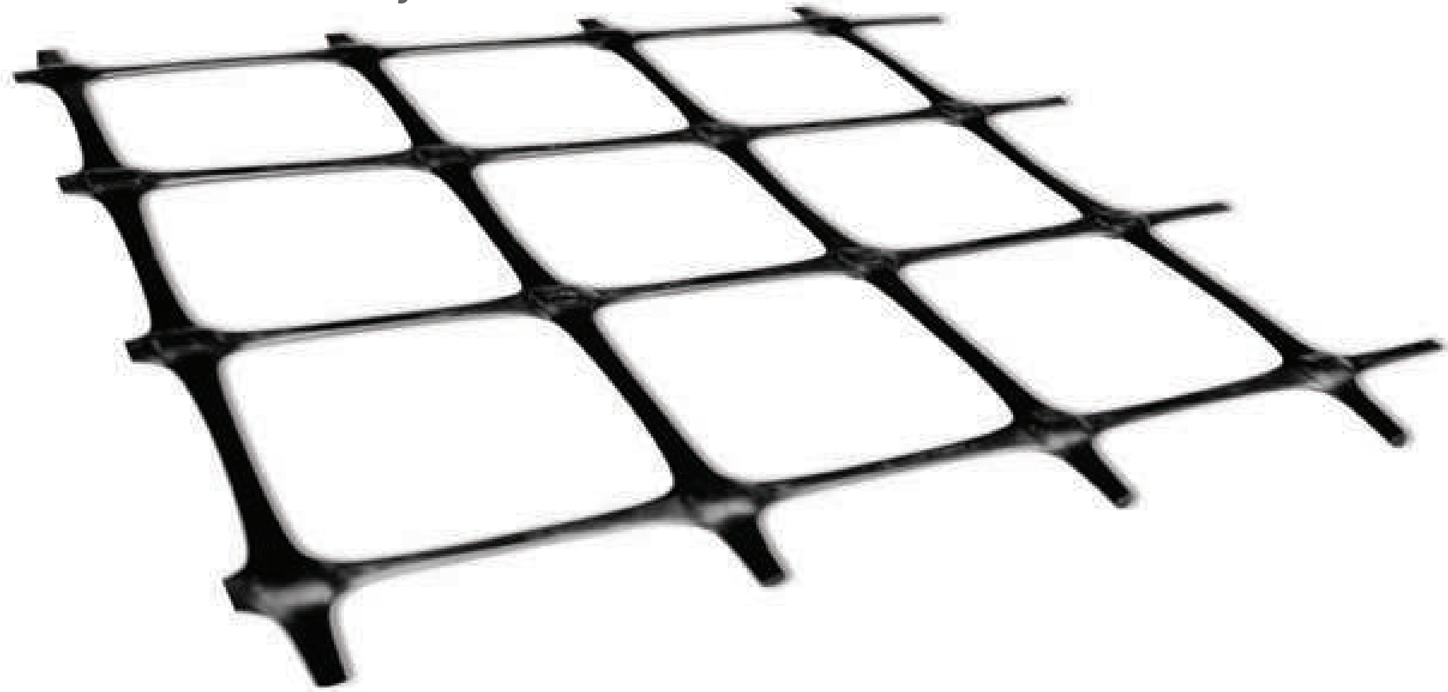
TENAX geogrids are used to reduce deformation in crushed stone layers by providing a solid connection along their surface.
This process reduces the creation of gaps and consequently extends the lifetime of the stone. This leads to important benefits in terms of cost savings and environmental impact for the railway operator that adopts these solutions.

NEW RAILWAY LINES

TENAX geogrids are also used in the construction of new railway lines on poor quality foundation soils. The use of these geogrids within the insole allows the required layer thickness to be significantly reduced, due to their reinforcing effect. This solution can also make it possible to reduce the depth of excavations on inconsistent soils, with a consequent reduction in the costs of material disposing. Furthermore, geogrids can also be used in combination with recycled aggregates, such as crushed concrete for example.

