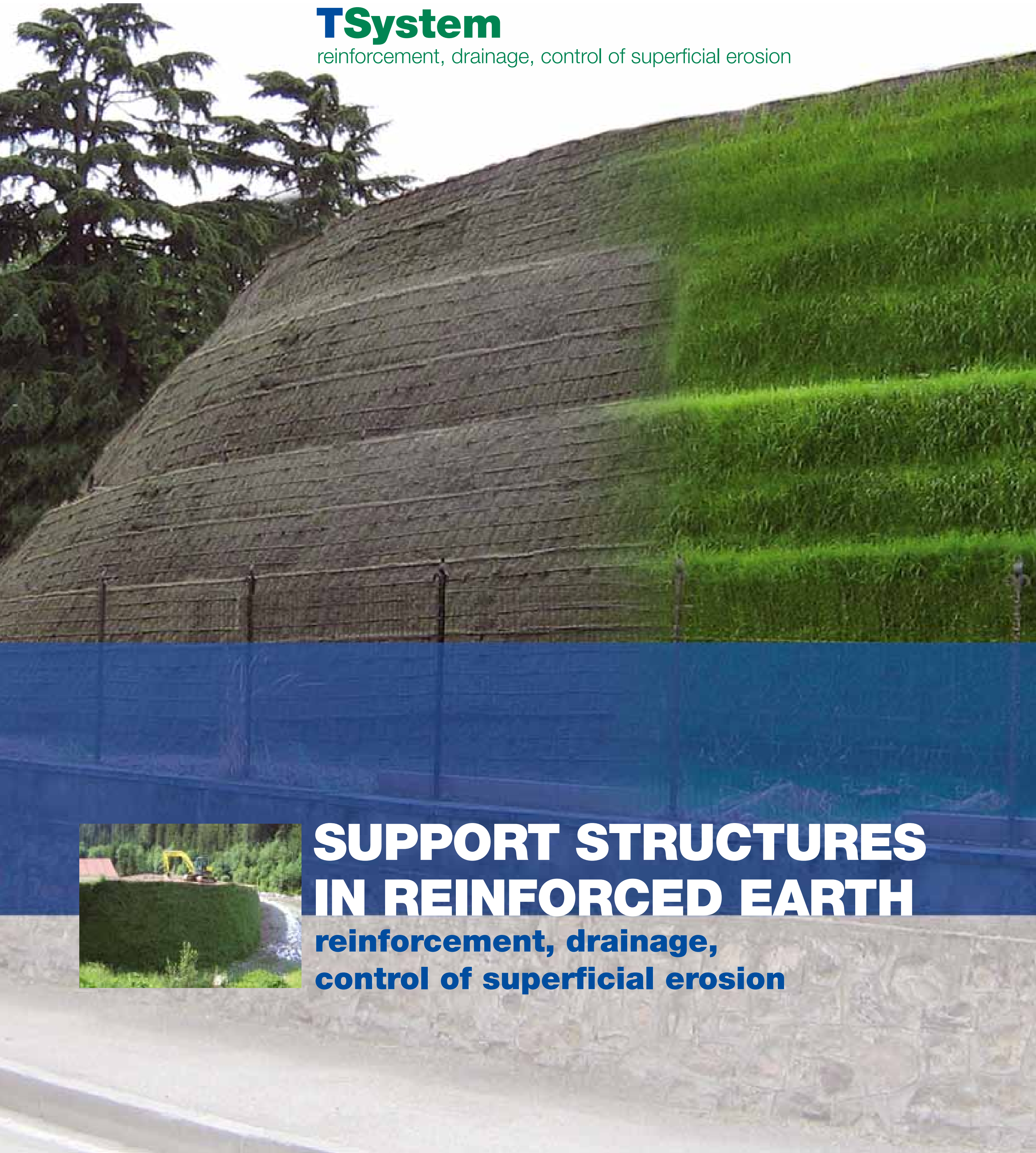
TeMa
Technologies and Materials

TSystem

reinforcement, drainage, control of superficial erosion



SUPPORT STRUCTURES IN REINFORCED EARTH

reinforcement, drainage, control of superficial erosion

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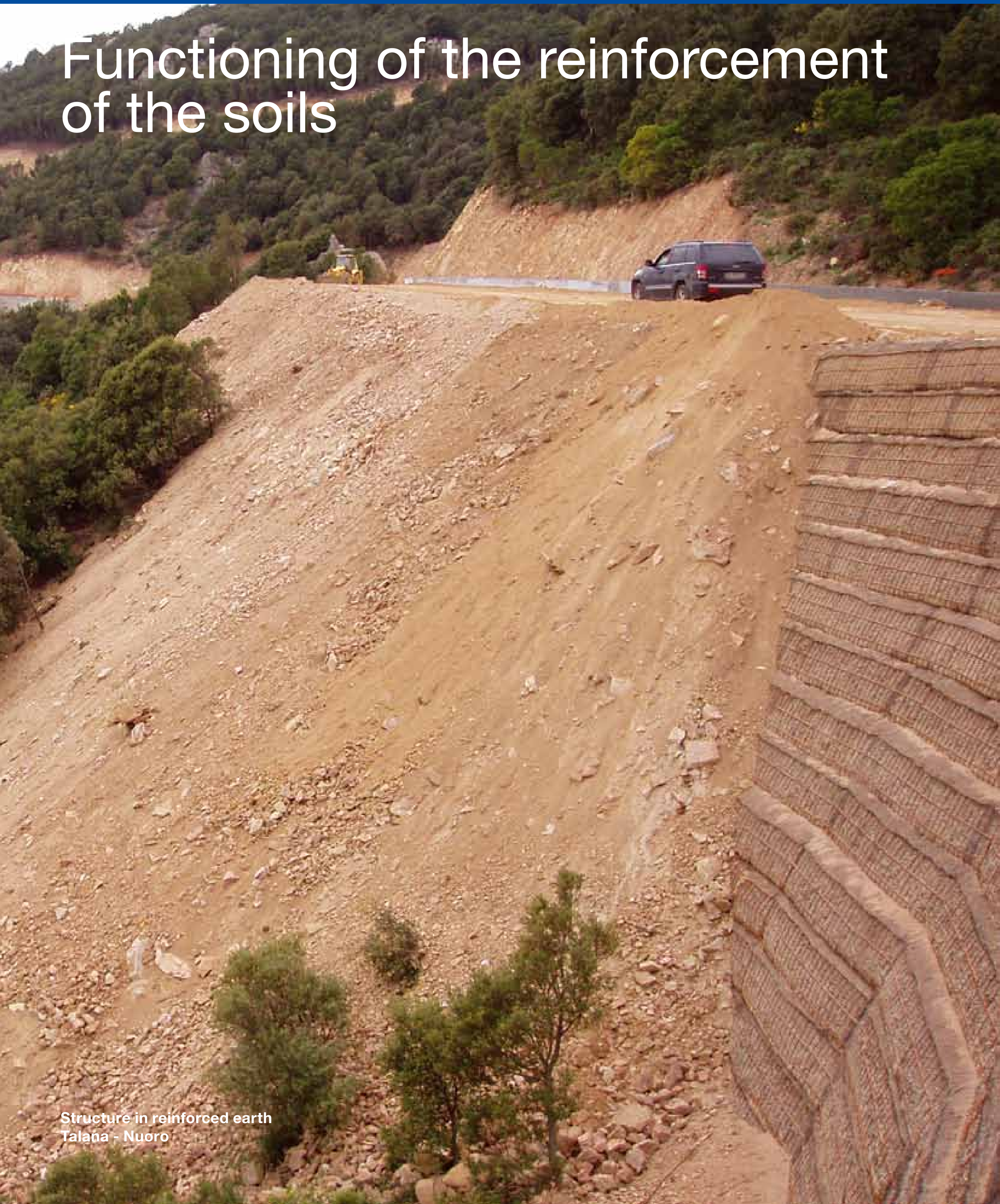
Functioning of the reinforcement of the soils



