LANDSCAPING AND GREEN AREAS

TENAX

Man. Technology. Environment.

LANDSCAPING AND GREEN AREAS

On the cover.
Milano Portello.
Slopes stabilization to allow the construction of artificial hills for a new public park.

In the following pages.
Northumberlandia.
The world's largest human form carved into the landscape, designed by the renowned landscape architect and artist Charles Jencks.

When designing outdoor spaces such as parks and gardens, creative originality is increasingly required in the combination of natural elements to model the landscape; in the past technical limits did not allow the creation of peculiar soil shapes. The use of reinforced slopes and slope protection allow to overcome the natural limits of the soil resistance, making it possible to use it to create innovative aesthetic elements that can be considered as real forms of art.

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 igs UNI AssIGeo

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

EARTH IS THE MOST VULNERABLE RESOURCE OF OURS, EASY TO DAMAGE AND HARD TO REGENERATE

During natural or artificial slope modeling, natural or spontaneous vegetation can be temporarily removed; the ground is very vulnerable to the erosive action of all the weather elements.
In such conditions, the main objective is to develop an adequate ecosystem that enables the restoration of natural vegetation as quickly as possible or, as an alternative, a suitable surface protection from erosion.

Phenomena of natural morphogenetic erosion happen spontaneously on "undisturbed" lands: during this process, a natural cycle keeping the balance between the development of natural soil and its erosion takes place.
However, when natural vegetation is disturbed, a different type of erosion takes place: accelerated erosion. This kind of erosion consists in not-compensated topsoil loss, generally occurring when the soil surface is disturbed by human activities.

The erosive action of the rain develops mainly through two mechanisms:
- detachment and transportation of soil particles caused by the impact of raindrops on the ground surface.
- detachment and transportation of soil particles caused by water flowing on the ground surface.

The detachment caused by raindrops impact on the ground and detachment caused by surface flows are the most destructive erosion processes; the effects are much more severe where the ground is steeper.
The former process depends on the soil erodibility and on the kinetic energy of raindrops, while the latter one occurs when the amount of water the soil can absorb is lower than the amount of rainfall water.

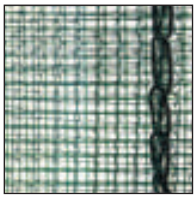
The erosion degree depends both on the energy of rainwater, wind and weather elements that act on the affected surface, and on the geological, geomechanical, and geometrical properties of the slope, and on the existing vegetation.

TENAX Solutions

TENAX MULTIMAT

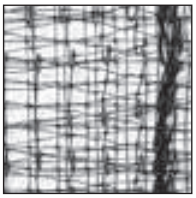
The Geomats which are made of two external layers of flat polypropylene (PP) geogrids and an internal layer mechanically folded in order to give solidity and three-dimensionality to the mat: available in widths of 2,20 m or 4,40 m.

The compressive resistance of TENAX MULTIMAT geomats is extremely high thanks to the folded and zigzag layers of the 3D structure that limits mat deformability when it is fill with any material (fine and dry topsoil, hydroseeding, sand etc.).



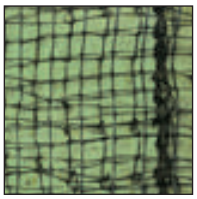
TENAX MULTIMAT 030

The International Erosion Control Association (IECA) defines TENAX MULTIMAT 030 geomat as ECRM (Erosion Control Regenerative Matrix). Once laid on a slope made up of soil suitable for vegetation growth and, even before the rooting and vegetative stage, it limits the speed of runoff rainwater preventing the erosion of the underlying soil.
The geomat does not need to be filled with topsoil but it can be directly hydroseeded.



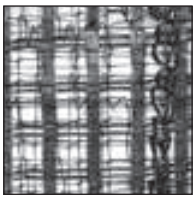
TENAX MULTIMAT 100

TENAX MULTIMAT 100 is emploied as TRM (Turf Reinforcement Mat): when it is laid upon a slope to be revegetated and covered with vegetative topsoil, it provides protection from rainwater runoff by retaining the superficial layer of the soil, seeds and sprout. It also provides immediate anchorage of thin roots and herbaceous essences which together with the geomat, form a single block even more resistant to the action of water as well as to gravity.
The mat must be filled with fine and dry topsoil that can be mixed with seeds.