The economic and environmental advantages deriving from the use of TENAX geogrids have been widely tested in recent years, particularly in the construction of new railway lines all over the world.

TENAX GEOGRID
to reinforce railway ballast



TENAX LBO 370 and **HM 3L** geogrids have been specifically designed with large rigid square openings of optimal dimensions to maximize mechanical interlocking with the railway ballast.

Laboratory tests conducted by independent organizations have confirmed that the rigidity and size of the openings are decisive for the structural performance of the floors.

TENAX geogrids represent an extremely convenient solution to reinforce crushed stone on soft substrates, offering significant advantages for the excellent final result of the work.

CERTIFICATIONS

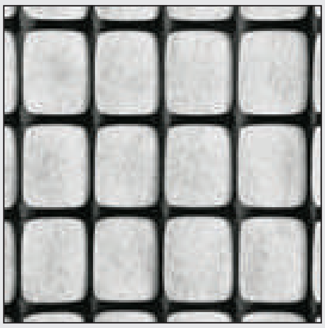
TENAX geogrids are certified by European railway authorities including Network Rail, the National Railway Authority of United Kingdom and the National Railway Authority of Netherlands.

NetworkRail

SEARCH AND TEST

Considering the characteristic of the material used for the ballast layer, which is one of the most aggressive materials for geosynthetic products (large angular stones), it is important to evaluate and verify the performance of the geogrid after its installation, too.

TENAX has conducted various full-scale tests in collaboration with independent bodies, simulating the damage from impact and abrasion due to friction according to the EN ISO 13427 standard.
TENAX geogrids have maintained residual strengths higher than 90% in both directions, thus resulting in an optimal solution to be used in these kind of applications.



SEPARATION AND FILTRATION FUNCTION

TENAX geogrids can be combined with a geotextile in order to obtain an additional separation-filtration function, besides the reinforcing/ stabilising function.

EXAMPLES OF APPLICATION

Midgham, England.
TENAX geogrids installed to increase ballast performance and reduce maintenance frequencies.

Vinkovci/Tovarnik, Croatia.
Reinforcement of the railway embankment with TENAX geogrid. 185,000 m2 of geogrid has been installed for the Croatian railway.

Mantgum, Netherlands.
The ballast refurbishment of the Frisian track was completed using a ballast cleaning train traveling at 3 m/s whilst simultaneously placing a geocomposite to stabilize the ballast/subgrade interface and to minimize the upward movement of the background.

LARGE AREAS

There are many other cases where geosynthetics are applied as base reinforcement for the reduction of settlements and the increase of bearing capacity.

Every time a new work is constructed on soft ground, the use of geogrids with a high elastic or isotropic modulus is the preferred solution.

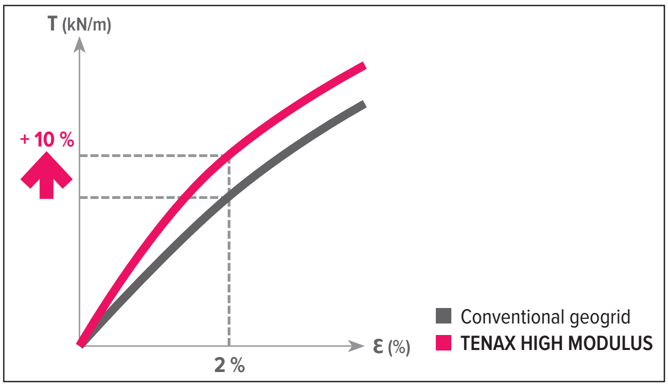
TENAX has developed both types to cover any project requirement.

