LANDFILLS AND CONTAMINATED SITES

TENAX

Man. Technology. Environment.

LANDFILLS AND CONTAMINATED SITES

The European Directive relating to Controlled Landfills defines landfill as: an area used for the waste disposal by spreading it on the ground or in the ground, including the area inside the place of production of waste, used for waste disposal by the producer of the same, as well as, any area where the waste is subjected to temporary storage for more than a year.

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

Memberships

AGI Associazione Geotecnica Italiana

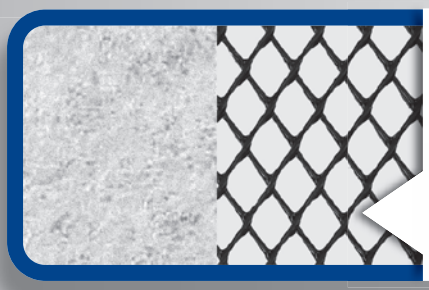
igs

UNI

AssIGeo Associazione Imprese Nazionali Geosintetici

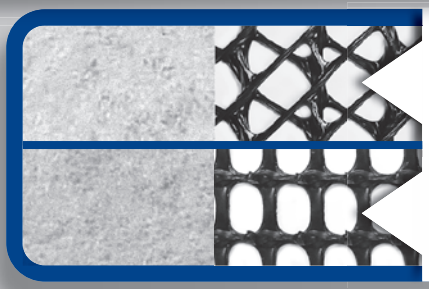
Active participation in Geosynthetics technical committees: UNI, CEN, ISO.

TENAX GEOSYNTHETICS: INNOVATIVE, HIGH PERFORMANCE, ECONOMIC AND SUSTAINABLE SOLUTIONS.



PROJECT REQUIREMENT
Use of a geocomposite at low costs

Our solution
TENAX SD filter/drainage geocomposite

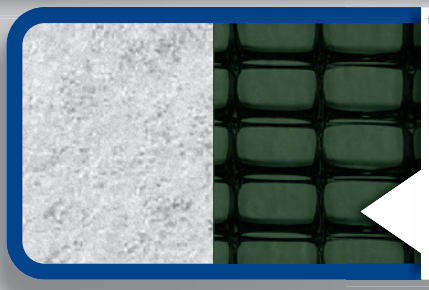


PROJECT REQUIREMENT
High Hydraulic performance
under high pressure

Our solution
TENAX TENDRAIN triplanar geocomposite with three strands tested at over 500 kPa normal pressure
+ TENAX TDP with excellent transversal drainage

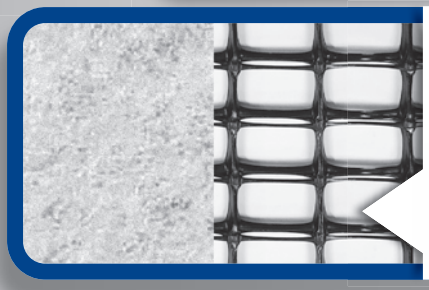
PROJECT REQUIREMENT
Interface High friction
drainage geonet/impermeable geomembrane

Our solution
TENAX HF “High Friction”
>36° interface friction



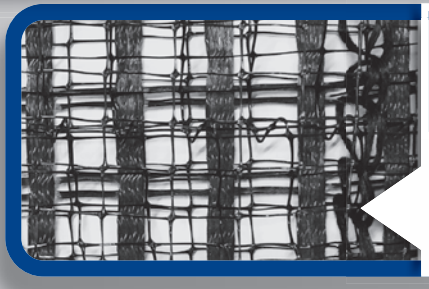
PROJECT REQUIREMENT
Complete the compacted clay barrier
or the GCL layer

Our solution
TENAX HDcu. The whole TENAX range is available with an impermeable membrane on one side



PROJECT REQUIREMENT
Pressures are moderate
but flow rates are significant.

Our solution
TENAX HD “High Drainage”
3,00 litres/m/sec under 20 kPa pressure



PROJECT REQUIREMENT
1 m soil stability on landfill capping

Our solution
TENAX MULTIMAT R
3D gripping and reinforced 3D Geomat

GROUND AND WALL DRAINAGE

Geonets and geocomposites TENAX are now used in a wide range of applications on controlled landfills, providing mechanical protection to geomembranes, gas drainage, collection and drainage of leachate and other liquids in the ground, as well as a barrier against capillary action.