Structure in reinforced earth
Talana - Nuoro

The support structures in reinforced earth can be used in different fields of application, the main ones are:

- **Road and railway embankments**
- **Restore and consolidation of a caved in soil on the road**
- **Realisation of ascent and descent ramps from flyovers**
- **Levee rises channels and rivers**
- **Falling stones barrier**
- **Noise protection barriers on roads or railways**
- **Widening of overhead parking**
- **Realisation terracing in vineyards-cultivated soils**
- **Consolidation of the soil at tunnel entry**

The support structures in reinforced earth have, in the last few years, received growing consent from designers dealing with both public tender bids and with work for residential building.

The geosynthetic elements used to reinforce the natural soil are geometrically two-dimensional planar structures with a characteristic stresses/ deformations bend that can be compared with that of the solid matrix in which they will be inserted. Suitably installed inside the soil to be "reinforced", the geosynthetic reinforcements (fabrics geotextiles or geogrids) develop, by friction, a tensioning state of by-pass nature, enabling the composite system to support levels of stress, otherwise incompatible with the nature of the material. From a geotechnical point of view, the soils are characterised by a good resistance to compression but by a virtually null resistance to traction. The presence of the geosynthetic reinforcement confers to soil, those characteristic of resistance to traction of which it is naturally without.


Reinforced earth in the private building sector


Support work in the road sector


Vineyard terracing

Interaction soil-geosynthetic reinforcement

The usefulness in inserting geosynthetic reinforcement materials inside the soil (in our case fabric geogrids in PET, XGrid PET PVC type), substantially consists in creating a pseudo composite natural material, which mechanical features are definitively more performing compared to the original "bald" soil.
The effect generated inside the composite structure (soil-reinforcement), mainly depends on the flexible rigidness of the reinforcement used; the inclusion of flexible elements, which geogrids, determines the arising of tensions of by-pass nature, for effect of the friction generated at interface between the two materials (soil-geosynthetic).
Whereas, in case of rigid inclusions (bars, metal profiles...), the interaction between the two materials determines the arising of not only stresses of by-pass type, but also tensional state of flexible and shear type.
With regard to stresses of "flexible" type only, for there to be an effective synergy between the two materials and, therefore, the recording of the load transfer from the soil to the reinforcement, it is necessary for the reinforcement to have certain features, which for example:

- **suitable resistance features to traction and rigidness.**
- **Use of raw materials (polymers) able to resist even in aggressive chemical-physical conditions (attacks from chemical agents, pH of the soils...).**
- **have a suitable geometrical structure, to be able to best develop the stabilising effect.**

Application of the geogrids as road base reinforcement

**View of the vineyard:
a) completed work**

Even the soil must have suitable features to be able to better interact with the geosynthetic element.
In particular, attention must be given to the following sizes:

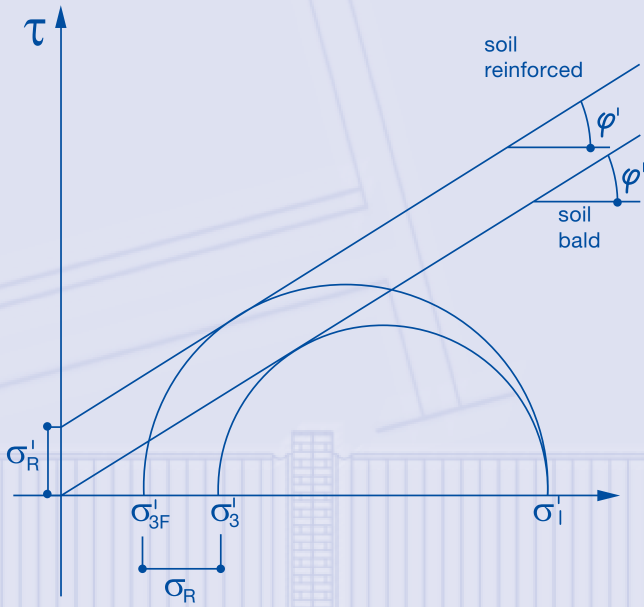
- **Granulometry;**
- **Thickening state;**
- **Resistance to cut and the dilatancy phenomenon.**

The analytical model used to represent the geomechanical behaviour of the reinforced soil, is the traditional criteria of Mohr - Coulomb.
Admitting that the contribution made available by the reinforcement is equal to the maximum resistance to traction that the material is able to activate, its limit state will obviously correspond to the break value.
Therefore, the composite material (soil-geosynthetic) can be represented, on the plan of Mohr, as if it were soil provided with efficient cohesion c'r (Schlosser and Long, 1972).