TENAX MULTIMAT 100 P

In order to support and speed up revegetation, TENAX MULTIMAT 100P mat has a geotextile made with natural and biodegradable cellulose fibers containing grass seed and fertilizers, positioned among the layers that make up the MULTIMAT 100 geomat.
Both products are indicated to maintain a minimum thickness of topsoil on the slope which can facilitate vegetation growth.
The mat must be filled with fine and dry topsoil to protect the underlying seeds from thermal excursion.



TENAX MULTIMAT R

The 3D structure of TENAX MULTIMAT R is reinforced with a polyester (PET) geogrid that increases its longitudinal tensile strength up to 350 kN/m. This range of products is mainly used in landfill capping to hold thick layers of topsoil on the waterproofing cover system.
Since often intermediate junctions of the reinforced geomat on landfill slope are not allowed, TENAX MULTIMAT R geomats lengths are generally “tailor made”, thus limiting wastage.

The engineering approach to this range of products and the production flexibility enable TENAX to produce custom-made geomats both in terms of length and of tensile strength of the reinforcement geogrids, which vary according to each specific design requirement.
The 3D structure and the geogrids are integrated by means of industrial-mechanical stitching using a highly tough PP yarn and with a distance between a stitch and the following one of around 0.40 m. This process prevents the separation between the 3D structure and the reinforcement geogrid and therefore keeps the reinforcement effect.

COMPARISON BETWEEN 3D ANTI-EROSION MULTI-LAYERED GEOMATS AND PP MONO-FILAMENT GEOMATS

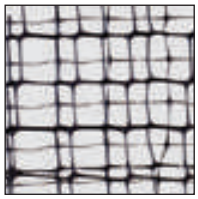
Three-dimensional anti-erosion geomats are generally manufactured by extruding thermoplastic polymers (mainly Polypropylene or Polyamide); their structure is made by heat tangle of monofilaments welded at the contact point, or it can be a multi-layered structure, made of two external layers of flat polypropylene (PP) geogrids and an internal layer mechanically folded (**TENAX MULTIMAT**).
Although the structures are different, they are used in the same way, while their mechanical characteristics are considerably different:

	THICKNESS between 8 and 20 mm for all the structures	
	MONO-FILAMENT MATS	**TENAX MULTILAYER MATS**
MAXIMUM TENSILE STRENGTH MD	1.8 - 2.0 kN/m	**3.8 - 10 kN/m**
ELONGATION AT YIELD	60%	**23%**

Higher tensile strength and smaller elongation provide a higher safety factor: thus allowing safe use of TENAX MULTIMAT multilayer mats on long and/or very steep slopes too.

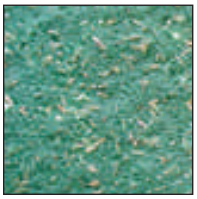
TENAX TENWEB

TENAX TENWEB geocells (available with thicknesses: 75 and 100 mm) are manufactured by a continuous extrusion process of Polyethylene without welding or studding.
Cells are interconnected by open junctions through which liquids and fluids can freely flow so to avoid stagnating and reduce weight to the coverage.



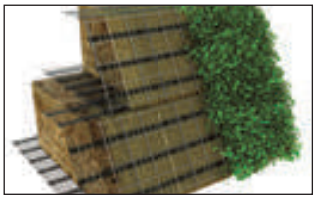
TENAX GRIDS

Bi-oriented polypropylene geogrids that guarantee high stiffness and low strains: TENAX GRIDS range is proposed to anchor TENAX TENWEB panels on waterproofed surfaces and mainly as cortical coating of rocky slopes. Geogrids TENAX are also used to protect rocky slopes subject to micro-collapses caused by ice, thermal expansion, spreading action of roots, mechanical and explosive excavation. Their use makes it possible to limit the fall of the smallest fractions of the wall itself without undermining the overall stability of the rock face.



TENAX FVP

TENAX FVP Vegetative Pre-seeded Felt is made up of natural biodegradable cellulose containing seed of grass species and fertilizers suitable to obtain a quick vegetation growth.



TENAX RIVEL SYSTEM

TENAX RIVEL System allows the construction of reinforced soil works with a greened facede that can be the right solution in different situations. The construction of reinforced soil is easy, fast and does not require manpower or special means. The flexibility of this system allows the creation of curves and terracing, in this way it is possible to adapt the shape of the structure by harmoniously inserting it into the surrounding environment.