The importance of the rigidity of a geogrid

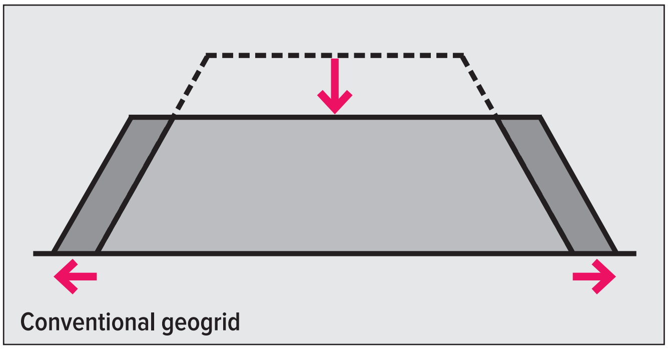
The peak tensile strength is a parameter that is often applied in the specifications of the products, since it is particularly easy to find this information in the technical data sheets and since this parameter is one of the fundamental requirements required by the harmonized standards for the CE marking of geosynthetics.
Actually, this value has no real project significance, and this is mainly for two reasons:

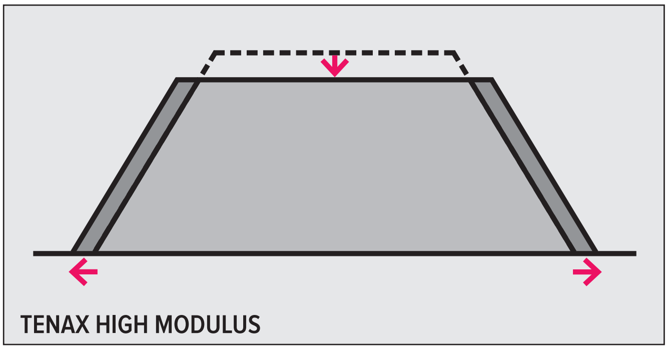
1. At peak stress any geogrid develops deformations which are not compatible with the stability of any structure.
2. At peak stress, the viscous behavior of the reinforcement could make structures unsafe.

Keeping on considering the peak tensile strength as a fundamental parameter for the project itself is therefore not what happens in real operating conditions when making the work: in fact, excessive deformations have now developed for these values which are not compatible with the stability of any structure.



The right value to be used during the project phase, in drafting a specification, or in the comparison between different materials is the tensile strength which corresponds to a deformation of 2%.