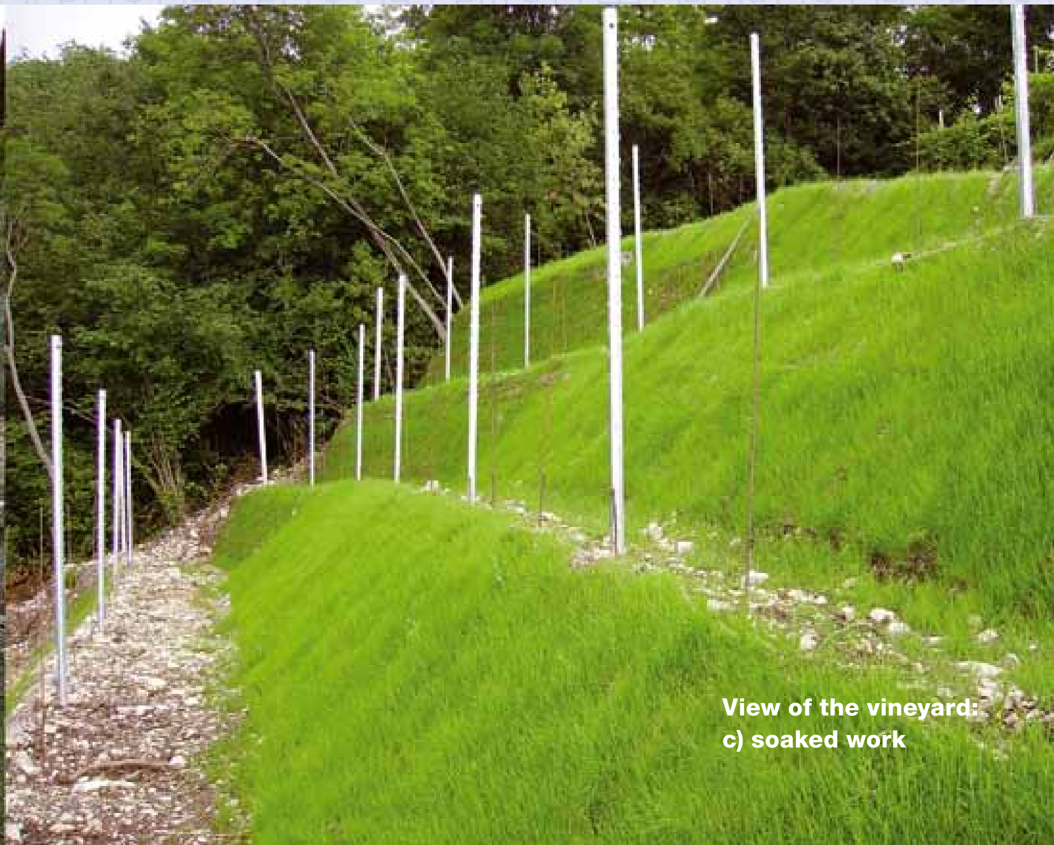
$$C'_r = \frac{\sigma'_r * \sqrt{K_p}}{2} = \frac{\sigma_s * A_s}{2 * \Delta B * \Delta H * K_a}$$

Where:
σ'_r = efficient equivalent confining tension developed by the reinforcement;
σ_s = resistance to traction of the reinforcement;
A_s = transversal section of the reinforcement;
ΔB and ΔH = vertical and horizontal centre-to-centre of the reinforcement.

apparent cohesion in case of reinforced soil



View of the vineyard:
b) revegetation work



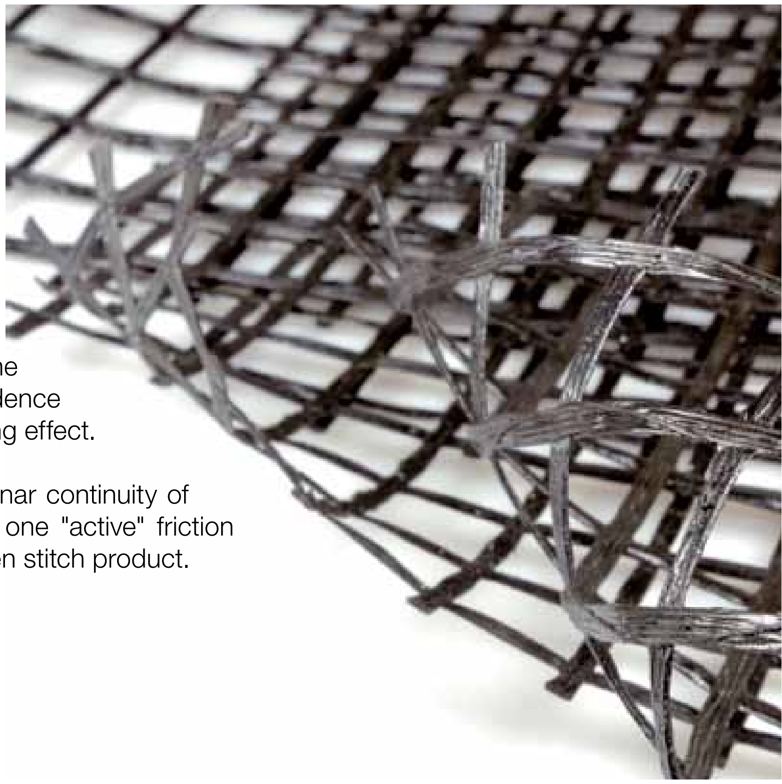
View of the vineyard:
c) soaked work

Why use a geogrid instead of geotextile fabric

There are mainly two types of geosynthetic reinforcements used to reinforce a soil:

- **Geogrids;**
- **Fabric geotextiles.**

Geometrically, the geogrid has an open stitch structure, whereas the geotextile fabric has a closed stitch surface. From a performance point of view, the two types of materials have significant differences following their intrinsic different geometrical configuration.



- **Geogrid:** the presence of an open stitch structure allows the product to develop the "passive" resistances in correspondence of the transversal elements, increasing its intrinsic stabilising effect.

- **Geotextile fabric:** having a closed stitch geometry (planar continuity of its contact surface), the material is able to develop only one "active" friction component, resulting less performing compared to an open stitch product.

Possible interaction mechanisms geosynthetic-soil

The interaction soil/geosynthetic problem is faced by introducing the concept of by-pass tension of equivalent friction.
The by-pass tension that generates at interface represents the resistance to sliding of the geosynthetic towards the soil in which it is inserted.
Through the estimation of this size (meaning introducing suitable coefficients), it is possible to evaluate the entity of the resistance mobilised by the geosynthetic in relation to two possible critical mechanisms:

- **the sliding of a portion of handmade on an individual reinforcement element (direct sliding),**
- **the removal of the reinforcement from the stable portion of soil (pullout).**

In 1991 Jewell introduced reports aimed at expressing fully and analytically the above concepts.