Drainage systems for leachate collection and removal serve to limit the hydraulic head within the drainage layer.
The use of geocomposites to capture and gather leachate or other liquids entails both technical and practical benefits, in comparison to granular materials (aggregate) they are readily available and easy to install, they confer major stability to the slopes they are laid on, and exhibit considerable chemical resistance and excellent erosion/corrosion resistance. Synthetic geocomposites also provide real economic advantages if we compare their purchase price and installation costs to those of a traditional drainage system made up of layers of sand and gravel. The minimal thickness of the geosynthetic layers and the possibility of building landfills with steeper slopes also allow to increase landfill capacity as more usable volume is available for waste storage. The estimate of average cost savings is approximately 50% when using a synthetic product instead of a traditional one. Last but not least, another possible evaluation that can be made refers to the environmental impact caused by the use of natural materials and to the consequent sustainability of their application. In particular contexts, the use of gravel involves considerable costs also from an environmental point of view; these costs arise from the quarrying and road traffic caused by the transport of material.

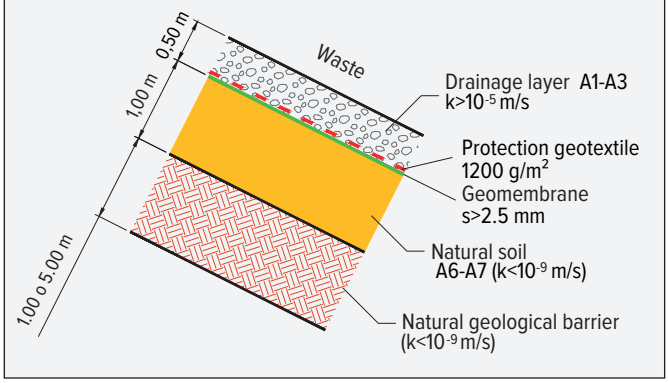
COLLECTION AND REMOVAL OF LEACHATE IN LANDFILLS

The leachate collection and removal system (LCRS) is usually installed on top of the primary liner layer inside the landfill.
TENAX TENDRAIN and **TENAX TDP** are geocomposites made up of a highly resistant drainage core coupled with non-woven geotextiles, particularly suitable for the drainage and collection of leachate (LCRS).
The inner strands of the geocomposite TENAX TENDRAIN, which are the thickest and heaviest ones, provide a very high transmissivity and resistance to load compression while the cross strands prevent intrusion of the geotextile and the soil under sustained normal load which would otherwise cause clogging in the flow channels of the system.
The inner drainage core of the geocomposite TENAX TDP is a combination of flat cuspated structure laminated to nonwoven geotextiles; particular shape of the core provides high compressive resistance and a considerable flow rate even in transversal direction.
TENAX TENDRAIN and TDP assure the collection and removal of the leachate under heavy compressive loads while maintaining constant hydraulic performance over a long period of time to limit hydraulic head within the drainage layer, in contrast to traditional geocomposites that may show a reduction in draining capacity due to compressive creep as a result of sustained normal load and to intrusion of the geotextile inside the geocomposite.

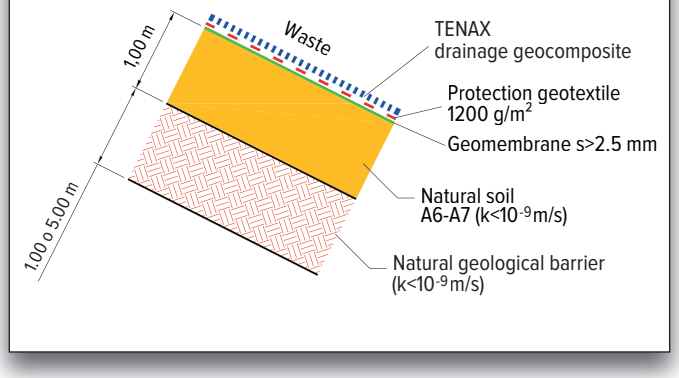
GROUND "BARRIER SYSTEM" 0^{-5}

GROUND LANDFILL FOR NON-HAZADOUS AND DANGEROUS WASTE WITH SLOPE > 30°

CONVENTIONAL DESIGN



PROJECT WITH TENAX GEOCOMPOSITE

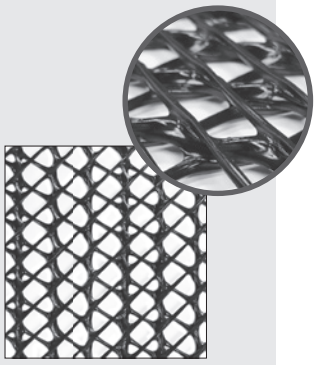


BENEFITS IN USING TENAX GEONETS AND GEOCOMPOSITES

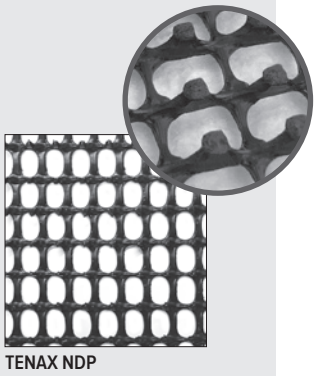
TENAX CE, **GNT**, **MDP** geonets and **TENAX TENDRAIN TN/TNT** geocomposites are easy to install, readily available, and totally inert to chemicals; these are some of the features that make each product a top solution for controlled landfills:

- **If installed beneath the geomembrane they prevent mechanical damage and drain fluids and gases from the soil**.
- **If used on top of the geomembrane they provide mechanical protection and help with leachate drainage.**

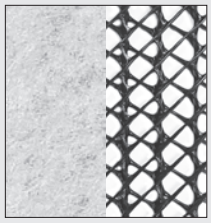
Due to their high transmissivity, they are safe and efficient substitutes for granular materials as foreseen by current legislation in force.
The net capacity available for waste disposal will increase considerably by using TENAX geonets and geocomposites allowing much steeper slopes with increased slope stability in comparison to a traditional mineral drainage layer.



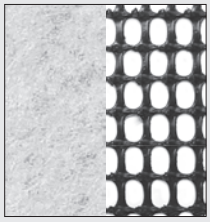
TENAX GNT



TENAX NDP



TENAX TENDRAIN



TENAX TDP

CAPPING AND REMEDIATION OF CONTAMINATED SITES

The TENAX geonets and geocomposites limit the infiltration of water inside the landfill cover system. This eliminates the possibility of water flowing over the membrane, reducing the soil/ membrane friction coefficient to practically zero which in turn would cause sliding of the cover soil over the waterproofing cover layer.

In accordance to the European Directive 1999/31/ EC, a capping system for an exhausted landfill must guarantee:

- insulation of waste from the external environment;
- minimization of water infiltrations;
- minimization of maintenance costs;
- minimization of erosion phenomena;
- resistance to settlement and to localized subsidence phenomena;
- **stability along the slopes which also include the interfaces between the different materials used;**
- **landscape integration.**

The required layer for the **biogas collection** (both for non-hazardous and hazardous landfills) as well as surface water (for any type of Landfills) must be made up of granular materials suitable protected from clogging, usually having a minimum thickness of 0.50 m.

The **drainage layer for the surface water** (for any type of Landfills) must have a minimum thickness of 0.50 m and a hydraulic conductivity k > 1x10-5 m/s.

The drainage layer for water can consist of a drainage geocomposite provided that it is possible to demonstrate its equivalence with the layer of material it substitutes and provided that it is suitable for drainage of a meteoric flow rate with a return time of 30 years.

Modern production technologies and even more stringent quality control requirements make sure that a geocomposite with CE marking supplied by a ISO 9001 certified Company will provide to clients and designers efficiency guarantee, durability and reliability grater than any other granular material.

REASON TO SUBSTITUTE CONVENTIONAL DRAINAGE MATERIALS WITH TENAX GEOSYNTHETICS

TECHNICAL REASONS

The stratigraphy with natural materials is frequently incompatible with the geometries of landfills. Such difficulties are amplified where design must be carried out in seismic conditions. Similar considerations apply, as far as the upper parts are concerned, with regard to the latest requirement of the capping system: it is certainly clear that settlements and localized subsidence phenomena can be greater the greater the weight of the capping, and that replacing the granular materials, which have a minimum thickness of 1.00 m and a weight close to 2 t/m^2, with synthetic materials of minimum thickness and total weight of less than 2 kg/m^2, means reducing the load transmitted to the body of the landfill by at least 40%, and therefore reduce the possible settlements by 40%.

ECONOMIC REASONS

The materials that are generally used for the drainage layer are gravels or clean sands: the need to deliver large quantities of a valuable and expensive material to the construction site, difficult to find in such quantities from a single source and, therefore, difficult to control on site, make this solution extremely expensive.