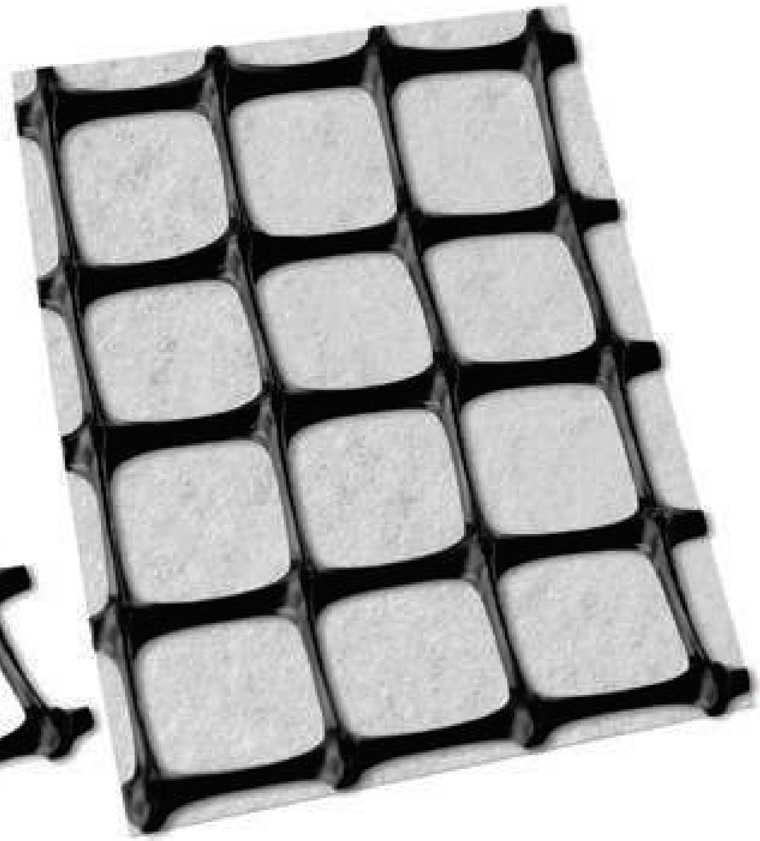




EXAMPLE

If we had to size an embankment with a width of 30 m using the Peak Tensile Strength as a design parameter, it would mean accepting a deformation in the reinforcement of at least 10%.
This deformation would correspond to an elongation in the geogrid of 3 m (10% of 30 m) while the development at the base of the embankment would pass from 30 to 33 m, and therefore a deflection of [(33/2) 2-152]1/2 - 6.87m could develop in the middle of the embankment.

TENAX LBO HM and TENAX GT HM



TENAX LBO HM geogrids and **TENAX GT HM** geocomposites are the evolution of the traditional bi-axial geogrids with integral junction in extruded polypropylene.

Their unique characteristic is the increase of the Elastic Modulus, i.e. the improvement of mechanical performance at low deformations (0.5% and 2.0%).

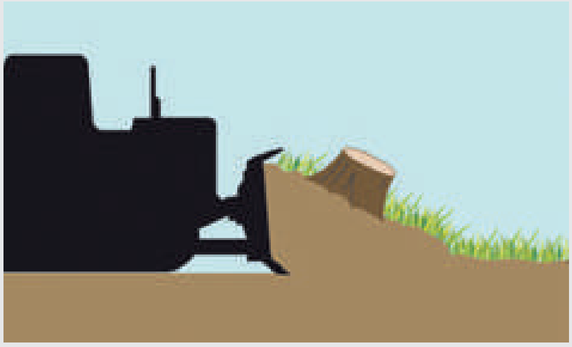
ADVANTAGES

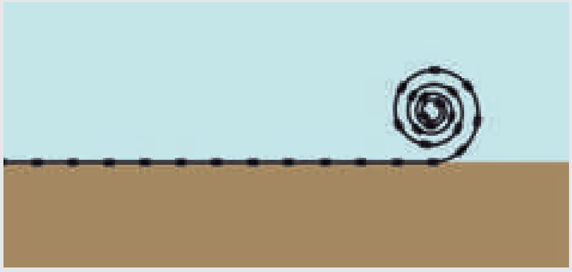
- For the same load, **less settlements of the structure**
- **Elastic modulus grater than 10%**, compared to all traditional bi-axial geogrids
- Best performance **right away**
- **No viscous phenomenon** (creep) within the operating strain limits
- Higher performance **at a lower cost**

Instead, when the use of isotropic double-stretched geogrids is expressly required, TENAX offers its ***LBO SAMP*** *and* ***GT SAMP*** *range.*

HOW TO INSTALL
TENAX 3D GRIDS, LBO, GT GEOSYNTHETICS

1. Remove rubble, logs, etc from the ground. Grade and level the substrate to the right level as required by the project;
2. Unroll the Tenax geogrids on the ground and press down with your hands to avoid creases. Overlap the geogrid panel, either horizontally or vertically, depending on soil resistance.





Ask the opinion of the technician, or alternatively use the table below for its orientation. The overlap should be done in the direction of the ground to avoid the geogrid to uplift. Tenax geogrids can be stretched and fixed along the outer edges with “U” bars or with stones.