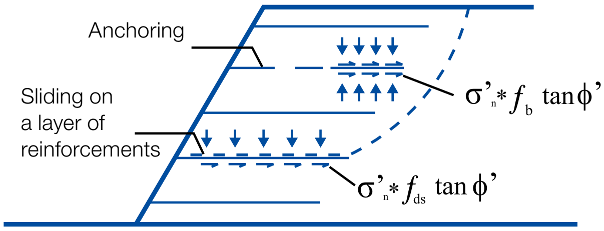
$$T_{ds} = L_r * W_r * \sigma_n * f_{ds} * \tan(\phi)$$

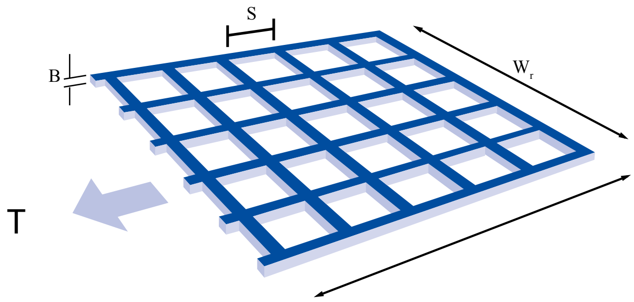
$$T_b = 2 * L_r * W_r * \sigma_n * f_b * \tan(\phi)$$

Where:
W_r = width of the reinforcement;
L_r = length of the reinforcement;
σ'_n = efficient tension in orthogonal direction to the reinforcement plan;
f_{ds} = equivalent friction coefficient for sliding;
f_b = equivalent friction coefficient for pullout;
ϕ = internal friction corner.

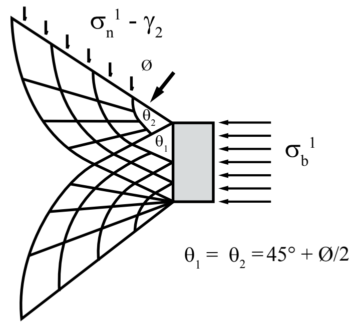
Presuming the full copenetration of the soil inside the open stitches of a synthetic reinforcement element like a grill, Jewell formulated the following expressions for the friction coefficients:

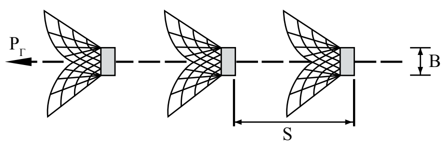
$$f_{ds} = 1 - \alpha_s \left(1 - \frac{\tan(\delta)}{\tan(\phi)}\right) \qquad f_b = \alpha_s * \left(\frac{\tan(\delta)}{\tan(\phi)}\right) + \left(\frac{\alpha_b * B}{S}\right) * \left(\frac{\sigma'_b}{\sigma'_n}\right) * \frac{1}{2 * \tan(\phi)}$$





Forms of interaction between the synthetic reinforcement and the soil





Behavioural layout of a geogrid for the definition of f_{ds} and f_b

Where:

α_s = solid fraction of the surface of the geogrid;

α_b = quota part of the width of the geogrid able to mobilise passive resistance;

S = distance between the transversal elements able to mobilise passive resistance;

B = thickness of the transversal elements;

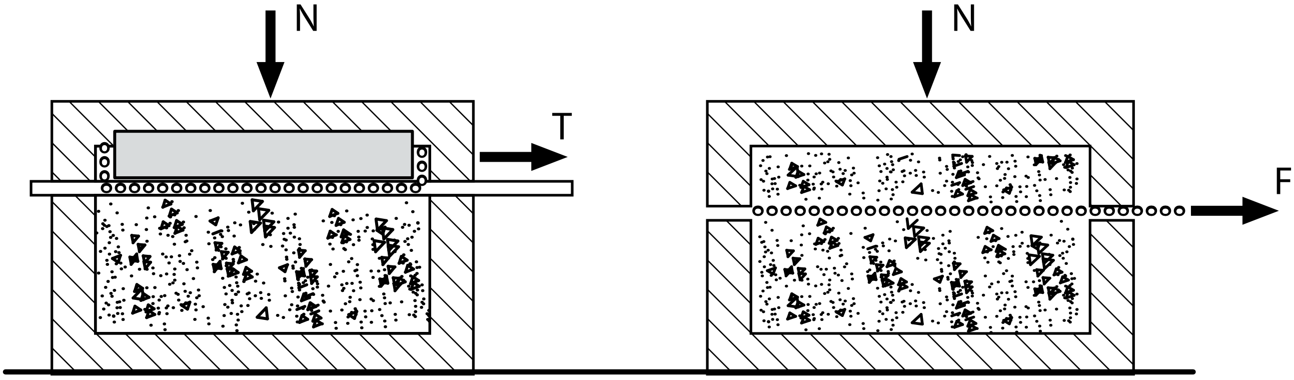
σ'_b = passive limit pressure along the pullout direction;

δ = friction corner between solid part of the geogrid and soil.

In the photo, copenetration of the soil in the stitches

Usually, to reproduce the behaviour stresses-deformations of the composite material in the laboratory, particular equipment is used to simulate the direct shear of the soils.

Direct shear and removal test (ISO 13430);