REASON RELATED TO THE ENVIRONMENTAL IMPACT

Finally, a further reason is related to the environmental impact.
In particular contexts, the use of natural materials (clay, sand, gravel) involves significant “environmental” costs due to excavations and road traffic caused by the transport of the material.
To understand this aspect, just think that for a modest landfill, with a coverage of 40,000 m^2 (extension 200 x 200 m), the following materials are necessary:

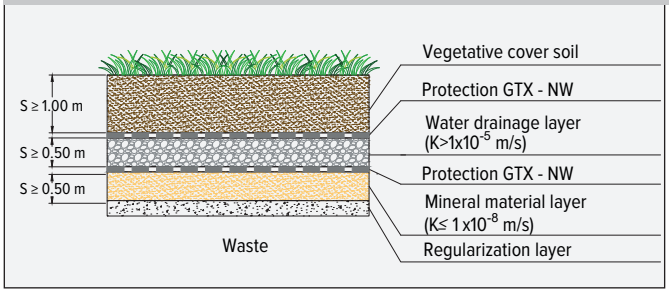
- 40.000 m^3 gravel (about 4.000 trucks 10 m^3 capacity);
- 20.000 m^3 compacted clay (25.000 m^3 loose clay 2500 trucks);
- 40.000 m^3 vegetative soil (again, 4.000 trucks) for a total of 10.500 trucks with capacity exceeding 200 q.

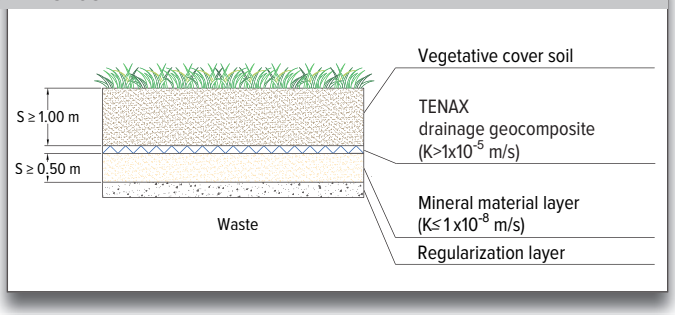
CAPPING SYSTEM

CONVENTIONAL DESIGN

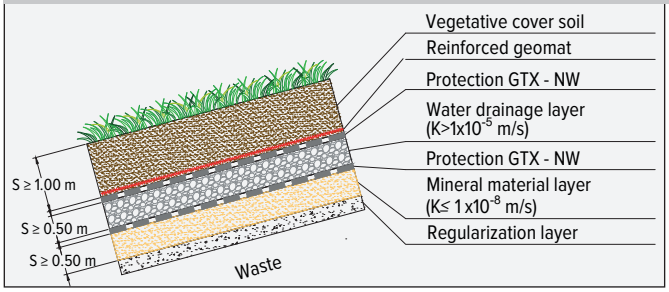
TENAX GEOSYNTHETICS DESIGN SOLUTION

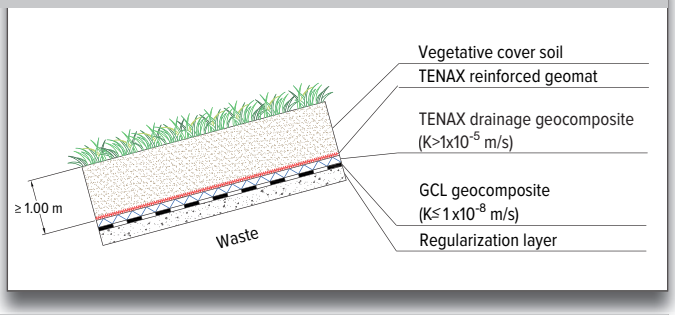
LANDFILL FOR INERT WASTE DISPOSAL – PLAIN