CBR(%) > 3	*Overlap 300 mm*
1 – 3	*500 mm*
< 1	*750 mm*

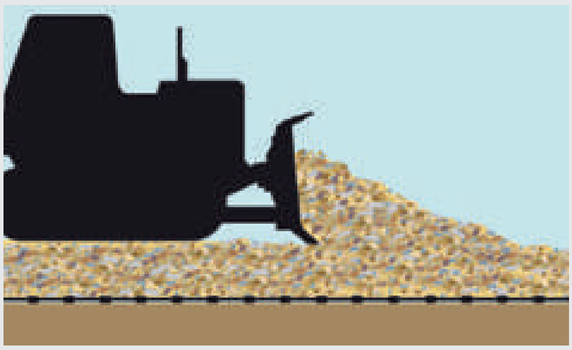
Table 1: Advice for overlapping

3. The diameter of the backfill soil particles should be carefully selected in order to optimize the performance of the geogrid.

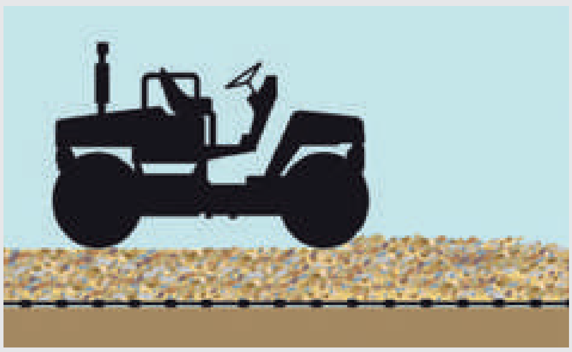
4. Two distinct installation procedures needs to be used considering the resistance and characteristics of the soil of the site being worked on:

On a stable soil foundation
- For the application of the backfill material on the ground (CBR > 3), a truck with rubber wheels can drive directly on the geogrid very slowly (the speed must not exceed 10 km/h) and unload the backfill material.
  The workers will not have to add any material as the truck moves along the geogrid.
- Tracked vehicles cannot drive directly onto the geogrid unless a minimum of 150mm of backfill is placed between the geogrid and the ground to prevent it from cracking.
- The base layer material should be placed in vertical thicknesses and compacted in accordance with the project requirements.
- Any furrow which creates during the spreading and compaction of the material needs to be filled with additional backfill material to achieve the predefined thickness.

On a soft soil foundation
- For a soft (CBR between 1-2) or very soft (CBR <1) soil foundation, it is recommended to perform an initial backfill of 300 mm with support equipment. To backfill a soft soil foundation it is recommended to use pressure equipment for distribution and backfilling specifically for a soft subfloor.
  Dump the backfill onto the geogrid where the soil foundation is most stable, and then spread the backfill past the grid into the weakest foundation. Sharp bends, sudden brakings or bends are to be avoided.
- Trailer trucks or other machinery should not travel over the material until the backfill is fully compacted and thick enough to support their load.
- Compaction of the backfill material, according to the prescribed density, must be carried out without overloading the subgrade. It is recommended to use light equipment only to compact the first layer on very weak foundations. If it is necessary, wrap the geogrid on the outside edges to improve its performance.
- Any furrow which creates during the spreading and compaction of the material needs to be filled with additional backfill material to achieve the predefined thickness.



5. If more than one layer of geogrid is planned, repeat steps: 2, 3, and 4.



NOTES

Repairing The parts of the geogrid that have been damaged during their installation must be repaired with patches. Remove backfill material from the 500mm surrounding the damage area and then place a patch over the Geogrid to cover the damaged area, ensuring it extends for at least 500mm from the area.

Cutting Tenax geogrids can be easily cut using shears to create hatches, curves, etc.

Protection The geogrid must be protected from long exposure to direct sunlight during transportation and storage.
After placement, the geogrid should be covered as soon as possible.