SURFACE	TENAX SOLUTIONS						
	MULTIMAT 100	MULTIMAT R	MULTIMAT 030	MULTIMAT 100 P	TENWEB	GRIDS	RIVEL SYSTEM
SLOPES WITH VEGETATIVE MATRIX	●	●	●	●	●		
SLOPES WITH ARID AND ROCKY MATRIX		●			●	●	
CANALS, PONDS AND RESERVOIRS BANKS	●	●	●	●	●		
LANDFILL COVERING (CAPPING)		●			●		
REINFORCED SOILS			●	●			●

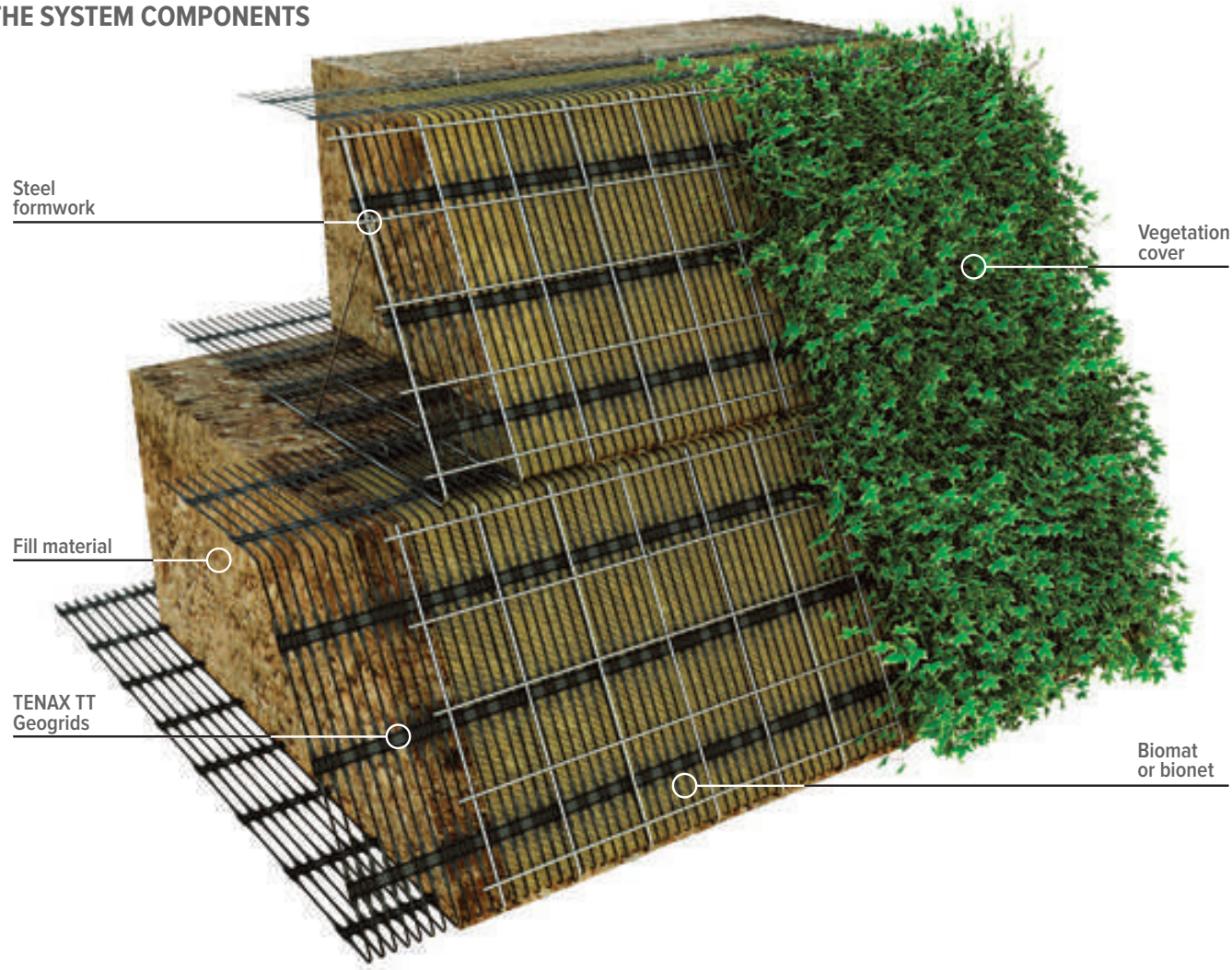
LANDSCAPING

The outdoors architectural modeling of artificial embankments, even of considerable sizes, involves design solutions that, ones they are realized, can successfully integrate with the landscape and the surrounding environment.
Flexibility and versatility of **TENAX RIVEL System** for reinforced slopes, as well as **MULTIMAT** and **TENWEB** range of products, provide designers, landscapers, and architects a wide choice of design solutions, allowing the creation of original aesthetics elements.
The advantages in terms of time saving and therefore construction costs are significant.