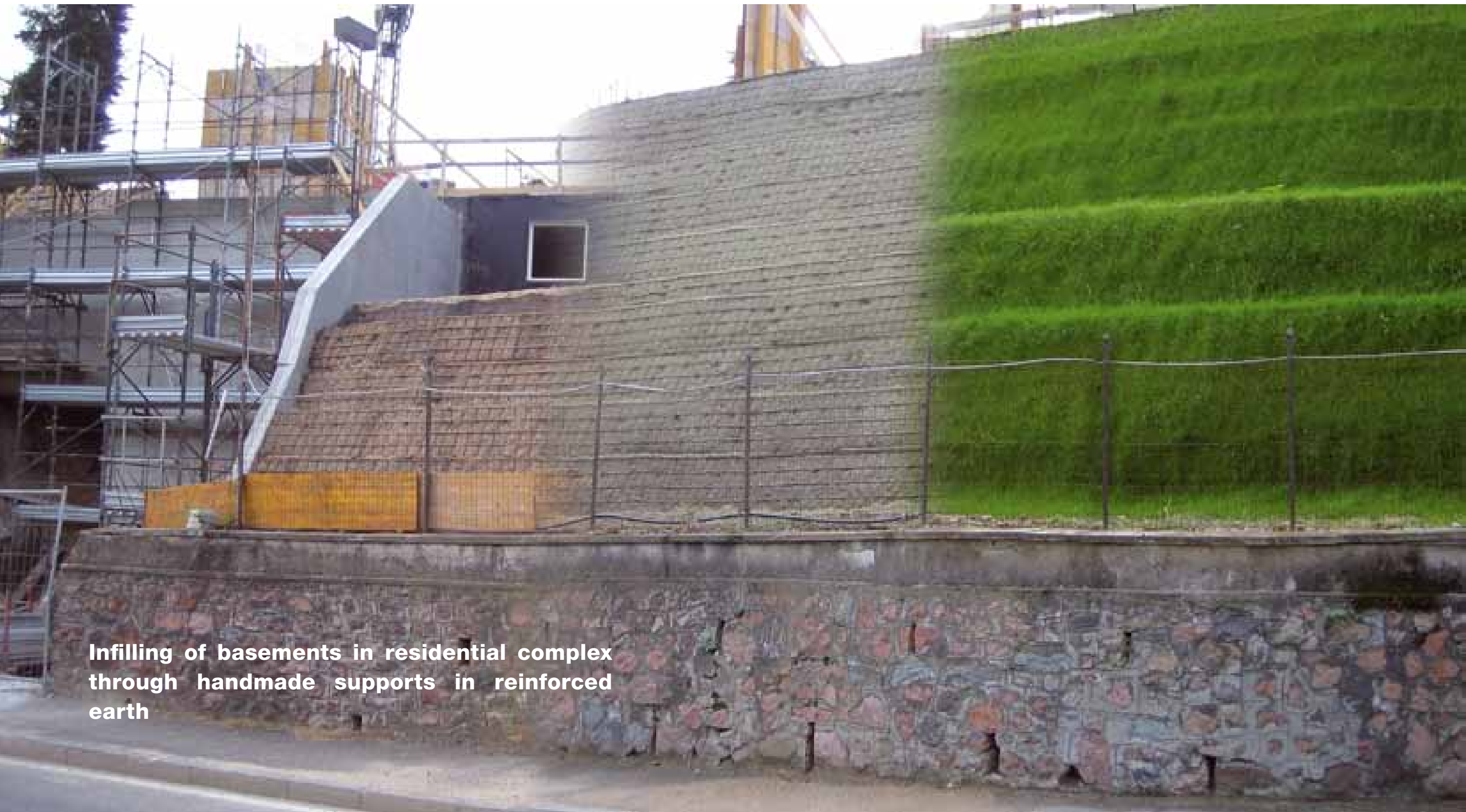
direct shear test

pullout test

work progress

reinforced earth

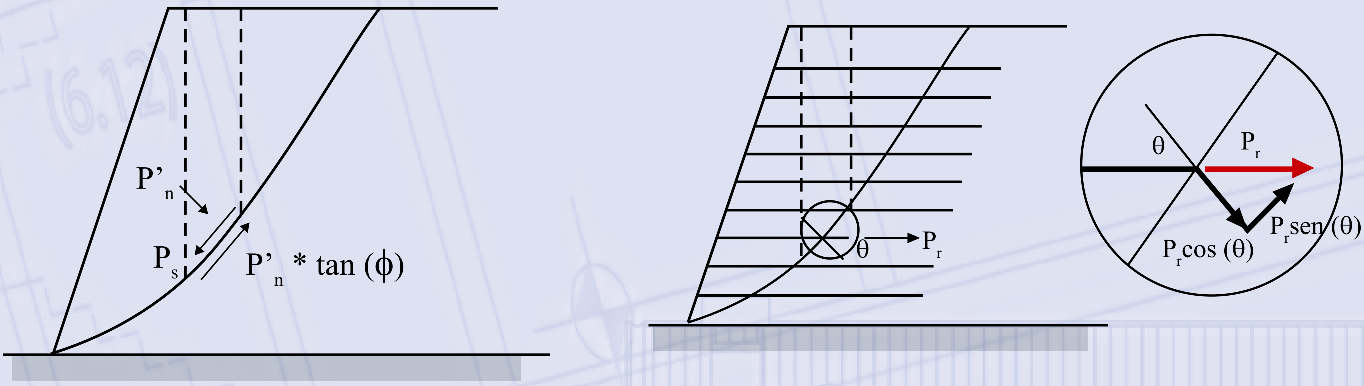
revegetated reinforced earth



Infilling of basements in residential complex through handmade supports in reinforced earth

Contribution of the geosynthetic reinforcement

To evaluate the real benefit recorded in inserting a geosynthetic reinforcement inside a solid matrix, it is possible to use a simple conceptual model that reproduces what happens when a composite material is created.
Let us presume to submit a soil sample to a direct shear test; the material remains in its undisturbed state until the value of the stress applied (axial and shear load) determines the reaching of the limit resistance of the sample.
Starting from the assumption that the soils have scarce inclinations to supporting traction stresses but have a good resistance to shear, it is clear that if it were possible to find a system able to transfer the traction stresses from the soil to another component, the composite system would be guaranteed with a greater resistance capacity towards the external stresses.
Therefore, the forming of a two-component synthetic/soil system, would have the benefit of using at best the performance features of the two materials used.
To prove the real efficiency of the system, it can be assumed to submit a soil sample, without synthetic reinforcement, to an external load system (Pv and Ps) and bring it to break, by means of a general shear test.
In fact, the soil sample is able to support the externally transmitted stresses, as long as its constitutive law allows it, meaning until the conditions of initial collapse are reached.



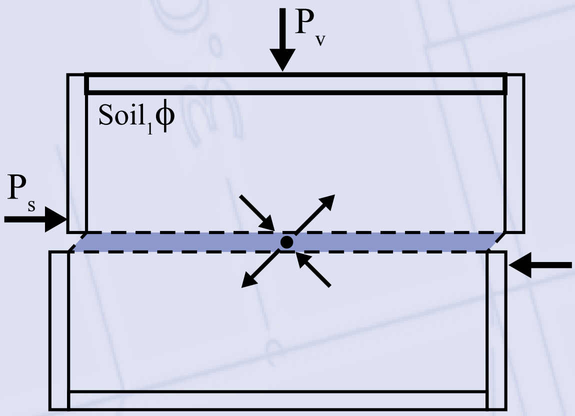
Activation of the traction resistance of the reinforcement when intercepted by the sliding bend

Consolidation of a channel during the restructuring of a private building
In detail, application of the pre-sowed geomat KMat F Sedum

Without reinforcement, the soil, provided with an internal friction corner equal to ϕ', in view of a Pv axial load (stress equal to v), develops a shear resistance equal to:

$$P_{res} = P_v * \tan(\phi')$$

Soil sample subject to shear test without reinforcement;



Braking strip

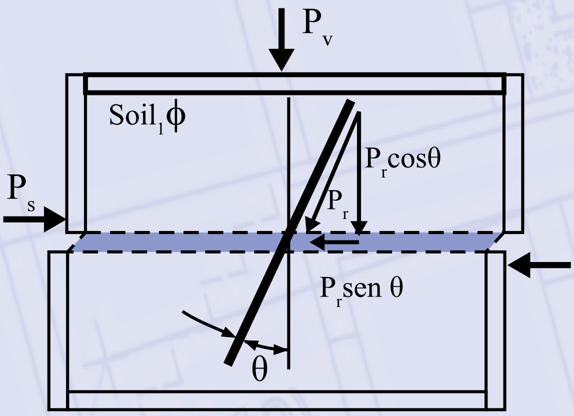
Compression stress

Traction stress

Resistance to break in absence of reinforcement:

$$P_{res} = P_v * \tan(\phi')$$

Soil sample subject to shear test with reinforcement;