COMPLEMENTARY APPLICATIONS

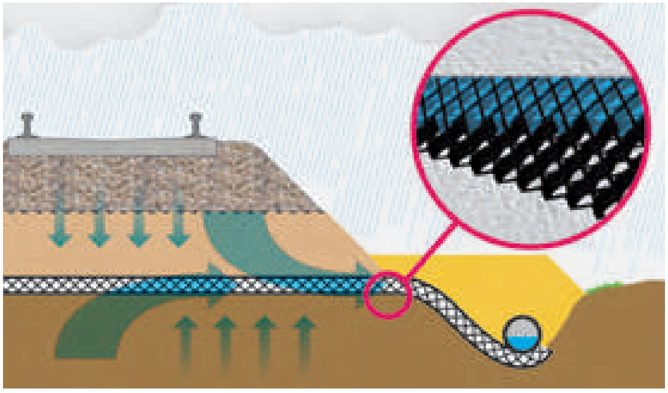
For the construction of large works, stabilization is one part of the interventions necessary for their completion, there are other TENAX solutions that can be applied in the same work with different complementary functions.

Padova-Mestre, Italy.
Capillary break layer beneath the high-speed railway line Milan-Venice in the Venice-Mestre area.

ANTI CAPILLARY RISE

If an aquifer is present, it can cause the phenomenon of capillary rise. Over time, this phenomenon generates problems to the stability of the overlying soil layers due to the erosive action and leaching which reduces the compactness of the layers.

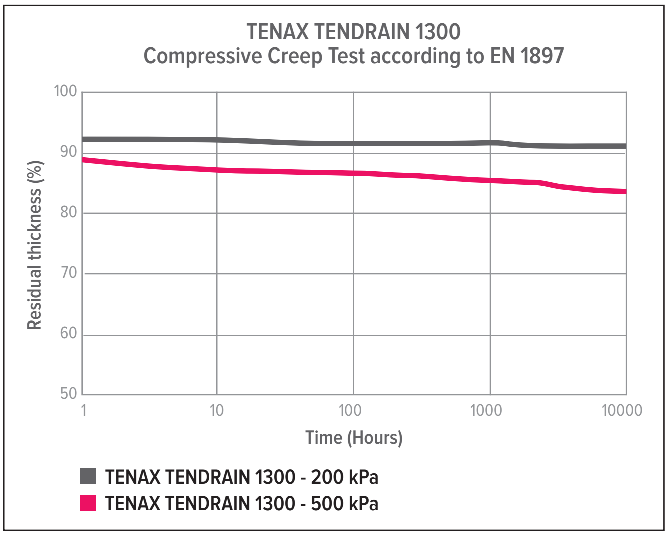
It is essential to provide adequate soil protection to avoid this problem.



An effective solution consists in using a **TENAX TENDRAIN** or **TENAX HD** geocomposite as an anti-capillary barrier layer.
These materials replace traditional draining soils and combine the functions of separation, filtration and drainage.
In addition to avoiding capillary rising, they allow for considerable economic savings, reducing the means necessary for transportation and speeding up the full installation process.

In the project phase it is important to consider the operational lifetime of the drainage geocomposite and the reduction in thickness, which directly affects the drainage capacity of the product itself, throughout its lifetime.

TENAX HD and **TENAX TENDRAIN** have been tested according to the EN 1897 standard and are perform up to 95% of the initial value even after 10,000 hours under heavy loads (up to 500 kPa) which demonstrates that they maintain their hydraulic capacity in the long term even under high compression.