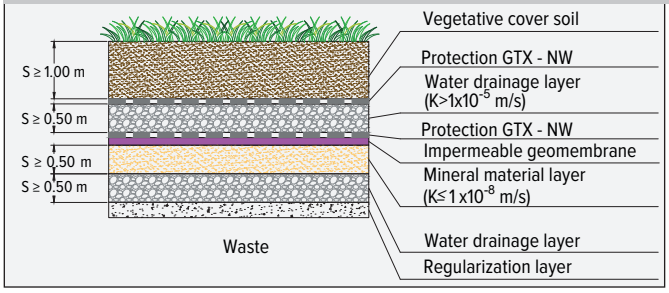


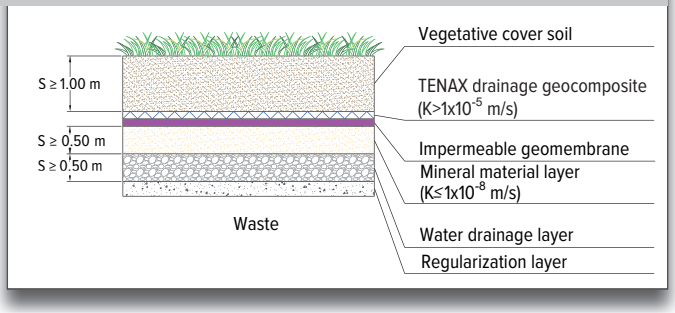
LANDFILL FOR INERT WASTE DISPOSAL – INCLINED



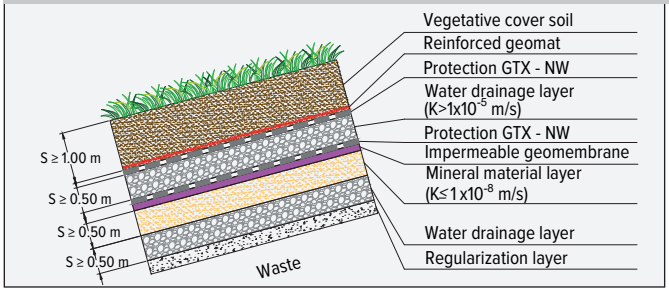


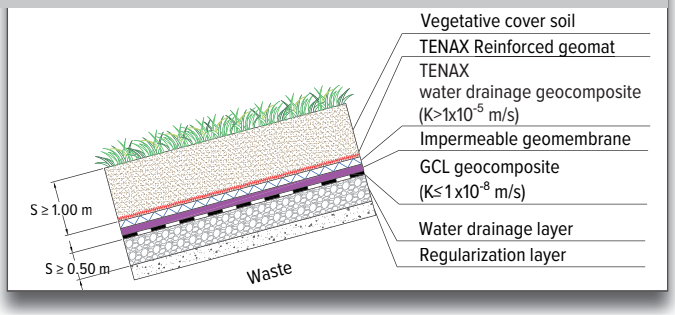
LANDFILL FOR NON-HAZARDOUS AND HAZARDOUS WASTE DISPOSAL– PLAIN





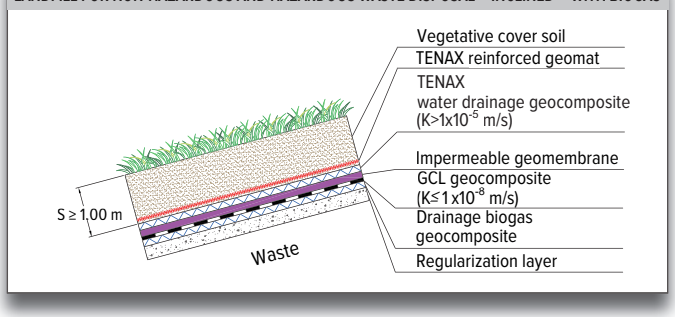
LANDFILL FOR NON-HAZARDOUS AND HAZARDOUS WASTE DISPOSAL – INCLINED





Drainage geocomposites may represent the only technically acceptable solution on slopes with significant developments and gradient, particularly in areas with high seismicity; such solutions came regularly and successfully used in landfills.

LANDFILL FOR NON-HAZARDOUS AND HAZARDOUS WASTE DISPOSAL – INCLINED – WITH BIOGAS

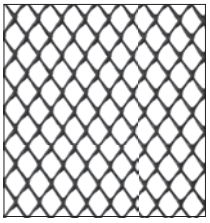


CAPTURING BIOGAS

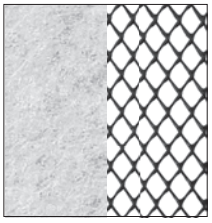
The stability of the cover soil can be considerably reduced by pressures produced by biogas built-up beneath the capping layers (geomembranes or GCL's) until failure occurs.
According to recent research on the transmission rate of gas and based on the theory of intrinsic permeability, the transmissivity of LFG (landfill gas) results to be ten times lower than the hydraulic transmissivity of water in any porous medium.
This means that, to drain biogas, drainage layers with a high hydraulic capacity are required.

COLLECTION AND DISPOSAL OF SURFACE WATER

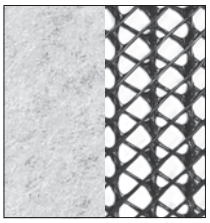
If percolating water is not appropriately drained and water is allowed to flow through the cover soil it will gather on the waterproof liner causing dangerous conditions.
The extremely high hydraulic head caused by inadequate drainage can bring about catastrophic cover soil failure; in fact, numerous failures in landfills triggered by infiltration have been recorded and analyzed.
TENAX drainage geocomposites that are correctly installed on top of the waterproof layers, are a guarantee for disposal of the total amount of precipitation that might filter through the vegetative soil cover.