Braking strip

Resistance to break:
$P_v \tan \phi$

Reduction of the strengths determining the break:
$P_r \text{sen } \theta$

Increase of the strengths opposing to break:
$P_r \cos \theta \tan \phi$

Resistance to break with reinforcement:
$P_{res} = P_v \tan \phi + P_r(\text{sen } \theta + \cos \theta \tan \phi)$

The insertion of a synthetic reinforcement in the sample determines the arising, inside the same reinforcement, of two components:

$$P'_{res} = P_r * \text{sen}(\theta)$$

$$P''_{res} = P_r * \cos(\theta)$$

The first component reduces the stress that tends to bring the sample towards the breaking condition, whereas the seconds, tends to increase the resistance capacity of the soil.
Therefore, by analysing the explanatory layout shown, the effective benefit that the insertion of a synthetic reinforcement element inside the soil determines in the two-phase system is immediately understood.

Traction resistance made clear by the sample without reinforcement	Traction resistance made clear by the sample with reinforcement
$P_{res} = P_v * \tan(\phi')$	$P_{res} = P_v \tan \phi + P_r(\text{sen } \theta + \cos \theta \tan \phi)$

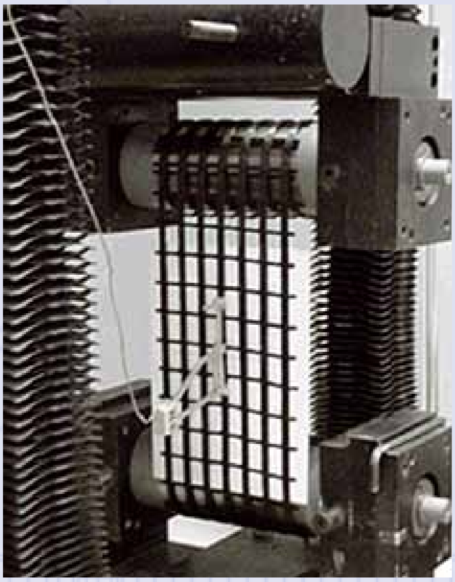
The concept of reinforced soil is valid the moment the perfect connection between the two materials (soil and reinforcement) is guaranteed, being in this way able to count on the best geomechanical features of the two components.

The concept of resistance to allowed traction

To correctly dimension a support work in reinforced earth, the designer must know the meaning of the following three sizes:

- Requested resistance (T_{design}): it represents the resistance that the reinforcement geosynthetic must make available to stabilise the handmade;
- Nominal resistance (T_{ult}): depending on the laboratory test run, it represents the nominal resistance at the time t=0 of the reinforcement;
- Allowed resistance (T_{allow}): it is the resistance value of the reinforcement obtained by applying the reduction factors to the nominal resistance data. The number and meaning of the reduction factors depends on the algorithm of calculation used (BS 8006/1995, FHWA, etc..).

The calculation method shown merely as an example is taken from the document of the American *Geosynthetic Research Institute (GRI)* **"GRI standard practice GG4(b) – Determination of the long term design strength of flexible geogrids".**
To evaluate the resistance to allowed traction of the reinforcement it is necessary to use reduction factors. Such coefficients will be applied, depending on the used calculation procedure, to the normal resistance.
The approach used by the **GRI** is substantially similar to that used by the Anglo-Saxon procedure (BS 8006) which envisions the following steps:



Laboratory test to calculate the resistance of the geogrid at maximum traction (value T_{ult})

$$T_{allow} < T_{ult}$$

$$T_{allow} = \frac{T_{ult}}{\prod_{i=1}^{5} FS_i} = \frac{T_{ult}}{(FS_{ID} * FS_{CR} * FS_{BD} * FS_{JNT})}$$

Where:

- $\mathbf{T_{allow}}$ = allowed traction resistance (kN/m);
- $\mathbf{T_{design}}$ = design resistance used to dimension the work (kN/m);
- $\mathbf{T_{ult}}$ = nominal resistance of the reinforcement (kN/m);
- $\mathbf{FS_{ID}}$ = reduction factor for the laying of the material (ad.);
- $\mathbf{FS_{CR}}$ = reduction factor for effect of the creep of the plastic material (ad.);
- $\mathbf{FS_{CD}}$ = reduction factor for effect of the chemical aggression level of the ground (ad.);
- $\mathbf{FS_{BD}}$ = reduction factor for effect of the biological aggression level of the ground (ad.);
- $\mathbf{FS_{JNT}}$ = reduction factor for effect of the overlappings (ad.);
- $\mathbf{FS_{design}}$ = additional safety factor (ad.)

$$T_{design} = \frac{T_{allow}}{FS_{design}}$$

Certain reduction factors are independent from time whereas other strongly depend on time variation (variable time property), like, for example, the creep.

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reinforcement, drainage, control of superficial erosion

Dimensioning of the support structures in reinforced earth: calculation verifications

To dimension a reinforced earth work it is necessary to carry out, through appropriate calculation programmes, verifications of both external and external nature.
The internal verification is aimed at analysing the possible collapse mechanisms that partially or fully involve the portion of reinforced soil. The main aim of the internal verification is that to determine the features of the geosynthetic reinforcements, in terms of space, length, and traction resistance requested, for the reinforced composite system to be stable.
It is therefore necessary to verify that the reinforcement, inserted inside the soil, does not break and pullout from the stable part of the slope (in technical terms, internal and compound check).
As well as defining a layout that guarantees the system from manifesting of breaking and/or pullout phenomenons, it is important to verify that possible transfer movements along the laying plans defined by each reinforcement (direct sliding) do not happen. Finally, in case of opting for a constructive solution that envisions the wrap around in front of the reinforcement, it is necessary to pre-emptively ascertain that the length practiced in the upper part of the individual layer is stable.
The internal verifications to be carried out are:

- **resistance verification of the reinforcements;**
- **verification upon pullout;**
- **verification upon direct sliding;**
- **verification of the wrap around.**

"As well as the internal verifications, it will be necessary, during execution, to also carry out external verifications, which:

- **sliding verification**
- **overturning verification**
- **supporting capacity verification**
- **global stability verification**

Terraced vineyard by means of reinforced earths
Farra di Soligo – Treviso

Preliminary data it is necessary to know to dimension a reinforced earth

In order to evaluate the technical feasibility of a support work in reinforced earth, it is necessary to acquire a series of fundamental preliminary information.
The input data on which it is possible to realise a feasibility study is the following:

- **geognostic surveys relating to the area on which the realisation of the structure has been presumed**
- **spot levels samples**
- **significant sections about the matter of fact**
- **geometry of the future work (in terms of inclination of the front, height, subdivision in more ledges, slope of the top part)**
- **external loads applied to the structure (top loads in case of parking or road)**
- **seismic classification**
- **geotechnical features (internal friction corner, cohesion and specific weight) of the soil behind the future work, of the foundation soil, of the filling soil**
- **presence of suspended pitches or infiltrations of other nature**

Reconstructed the boundary conditions, it is possible to start the dimensioning process using specific calculation programmes.