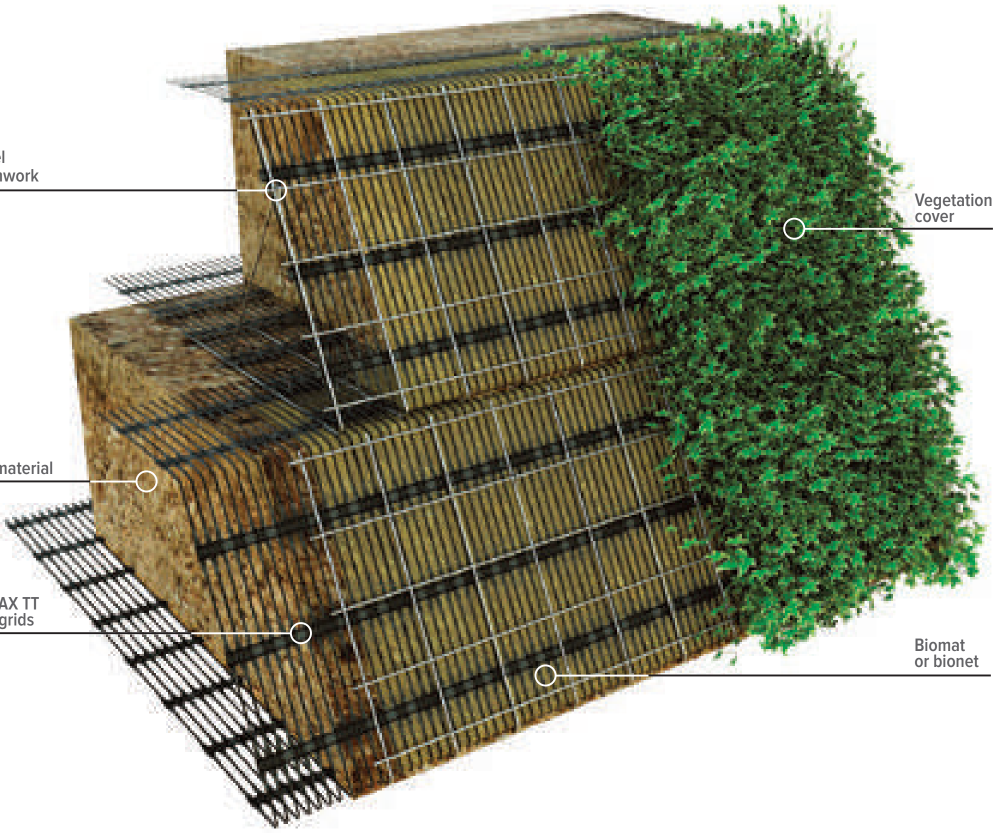
ADVANTAGES

- **A significant cost savings compared to traditional filtration methods, such as imported granular filtration blankets.**
- **An improvement in the stiffening and overall strength of the ballast and sub-ballast layers due to an improved control over the water.**
- **A marginal potential for hydraulic pumping of fine soils from the subsoil to the footbed and crushed stone.**
- **A marginal potential for excess pore pressure to rise under cyclic loading.**
- **A reduction of ballast degradation due to sludge abrasion, chemical action and water freezing.**

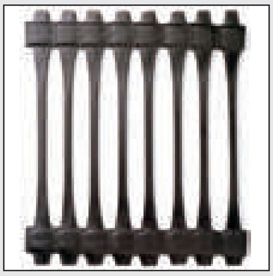
REINFORCED SOILS
for noise barriers and rockfall barriers

TENAX RIVEL SYSTEM

The versatility of the system allows it to be applied as a noise barrier, rockfall barrier, bridge abutment support, reinforcement for road and railway embankments and much more.



TENAX TT geogrids
They are two-dimensional structures made of HDPE using a one-way extrusion and stretching process and are certified for the construction of reinforced steep slopes with an inclination of up to 85°.



Filling material
The reinforced-lands technique allows you to use any type of fill terrain; however, it is preferable to use a draining granular material with a high angle of internal friction, possibly without pebbles.

Formwork in electro-welded mesh
The TENAX RIVEL system foresees the use of a “disposable” electro-welded mesh guide and support formwork on the facade (ø 6-8 mm / 15x15 cm mesh). It has no structural function, but allows rapid laying rates.

TENAX FVP anti-erosion mat
In every naturalistic engineering intervention, the vegetation plays an active role in the protection of the slope. To avoid the use and costs of hydroseeding, it is possible to use TENAX FVP, Pre-seeded Vegetative Felt.

Bridge abutment, Peljesac Bridge, Croatia.

