TENAX

GEOSYNTHETICS

LANDFILL and CONTAMINATED SITES

BOTTOM AND SLOPES

Geonets and geocomposites have found a wide range of applications in controlled landfills by now, providing mechanical protection to geomenbranes, 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 allows to increase landfill capacity as more usable volume is available for waste storage. The estimate of average cost savings is about 50% when using a synthetic product instead of a traditional one.

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 is a geocomposite consisting of a drainage core with a texture of three overlapping intersecting series of strands, especially designed for the drainage and collection of the leachate (LCRS). The inner strands, 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.
TENAX TENDRAIN assures the collection and removal of the leachate under heavy compressive loads while maintaining constant hydraulic performance over a long period 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.

Leak Detection Function in Landfills

The leak detection system (LDS) is installed between the primary and the secondary liner. A leak detection system must:

- provide rapid detection of major breaches in the primary lining system (within less than 24 hours);
- limit the hydraulic head acting on the secondary barrier/layer to less than its thickness;

High flow triplanar **TENAX GNT** geonets provide the most efficient results for a rapid detection of leaks in the liner system . The high trasmissivity of **TENAX** Geonets allows for a rapid collection and discharge of all liquids to the leachate collection sumps, thus minimizing the time between breach and leak occurrence and its detection.

Benefits

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:

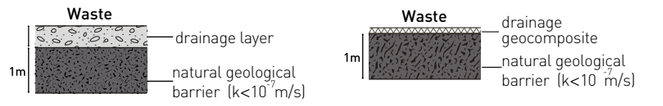
- if installed beneath the geomembrane they prevent mechanical damage and drain fluids and gases from the soil;
- installed between two layers of geomembranes in a double lining system they help leachate drainage;
- used on top of the geomembrane they provide mechanical protection and help with leachate 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.**


Municipal Solid Waste Landfill Grotte San Giorgio (CT)

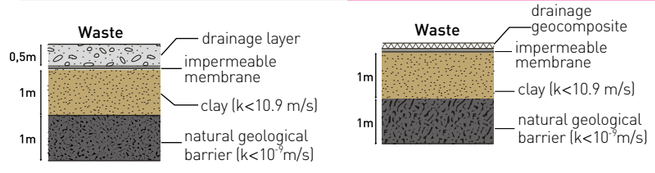
SITE FOR INERT WASTE – BOTTOM LINER SYSTEM

Conventional design	Geosynthetics design solution



SITE FOR NON HAZARDOUS WASTE

Conventional design	Geosynthetics design solution



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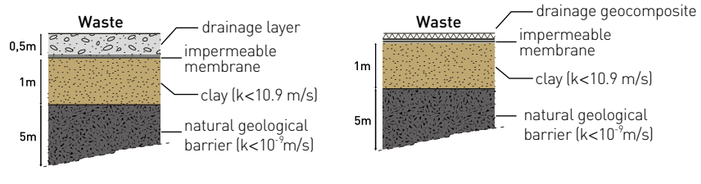


CAPPING AND REMEDIATION OF CONTAMINATED SITES

The **TENAX** drainage geocomposites in the landfill cover system limits the infiltration of water inside the landfill. 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.

Capturing biogas

The stability of the cover soil can be considerably reduced by pressures produceded 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 analysed.

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. 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**:

A **TENAX HF** Geocomposites exhibit high performance in terms of resistance at the geonet/impermeable membrane interface;

B **TENAX HD** Geocomposites can guarantee high performance in terms of flow rate and tensile strength.

A Tenax HD: the new High Drainage geocomposite generation

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 **2,50 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 based on PP provides to the geocomposite extreme flexibility and high tensile strength even at very low temperature versus structures based on PP plied monofilaments.

B Tenax HF: High Friction Geocomposite

TENAX HF High Friction geocomposites are a combination of drainage-protection geonet made with **HDPE/EVA bipolymers** and one layer filtering nonwowen 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.

The 3D gripping geomats **TENAX MULTIMAT R** are placed directly on the waterproofing/drainage system for trapping a consistent layer of topsoil even on very long sharply inclined slopes.

Installation of the Geocomposite for biogas drainage

Installation of the Geosynthetic Clay Liner or Geomembrane

Installation of the Geocomposite for drainage of infiltrating rain water

Laying of the "gripping" and reinforced 3D Geomat

Surface erosion control and cover soil stabilisation

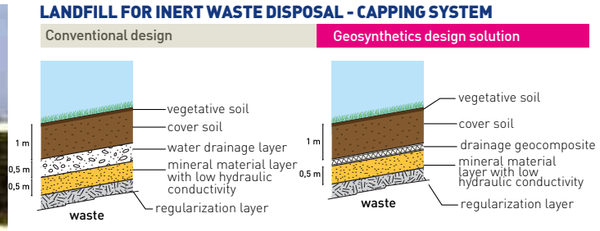
One of the major problems that arise during the design and construction of a permanent landfill covering system (capping) is how to keep a sufficiently thick layer of topsoil on slopes to permit the creation of lasting vegetative growth. As a matter of fact, the angle of friction at the interface between 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 MULTIMAT R** reinforced geomats allows the retention of vegetative material to a significant depth due to their three-dimensional structure and "gripping effect", even on very steep slopes; after placing the mats immediately above the waterproofing layer (or, in case, on top of a geocomposite with filter- drainage functions for meteoric water) and firmly anchoring them 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.
Another way of "capping", consists of the use of **TENAX TENWEB** geocells that allow the containment and stabilisation of vegetative soil into depths ranging from 7.5 to 10 cm, according to the type of geocell adopted, with the possibility of overlapping the geocells in several layers.