TENAX RIVEL SYSTEM
Landscape modeling with reinforced slopes system

TENAX RIVEL integrated System for reinforced slopes, foresees the use of 100% HDPE, integral junction **TENAX TT** geogrids as reinforcing elements.

THE SYSTEM COMPONENTS

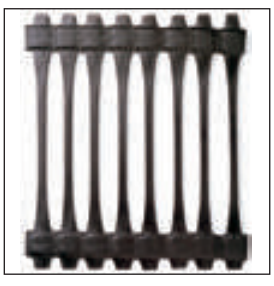


TENAX TT geogrids
TENAX TT geogrids are bidimensional structures in HDPE manufactured by extruding and uniaxial stretching process and are certified by the ITC-CNR (Institute for Construction Technology-National Research Council) for the construction of steep reinforced slopes up to 85°.

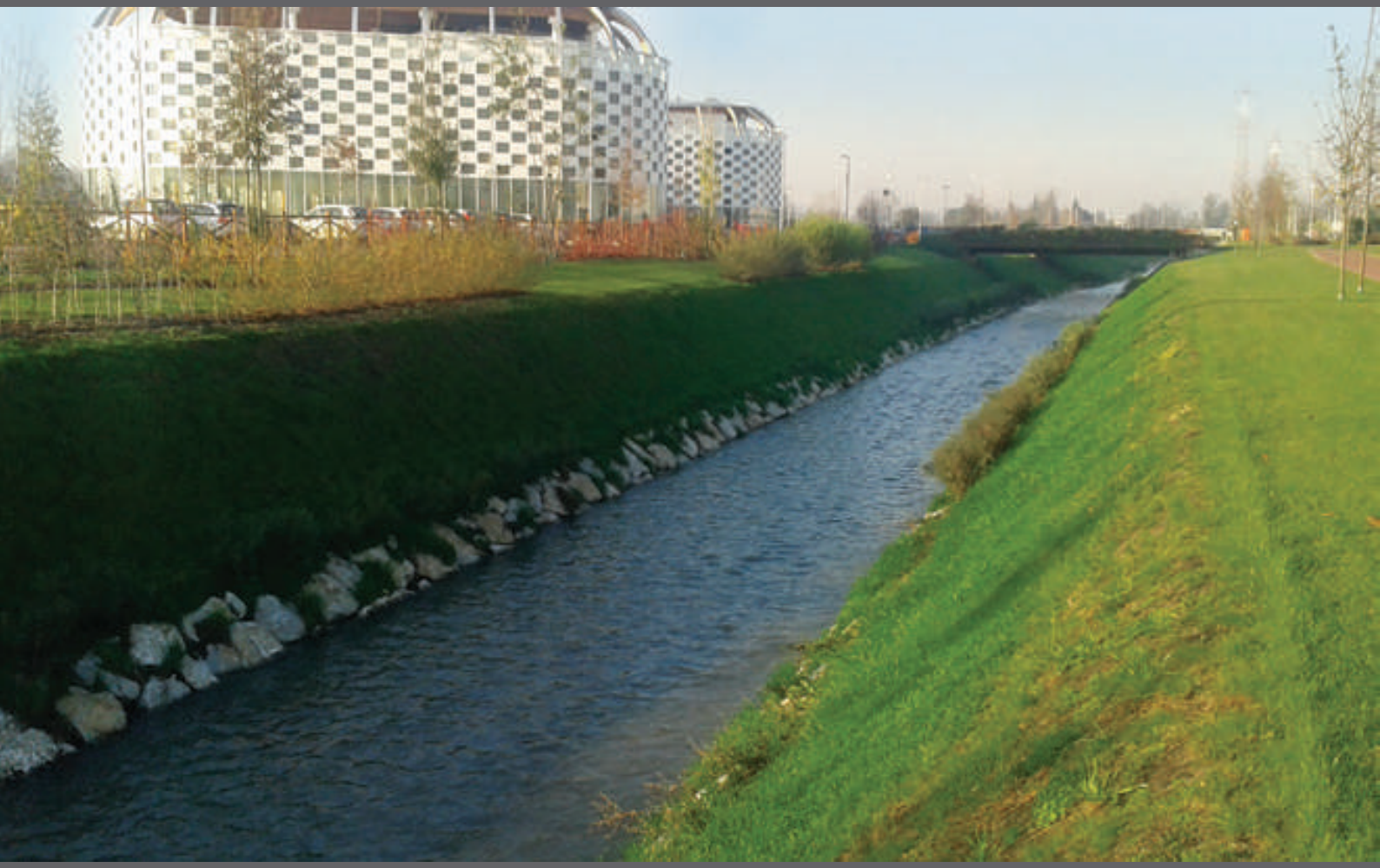
Filling material
Geogrids reinforced slopes technique allows the use of many types of fill soil; however, the use drainage granular material with a high internal friction angle, possibly without large size pebbles which would make compaction difficult, is preferable.