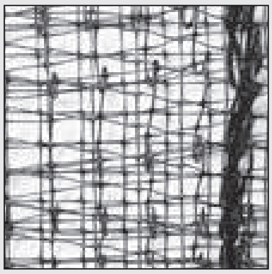
Rockfall barrier, Varenna (LC).

EROSION CONTROL

The grassing of an inclined surface mainly made up of topsoil is limited to the choice of a suitable sowing of herbaceous and shrubby essences, since the nature of the soil itself is indicated for the growth and maintenance of the vegetation.

This does not mean that, until the root system of the sown or hydro-seeded herbaceous essences develops, the blade of grass is easily washed away by surface runoff phenomena of rainwater.

For this reason, **TENAX MULTIMAT** multi-layer 3D geomats are suggested, since they are suitable for retaining the seeds and, consequently, for the immediate anchoring of the slender roots in the development phase, preventing the formation of furrows. They are made of polypropylene (PP) and consist of 2 external layers of flat geogrids and a pleated central one so as to give consistency and thickness to the geomat, making it particularly resistant to crushing; the 3 layers are industrially sewn together with a high tenacity yarn.



TENAX MULTIMAT

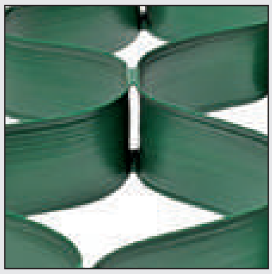
The TENAX MULTIMAT 100 geomat is used as a TRM (Turf Reinforcement Mat): if put on the slope to be covered with grass and filled with topsoil, it protects and retains the surface layer of soil, seeds and shoots from any dragging action of both rain water and runoff water; it also allows for the "anchoring" of the roots of the sown herbaceous and shrubby essences, which will form with it a single and even more resistant block to the action of water and the force of gravity.
The geomat must be filled with fine, dry vegetable soil in which a mix of seeds can be pre-mixed.

Often the land that forms a slope has a predominantly arid matrix and lacks organic material; this happens for example when cutting rocky or dry slopes for the construction of road embankments.

In these conditions it is necessary to lay an adequate thickness of cultivation soil to allow the growth of vegetation.

Since the topsoil has poor mechanical properties and can therefore easily slide down the slope, it can be washed away in case of heavy rainfall before vegetation growth.

TENAX TENWEB geocells allow for the stabilization of the topsoil even on very steep slopes, ensuring its lateral confinement. Once the panels have been opened to their maximum extension and the geocells have been filled with topsoil, a perfectly plantable stable layer is created, the surface of which can be further protected from surface erosion by using TENAX FVP Pre-seeded Vegetative Felt. When the surfaces on which to intervene are made up of weathered rocks and show an unstable presence of stones mixed with finer material, it is necessary to create a safe containment-retention system for heavier and larger material which could fall from the wall and at the same time "contain" small volumes of soil.



TENAX TENWEB

TENAX TENWEB geocells (thick 75 and 100 mm) are made following a continuous polyethylene extrusion process without subsequent welding or studding: the cells remain connected to each other through open joints through which liquids and fluids can flow to avoid them from stagnating and weighing down the cape.

23100038

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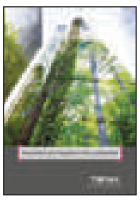
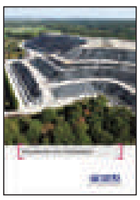
Further information on geosynthetics and TENAX solutions is available upon request and on our website:

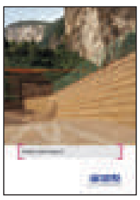
- Brochures;
- Technical Data Sheets;
- Installation Guidelines;
- Tender Specifications.



Geosynthetics for civil and environmental engineering

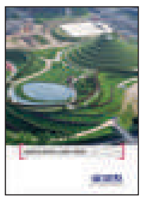


Landfills and contaminated sites



Geogrids reinforced slopes

Roads, railways, large areas



Landscaping and green areas