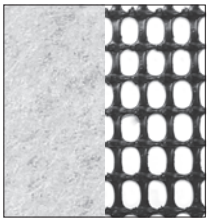
TENAX SN



TENAX SD



TENAX TENDRAIN



TENAX TDP

For the drainage of surface water, geocomposites consisting of a drainage core and two filtering geotextiles can also be available by ***substituting the lower geotextile with a film or an impermeable geomembrane*** *to integrate the underlying waterproofing (H**Dcu**, **SDcu** and **TENDRAINcu**).*

TENAX TENDRAINcu

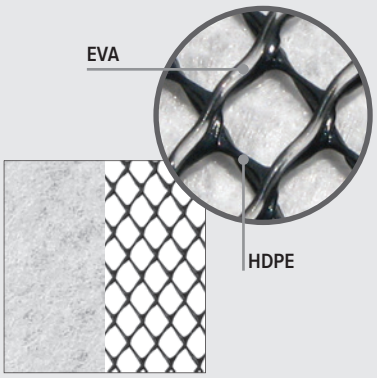
The choice of the type of draining structure is made on the basis of the drainage requirements, while the lower geomembrane, if compacted clay or bentonite gecomposites are present, help to keep a proper level of humidity thus preserving the characteristics of hydraulic conductivity of the same.

For the permanent capping of controlled waste landfills and the remediation of contaminated sites, TENAX has developed, in addition to its well-established range of **TENAX TENDRAIN**, and **SD** geocomposites providing filter/drainage protection, a new range of TENAX **HF High Friction** and TENAX **HD High Drainage Geocomposites**.

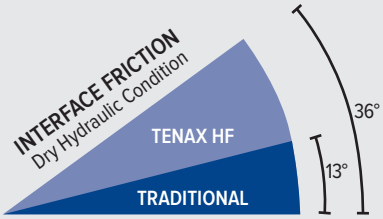
TENAX HF

High Friction Geocomposite generation
characterized by high performances in terms of resistance at the geonet/ impermeable geomembrane interface

TENAX HF High Friction geocomposites are a combination of drainage-protection geonet made with **HDPE+EVA bipolymers** and one layer filtering nonwoven geotexile in PP.
The EVA component (Etil Vinil Acetate) spread on the geonet surface with no geotexile and placed in contact with the waterproof geomembrane, allow a remarkable improvement of the friction characteristics against interface drainage geonet/geomembrane of any kind.



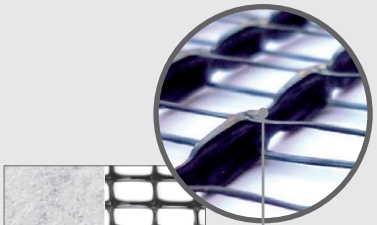
TENAX HF



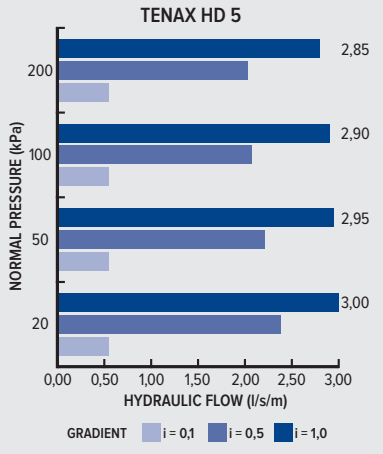
TENAX HD

The new High Drainage geocomposite generation
which provides high performance in terms of flow rate and tensile strength.

TENAX HD are High Drainage geocomposites based on a three dimensional **box-net** Polypropylene (PP) structure, obtained by extrusion and bi-oriented drawing, laminated with one (HD_1) or two (HD_2) non-woven PP geotextile for filtering purpose.
The inner core is composed of a 3D high profile quadrangular shaped mesh structure made by three sets of overlaid intersecting strands which guarantee 100 kPa compressive resistance, hydraulic flow rate up to 3,00 l/m*sec at gradient i=1.0 and 0,60 l/m*sec at gradient i=0.1 (corresponding to an inclination angle of about 6°).
The bi-oriented drawing process of the drainage structure made on PP provides to the geocomposite extreme flexibility and high tensile strength even at very low temperature versus structures based on PP plied monofilaments.



TENAX HD

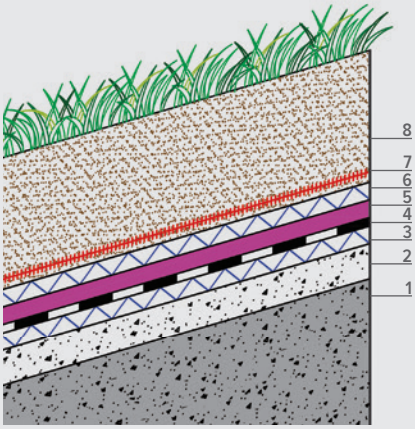


SURFACE EROSION CONTROL AND COVER SOIL STABILISATION

One of the problems that arises during the design and construction of a permanent landfill covering system (capping) is how to keep a sufficiently thick layer of topsoil on slopes to permit the creation of lasting vegetative growth.
As a matter of fact, the angle of friction at the interface between the impermeable layer and the vegetative cover soil has usually very low values, insufficient to prevent the sliding of topsoil, even on shallow slopes.