Cerro Maggiore (MI) - 1996

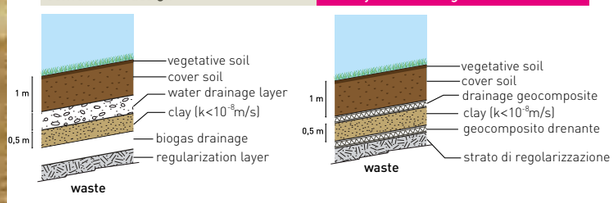

Containment of expanded clay on top of the modified capping system of the Modena Landfill


La Glacier Veolia landfill (Francia): capping system with High Friction drainage layer for meteoric water

LANDFILL FOR INERT WASTE DISPOSAL - CAPPING SYSTEM



SITE FOR NON HAZARDOUS WASTE



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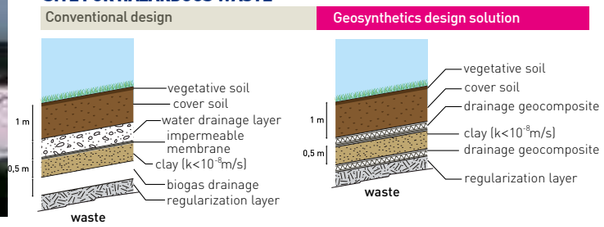


Anchorage of the complete covering system in appropriate anchor trenches, if necessary filled with concrete

Spreading of the upper layer of vegetative soil cover

Hydroseeeding or seeding

CONFINEMENT BARRIERS AND EMBANKMENTS

To enlarge the usable volume of a landfill two types of action can be taken basically: 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.

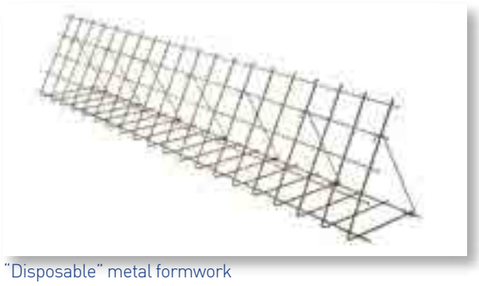
Benefits

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 resistent 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**

Proposed Geosynthetics


TENAX **TT**
Geogrids for reinforcement


Pre-sown textile


"Disposable" metal formwork

Confinement barriers in landfill and reinforcement for municipal waste disposal sites

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, 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 problems from the point of view of design: the calculation models are standard for reinforced embankments while waste volumes are merely involved as a thrusting force behind the structure. 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.


NENT, Hong Kong


Landfill perimeter confinement barrier in Villaputzu (CA)