Welded steel mesh formworks
On the facade of the structure, TENAX RIVEL System uses a welded "sacrificial" formwork (ø 6-8 mm / mesh 15x15 cm). It has no structural function but provides a guide for a quick installation and an accurate alignment. Formworks are supplied with stiffening rods (1 every 0,45 m approx.).

Erosion control mat TENAX FVP
In every naturalistic engineering work, vegetation plays an active role in the slope protection. A finish work without a proper vegetative cover will look uncompleted and less effective. Thus, to avoid hydroseeding costs and extra effort, TENAX FVP Pre-seeded Vegetative Felt provides the effective solution.



BANKS
of canals, lakes and reservoirs



Earth channels and waterways in general are continuously subjected to the erosive and washout action of rainwater and water flowing, both on the bottom and on the banks. Under these conditions the concentrated forces caused by the water flow rate can cause the formation of rills, holes, and under-excavations at the toe; the consequent sliding of the soil along the banks could deeply affect the hydraulic properties of the canal itself.

A dense vegetation on the canal banks guarantees an effective defense as it improves the roughness of the bank (reducing, as a result, the water speed) and increases the sedimentation of suspended solid particles preventing their detachment from the soil.

The formation of the vegetation cover is accelerated and eased by using 3D anti-erosion **TENAX MULTIMAT** geomat which, thanks to its flexibility, is easy to place on both the bed and banks of canals and waterways.

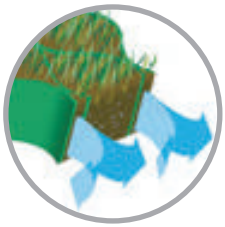
The vegetation process allows the roots of the grass to firmly anchor themselves to the three-dimensional structure, forming together a permanent protection.

Even before vegetation begins to grow, **TENAX MULTIMAT** geomat can drastically reduce the quantity of eroded soil from slopes, and mostly, avoids the formation of steams and rills, thus preventing channeled erosion.

Full-scale tests performed by the University of Utah (USA) and Enel Hydro S.p.A (MI) have proved that the limit velocity of water to prevent erosion of banks and bed considerably increases if they are covered with TENAX MULTIMAT geomats.

When the surfaces to be protected consist of weathered rocks and/or are a combination of loose rocks mixed with finer material, it is necessary to build a safe soil confinement system; it has to be capable to prevent the detachment of heavier and large size materials and at the same time to retain small amount of topsoil.

TENAX TENWEB geocells provide the stabilization of the vegetative soil even on very steep slopes, ensuring the lateral confinement of the soil itself.



Once the panels have been opened to their maximum extension and geocells have been filled with topsoil, a stable and plantable layer is formed.

CAPPING
Landfill covering

The main problem during the design and construction of a permanent landfill covering system (capping) is to maintain an adequate thickness of topsoil on the waterproofed slopes, both for law requirements, environmental and landscape factors.
The interface Friction angle between the cover system and the topsoil has usually very low values, inadequate to prevent soil sliding, even on shallow slopes.
Also, the cover must be designed to guarantee the drainage of rainwater entering into the vegetative soil and running on the cover, that would reduce the friction coefficient of the soil/ cover system to zero causing uplifts that could trigger the soil slippage over the cover itself.
The thickness of the soil spread on landfill slopes is subject to driving forces (making it slide) and resisting forces.
If these forces are not balanced with an adequate Safety Factor, it is necessary to use a reinforcement element capable to guarantee balance and stability.