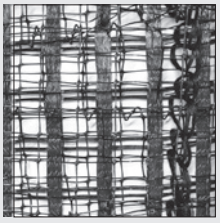
The problem is furthermore enhanced by the need to carry out checks that prove compliance to the new technical regulations for landfill construction.
The use of a suitable geosynthetic material is therefore essential to convey to the covering soil the properties required to confer stability.

TENAX GEOMATS



1. Waste
2. Regularization layer
3. TENAX geocomposite gas venting
4. Bentonitic geocomposite
5. Impermeable geomembrane
6. TENAX geocomposite water drainage
7. Geomat TENAX MULTIMAT R
8. Vegetative topsoil

TENAX MULTIMAT R reinforced geomat allows the retention of vegetative material to a significant depth due to its three-dimensional structure and "gripping effect", even on very steep slopes; after placing the mat immediately above the waterproofing layer (or, in case, on top of a geocomposite with filter-drainage functions for meteoric water) and firmly anchoring it at the top (in anchor trenches or by re-filling with appropriate material) TENAX MULTIMAT R is successively "filled" with an abundant amount of slightly compacted vegetative soil.



TENAX MULTIMAT R

- *Up to 4,40 m width.*
- *"Custom made" lengths, as typically no intermediate anchors are allowed.*

INSTALLATION SCHEME
Bottom, walls and capping drainage

1 INSTALLATION OF THE GEOCOMPOSITE FOR BIOGAS DRAINAGE

2 INSTALLATION OF THE BENTONITIC GEOCOMPOSITE OR IMPERMEABLE GEOMEMBRANE

3 INSTALLATION OF THE GEOCOMPOSITE FOR DRAINAGE OF INFILTRATING RAINWATER

4 LAYING OF THE "GRIPPING" AND REINFORCED 3D GEOMAT

5 ANCHORAGE OF THE COMPLETE COVERING SYSTEM IN APPROPRIATE ANCHOR TRENCHES, IF NECESSARY, FILLED WITH CONCRETE

6 SPREADING OF THE UPPER LAYER OF VEGETATIVE SOIL COVER

7 HYDROSEEEDING OR SEEDING

Confinement barriers and embankments

To enlarge the usable volume of a landfill two types of action can be mainly taken: the construction of reinforced embankments acting as confinement barriers or retaining walls at the base, and the insertion of geosynthetics directly inside the waste mass, thus building an embankment of reinforced solid urban waste.

CONFINEMENT BARRIERS IN LANDFILL

The construction of Reinforced Soil Embankments with TENAX TT geogrids provides extremely reduced cross sections in comparison to the non-reinforced ones, an increase in usable volume for waste disposal and, consequently, it reduces the amount of land required for the construction of the embankments. This technology is commonly used now, as it doesn't present any particular project issue: the calculation models are standard for reinforced embankments while waste volumes are merely involved as a thrusting force behind the structure.