Reinforced terracing with back drainage element.
The function of the back drainage geocomposite of the structures in reinforced earth is that to maintain the internal area of the work drained, in order to avoid possible infiltrations that might decrease the system performances, from a geomechanical point of view. Depending on the height of the structure, it will be opportune to insert at the base of the QDrain, cracked collectors for the collection and subsequent disposal of the intercepted waters.

Case histories

Terracing of vineyards realised by means of the reinforced earths technique - Treviso 2008

Sometimes the superficial drainage of the meteoric waters associated to the geotechnical nature of the filling soils, can determine problems of stability in the terracing of vineyards.
In these cases, the insertion of geosynthetic reinforcement elements associated to the front containing metal panelling (shaped electro-welded nets) manages to confer greater stability to the soil.
The cases briefly described in this project sheet, exposes the use of the soil reinforcement technique through the insertion inside the solid matrix of open stitch synthetic elements (geogrids XGrid PET PVC) for the constitution of new ledges in a vineyard.

For the compacting phase of the filling earth, a minicompactor at the front is usually used so as not to damage the metal casing.

The work in reinforced earth results a valid solution to take into consideration, especially if coupled with the use of particular drainage systems in thin trench **(Speedrain)** for the control of the sub-superficial outflow of the meteoric waters.

Particular of the completed work, from which it is evident the use of a rigid metal element and element reinforcement geogrid, for the control of the erosion Ecovernet J 500 (in 100% jute fibre).

Speedrain is a drainage geocomposite studied specifically for the drainage in thin trench. Its geometrical conformation with parallel channels facing the collector, optimises the percentage of water flow intercepted by the system. The possibility of reducing the excavation geometry, through Speedrain, avoiding to insert large amounts of gravel inside the same, makes it a quick laying system, economical and technically more performing than the classical drainage systems in geotextile and gravel.

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Case histories

Bank reconstruction of a channel near a private building - Verona 2008

During restructuring of a residential complex, the subsiding of a portion of a bank of a nearby water flow was recorded. The owner of the building wanted to rebuild the matter of fact prior to subsidence, without having to use the traditional support work in reinforced concrete.

In view of this specific requirement, a work in reinforced earth was studied, clearly equipped with the opportune technical cautions able to excellently manage the eventual interference of water.
In view of the reinforced earth work, granular material of adequate size was laid to avoid
possible erosion with consequent removal of the material upon transiting of the water.

To keep corrosion phenomenons due to the presence of water to a minimum, it was decided to use galvanised rigid panels, whereas to separate the granular material from the remaining cohesive material, a waterproofing membrane was interposed **(Isostud)**.

To increase the safety margin at the front, and avoid even the minimum material outflow, it was decided to envision the installation, between the granular material and the galvanised case, of a PP geosynthetic geomat, coupled with a pre-sowed vegetable bio-felt **(KMat F Sedum)**. The geogrid used, for 4 layers equally distant 30 cm, is of fabric type in PET with high cohesiveness, having nominal traction resistance equal to 40 kN/m **(XGrid PET PVC 60/30)**.
The height of the handmade is of 1.2 m, with front inclination of 70°.

The bank of the channel showed evident subsidence that required restoring interventions, also in consideration of the fact that the purchaser had a need to arrange for a safe transiting zone in the adjacent areas.

The completed reinforced earth work with at the base roadbed alloyed in concrete to protect the foot of the bank from possible erosions.

Particular of the bank

Case histories

Infilling work of basements in residential complex through handmade supports in reinforced earth - Varese 2006

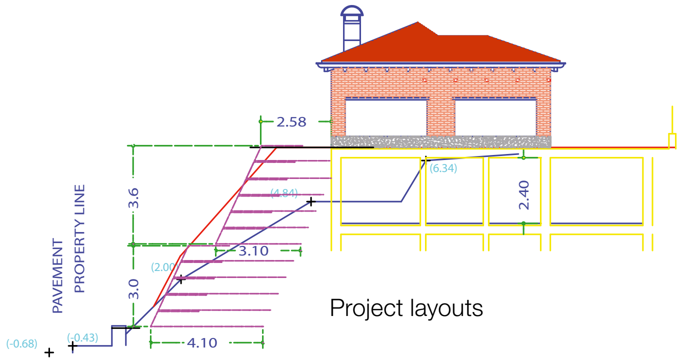
The realisation of new residential buildings, especially on geographically hilly contexts,
is entailing, in the last few years, the arising of a new problem: the infilling of above ground basements.

In fact, it is always more often to build basements above ground, with the consequent problem of having to find a solution able to cover the wall occupying less space possible.

The new materials, and especially the new techniques within the building sector, have identified a solution that not only solves the problem but also satisfies the aesthetical taste. It is to realise a structure in reinforced earth behind the wall, through the filling of the soil deriving from the excavations, prior insertion, for subsequent layers, of geosynthetic reinforcements (typically geogrids).

A work in reinforced earth is usually a support obtained by combining two materials having different performance features: the soil, material with good compression features but practically null from its intrinsic resistance to traction point of view, and the geosynthetic reinforcement element having excellent traction features but absolutely null from a compression point of view.

The coupling of these two materials manages to obtain a highly performing hybrid compost. In the specific case, the work does not cover a stabilising function, meaning it does not work as if it were a support in that placed behind a reinforced cement handmade, the reinforced fill does not receive any type of stress, having to simply self-support itself.



Project layouts

Particular of the drainage behind the work at the start of laying the reinforced earth system. The drainage collector is based at the bottom of the basement.

Installation phase of the reinforced earth work halfway on the wall to be covered.
The black studded membranes can be seen on the background, as mechanical protection of the waterproofing.

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The work is constituted by a front panelling in pre-shaped electro-welded net, to make the front as regular as possible and contain at best the previously compact layers of soil.

The support work in reinforced earth has reached the top of the building, fully covering the basement. Hydroseeding has already been carried out to guarantee good covering of the turf.