TENAX MULTIMAT R 3D reinforced geomats, thanks to their clinging structure, allow the retention of a thick layer of topsoil even on steep and long slopes. When placed directly on rainwater drainage composite (or less frequently upon the waterproof geomembrane or upon the GCL), duly secured on tope with an anchor trench, TENAX MULTIMAT R geomats can be covered with considerable layers of soil, slightly mechanically compacted and then hydroseeded.

Another possible solution, suitable for shallow and short slopes is the use of **TENAX TENWEB** geocells which allow the containment and stabilization of vegetable layer ranging from 7.5 to 10 cm, depending on the type of geocell used.

To avoid the risk of surface erosion before vegetation starts to grow, a **TENAX MULTIMAT** geomat or **TENAX FVP** Vegetative Pre-Seeded Felt is recommended.

SLOPES

SLOPES WITH VEGETATIVE MATRIX

Revegetation of a slope composed essentially of topsoil is limited to the selection of seeds having suitable herbaceous and shrubby species, because the quality of the soil itself is suitable for the growth and preservation of vegetation.
However, before the roots of the plants previously sowed or hydroseeded, fully develop, sprouts can be easily washed away by runoff water.

TENAX MULTIMAT 3D multilayer geomats are suitable for retaining the seeds and thus they provide immediate anchoring to the thin roots during the development phase, thus preventing the formation of rills.

SLOPES WITH ARID AND ROCKY MATRIX

Quite often, the soils on slopes are predominantly arid and lacking in organic fraction; this happens for example when cutting rocky or arid slopes during road construction. Under these conditions it is necessary to provide an adequate topsoil layer to allow vegetation growth. Since topsoil has poor mechanical properties and can slide easily down the slope, it could also be washed away by heavy rainfalls before vegetation begins to grow.

TENAX MULTIMAT R 3D reinforced geomats and **TENAX GRIDS** geogrids are suitable for retaining systems due to their high stiffness and their ability to modeling along the surface.
This provides an effective containment system, and protection from erosion phenomena associated with rainfall or runoff.

INSTALLATION GUIDELINE

TENAX MULTIMAT

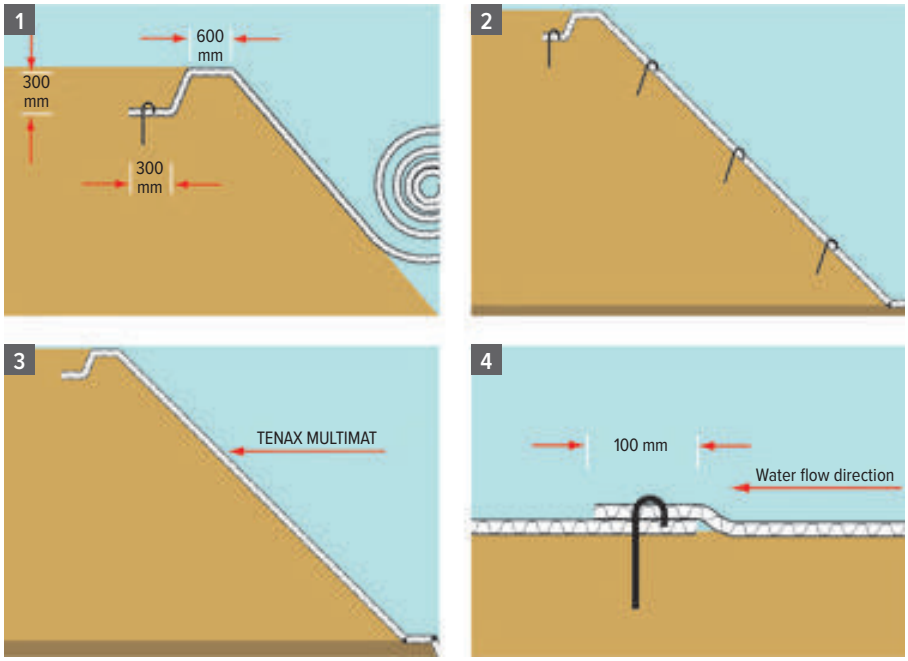
The area to be covered must be cleaned, free of clods, roots, and stones. Voids should be filled in order to obtain a smooth and compact surface, thus allowing **TENAX MULTIMAT** to perfectly adapt and to be in contact with the ground.