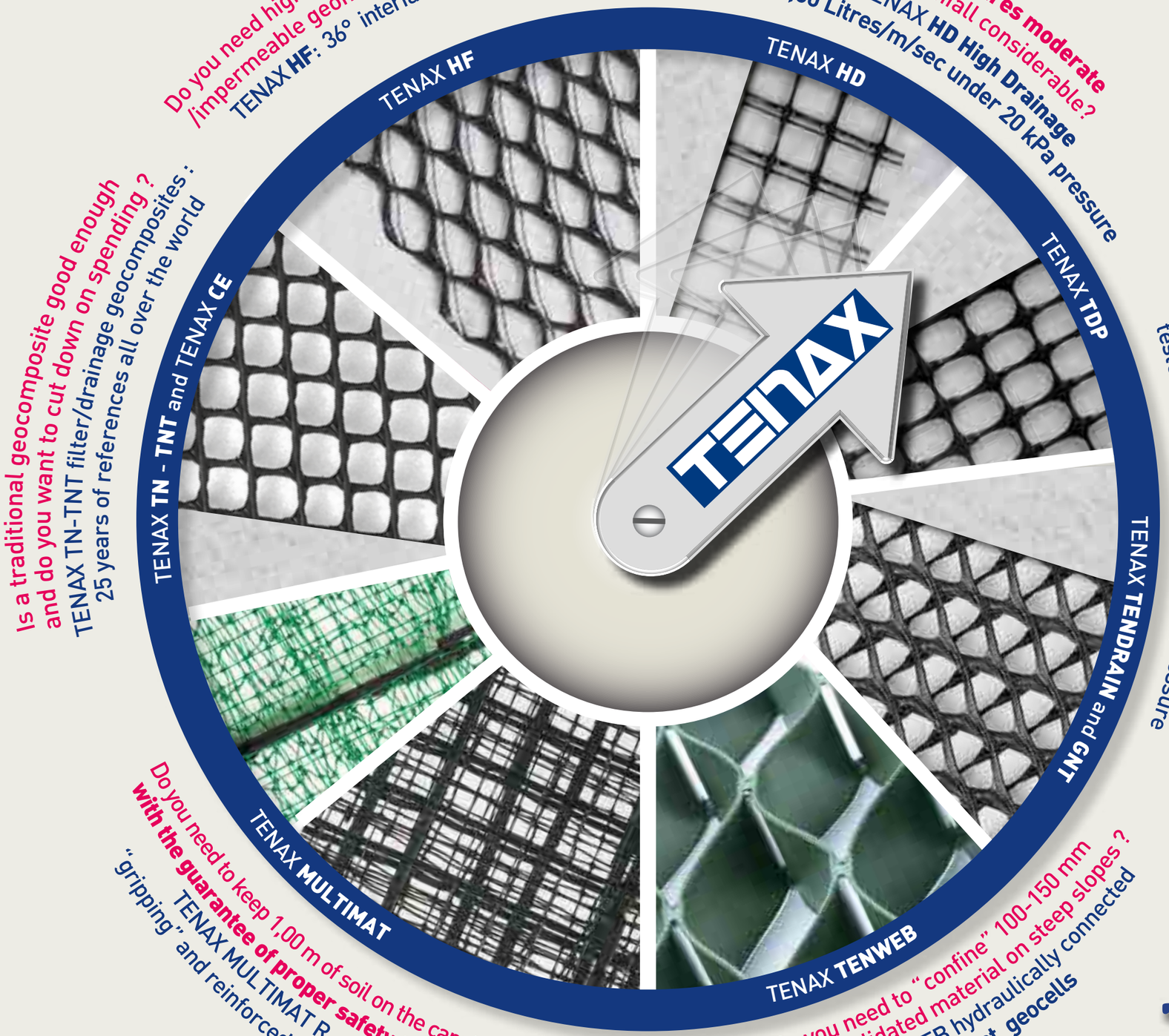

Confinement barrier and raised embankment in the ARPA 1 landfill of Colleferro (RM)

DESIGN SERVICE

The vast experience gained in designing technical solutions with geosynthetics, allows the **TENAX GTO** (Geosynthetics Technical Office) and its team of qualified Civil Engineers to assist their Customers (both public and private) with feasibility studies and complete construction plans, additionally assisting engineers and experts with :

- construction procedures;
- educational seminars, design workshops and customized 'in-house' training;
- specific software for designing projects with the use of **TENAX** geosynthetics that provide greater flexibility in organizing the project's criteria to meet specific needs.
  Such flexibility alllows the **TENAX team of engineers** to carry out the technically most appropriate sizing for safe and cost effective site structures.

TENAX Drainage systems and Geocomposites



Do you need high adhesion of the drainage /impermeable geomembrane interface?
TENAX **HF**: 36° interface friction

Are pressures moderate but rainfall considerable?
TENAX **HD High Drainage**
> 2,00 Litres/m/sec under 20 kPa pressure

Do you require high hydraulic performance **under high pressure?**
The range of TENAX TENDRAIN triplanar tested at over 500 kPa normal pressure

Is a traditional geocomposite good enough and do you want to cut down on spending ?
TENAX TN-TNT filter/drainage geocomposites : 25 years of references all over the world

Do you need to keep 1,00 m of soil on the capping **with the guarantee of proper safety factors ?**
TENAX MULTIMAT R "gripping" and reinforced 3D Geomats

Do you need to " confine" 100-150 mm of unconsolidated material on steep slopes ?
TENAX TENWEB hydraulically connected **confinement geocells**

...it's up to you!

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TENAX is an international group that manufactures and sells a wide range of geosynthetics, all certified by the most important technical and international organisations, and used in many construction projects of different sizes, importance and complexity all over the world.
For more than thirty years, **TENAX** has been a company at the forefront of constant process - product research in order to guarantee the highest quality standards anytime.

Some examples of the fields of application of geosynthetics :

- **stabilisation and reinforcement** of loose foundations and improvement of their bearing capacity (TENAX LBO, GT, 3D GRID);
- **horizontal and vertical drainage** through the removal of fluids and gas (TENAX CE, GNT, TENDRAIN, SD, HF, HD);
- **soil rinforcement** in embankments with vegetative geomat cladding or reinforced block walls (TENAX TT, RIVEL, T-BLOCK);
- **erosion control** applications and vegetation protection on slopes during germination, even on waterproofing (TENAX TENWEB, MULTIMAT).

Technical experts will assist you with precision and without delay from the first moment of design and development to the construction of your project, assisting you with expert advice to find appropriate solutions to any occuring civil engineering and environmental problem.

SGS ITALY Certificate no. IT93/0008a
SGS U.K. Certificate no. IT93/2568.1

0799-CPR-25

First issued: May 9,1994
TENAX geogrids have obtained the I.T.C. Certification.
I.T.C. is the Independent Institute in Italy and a member of the UEAtc.
UEAtc is the European network of Independent Institutes formed by each country (ITC for Italy, BBA for UK, DIBt for Germany, ect), and engaged in the issue of Technical Approvals for innovative construction products or systems.

TENAX

GEOSYNTHETICS

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