REINFORCEMENT FOR MUNICIPAL WASTE DISPOSAL SITES

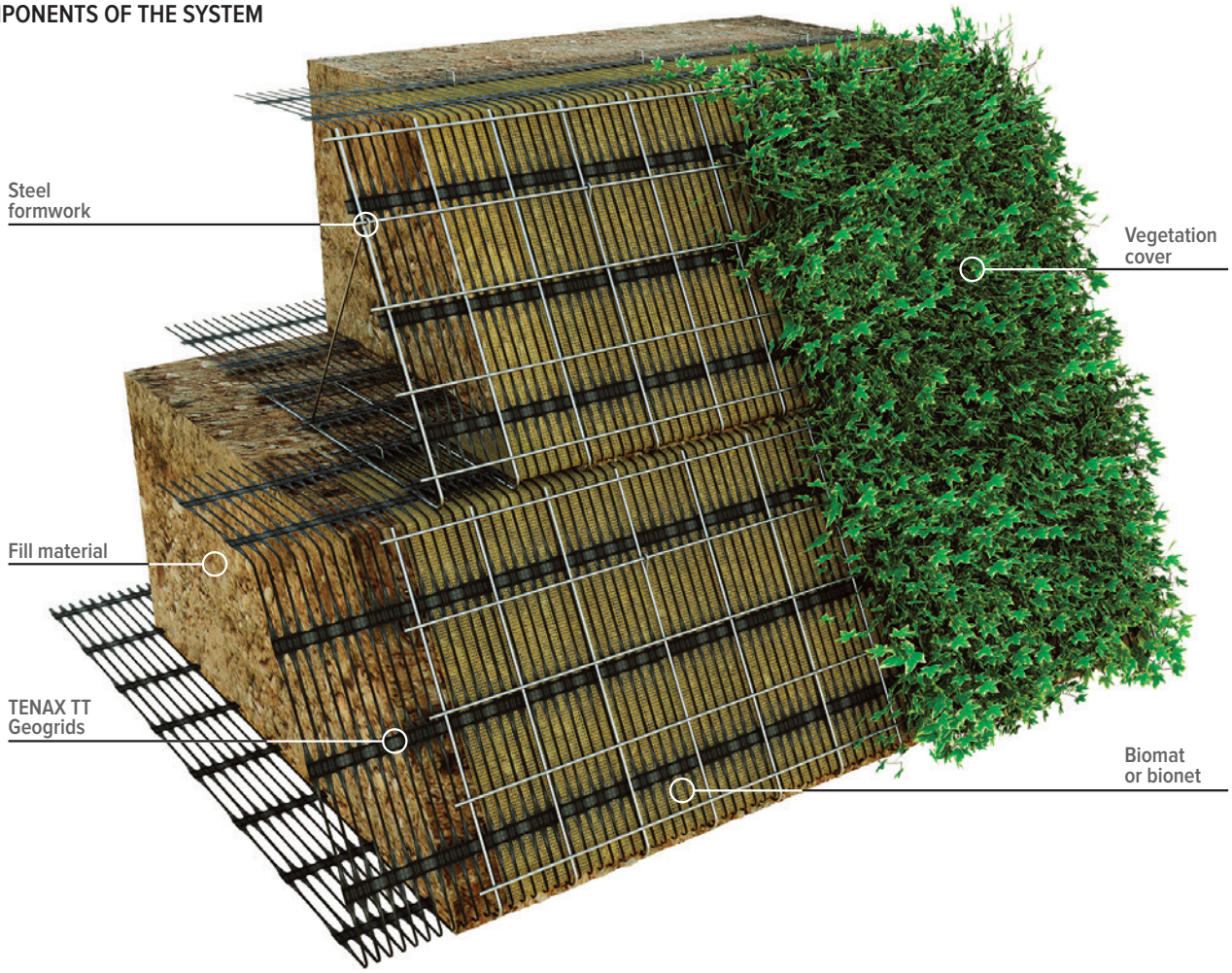
By applying the technology for Reinforced Soil Embankments directly on Municipal Waste Disposal sites, the usable volume available for waste disposal would be even more, with lower construction costs.
However, it is essential to carefully evaluate the geomechanical, granulometric and hydraulic properties of the waste to ascertain the effectiveness of the reinforcement.

TENAX RIVEL SYSTEM FOR REINFORCED SLOPES

The **TENAX RIVEL** integrated System for Reinforced Embankments features the use of **TENAX TT** 100% integral HDPE geogrids as reinforcing elements.

Thanks to the **TENAX RIVEL** System it has become possible to build extremely resistant reinforced embankments that can be superimposed and of minimum overall dimensions, providing an increase in useful volume. **TENAX RIVEL** can sustain both static load stress caused by the mass of waste and seismic accelerations.

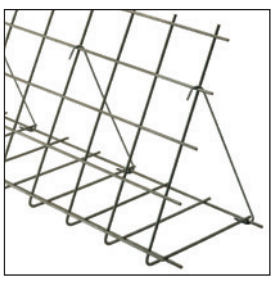
COMPONENTS OF THE SYSTEM



TENAX TT geogrids
They are bidimensional structures in HDPE manufactured by extruding and uniaxial stretching and they are certified for the realization of reinforced steep slopes up to 85° inclination from ITC-CNT (Istituto per le Tecnologie della Costruzione - Consiglio Nazionale delle Ricerche).

Filling material
Reinforced slope technique allows the use any kind of fill soil; however, it is better to use drainage granular material with a high internal friction angle, possibly without large sized pebble which would make compaction difficult.

Welded steel mesh formworks
TENAX RIVEL System uses a welded “sacrificial” formworks (ø 6-8 mm / mesh 15x15 cm) on the face of the structure. It has no structural function but provides a guide for a quick installation and an accurate profiling. Formworks is supplied with stiffening rods (1 every 0,45 m about).



Erosion control mat TENAX FVP
In any naturalistic engineering work, vegetation plays an active role in the slope protection. Final work will look uncompleted and less effective without its contribution. Thus, to avoid hydroseeding costs and extra work, Tenax FVP Preseeded Vegetative Felt provides the effective solution.

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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