Excavate the anchor trench at the top of the slope to secure the 3D geomat to the ground. Anchor trench details vary depending on the application, soil type, and slope geometry;

Unroll the **TENAX MULTIMAT** along the slope to be covered: overlaps (edge to edge) between adjacent rolls should not be less than 100 mm and should be in the direction of the water flow;

Always fasten the 3D geomat to the ground using "U-shaped steel staples" placed in staggered pattern at about 2.00 m spacing;

Fill **TENAX MULTIMAT** with fine and dry topsoil or directly with extensive hydroseeding or alternatively ceover the geomat with more soil.



TENAX TENWEB

The area to be covered must be cleaned, free of clods, roots, and stones. Voids should be filled in order to obtain a smooth and compact surface, thus allowing **TENAX TENWEB** to perfectly adapt to the soil;

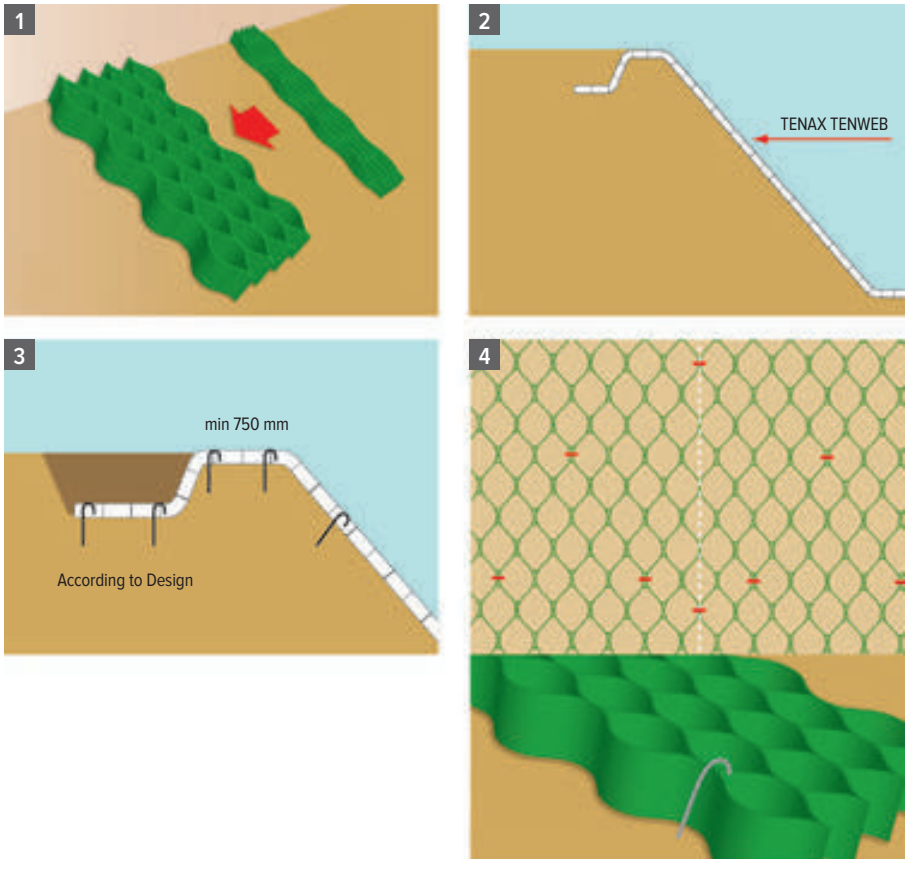
Excavate the anchor trench at the top of the slope if it's foreseen;

TENAX TENWEB panels shall be placed and expanded to their full open dimension, parallel to the flow direction;

The anchorage trench at the top may be filled with any suitable fill material (when possible), with concrete to reduce the trench dimension;

Along the slope, geocells should be anchored with U-shaped staples typically 300 mm-450 mm long, depending on the slope soil consistency (spacing between staples is defined by the project);

Geocells can be filled manually or with machinery like an excavator; **TENAX TENWEB** Geocells can be filled with topsoil, gravel or concrete, according to the final aesthetics and vegetation requirements.



233100036

TENAX SpA

Via dell'Industria, 17
23897 Viganò (Lecco) Italy
Tel. +39 039.9219300
Email: geo@tenax.net

www.tenax.net

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