The reinforcement elements used are the fabric geogrids in polyester fibres **XGrid PET PVC 60/30** wrapped around at front, according to the wrap around technique, installed every 60 cm. To avoid that, during meteoric events, there might be a wash-out at front before vegetation occurs, a twin-net in jute fibre of 500 gr/sq. m **Ecovernet J 500** has been installed.
The twin-net has been installed between the casing and the geogrid in PET.
Behind the work, to be able to create an hydraulic device able to guarantee a suitable drainage of the handmade, the laying of drainage collectors in HDPE **TPipe 125** has been envisioned.
Hydroseeding is envisioned at the end of the intervention to facilitate the growing of the turf.
The maximum height of the handmade is of 6 m, with front inclination of 70°.

After a few weeks from hydroseeding, the front is completely soaked.

View of the site during three different work phases.

Price comparison analysis: solution in reinforced earth

DEVELOPMENT IN LINEAR METERS	**m**	**35**	**Price per linear meter**
WALL HEIGHT	**m**	**3**	**€/m 335.48**
TOTAL FRONT AREA	**m²**	**105**	
above ground height	**m**	**3**	**Price per front square meter**
base plate	**m**	**0**	**€/sq. m 111.83**

DESCRIPTION	um	quantity	price	amount
Excavation section performed with mechanical means in soils of any nature and consistency, excluding rock, including any demolitions of old walls and findings of sizes not over 0.50 cubic meters, the trimming and the configuration of the bottom, even if in gullets, the eventual shaping of walls, slopes and curbs, bounce with one or more reaches, lifting, transport of filling or relief spoil to an average distance of 100 m and its arrangements in the deposit sites, or the transport to the site for loading on transport means within the same distance limits. Depth from 2.01 m to 4.00 m **excavation width: 2.7 m** **excavation length: 35 m** **excavation height: 3.5 m** **3 x 35 x 2.7**	m³	283,5	€ 3,71	€ 1.051,79
Fabric geogrid in polyester fibre coated in PVC having minimum resistance equal to 40 kN/m and elongation to maximum load not above 12%, for the structural reinforcement of the filling soil compensate apart, including rebound of 5% and the transport to site. **number reinforcement layers: 5** **anchoring length: 2.7 m** **wrap around length: 1.5 m** **front line length: 0.66 m** **tot. reinforcement length For individual layer: 2.7 + 1.5 + 0.66 = 4.86 m** **rebound 5%: 5.10 m** **square meters of reinforcement per linear meter: 5.10 x 5 = 25.5 sq. m/m** **tot. product square meters: 25.5 x 35 = 892.5 sq. m**	m²	892,5	€ 3,12	€ 2.784,60
Synthetic geomat with high index of the vacuum in PP coupled with a pre-sowed bio-felt KMat F Sedum type, located in front of the work in reinforced earth to avoid the wash-out of the end soil located in work to guarantee the growth of the vegetable blanket. Including rebound of 5% and transport to site **number reinforcement layers: 5** **width per layer: 1 m** **rebound 5%: 1.05 m** **square meters of geomat per linear meter: 1.05 x 5 = 5.25 sq. m/m** **tot. product square meters: 5.25 x 35 = 183.75 sq. m** **5.25 x 35**	m²	183,75	€ 8,90	€ 1.635,38
Three-dimensional drainage geocomposite QDrain ZM 8 14P type, obtained by coupling two non-woven geotextiles to an internal drainage soul in PP monofilaments having geometry with parallel channels in transversal direction to front length. At the base of the system, it will be necessary to envision laying a drainage collector T PIpe 125 type, externally and internally pleated to facilitate the evacuation of the infiltration waters. Including rebound of 5% and transport to site **square meters per linear meter: 3/sen(65) = 3.3 sq. m/m** **rebound 5%: 3.46 m** **front length: 35 m** **tot. product square meters: 3.46 x 35 = 121.1 sq. m** **3.46 x 35**	m²	121,1	€ 11,20	€ 1.356,32
Casing in shaped electro-welded net at 65° including 7 casing tie-rods for stiffening of the inclined line, **made of bars diam. 8 mm.** **exposed square meter for casing: 4.0 x 0.6 = 2.4 sq. m** **total front area: 35 x 3 = 105 sq. m** **number of casings: 105 / 2,4 = 44**	cad	44	€ 44	€ 1.936,00
Labour made of 1 specialised worker and 2 normal workers (8 hour per day per 3 days)				
Specialised worker	ore	24	€ 19,15	€ 459,60
Normal worker	ore	48	€ 16,54	€ 793,92
TOT.				***€ 1.253,52***
Means rental (presuming 3 days per 8 hours per day)				
Excavator	ore	24	€ 40,50	€ 972,00
Compactor	ore	24	€ 10,35	€ 248,40
Vibro-tamper	ore	24	€ 8,00	€ 192,00
Mini excavator	ore	24	€ 13,00	€ 312,00
TOT.				***€ 1.724,40***
				TOTAL € 11.742,01

TSystem

reinforcement, drainage, control of superficial erosion

TSystem
reinforcement, drainage, control of superficial erosion

Price comparison analysis: solution in reinforced concrete

DEVELOPMENT IN LINEAR METERS	**m**	**35**	**Price per linear meter**	
WALL HEIGHT	**m**	**3,3**	**€/m 631.43**	
TOTAL FRONT AREA	**m²**	**98**		
above ground height	**m**	**2,8**	**Price per front square meter**	
base plate	**m**	**0,5**	**€/sq. m 225.51**	

DESCRIPTION	um	quantity	price	amount
Excavation section performed with mechanical means in soils of any nature and consistency, excluding rock, including any demolitions of old walls and findings of sizes not over 0.50 cubic meters, the trimming and the configuration of the bottom, even if in gullets, the eventual shaping of walls, slopes and curbs, bounce with one or more reaches, lifting, transport of filling or relief spoil to an average distance of 100 m and its arrangements in the deposit sites, or the transport to the site for loading on transport means within the same depth distance limits from 2.01 m to 4.00 m. **excavation width: 3 m** **excavation length: 35 m** **excavation height: 3.5 m** **3.5 x 35 x 3**	m^3	367,5	€ 3,71	€ 1.363,43
Supply ad laying of concrete for underpriming of foundations, packaged with 2 or more inert pieces, in order to obtain a granulometric distribution suitable for the work to be carried out, cast with the aid of casings, separately accounted for. Scaffoldings, work plans, transport, hoisting and vibration are included. With characteristic cubic resistance at 28 days of maturing not below kg/c sq. m 150. **35 x 2.5 x 0.2**	m^3	17,5	€ 110,00	€ 1.925,00
Supply ad laying of concrete slab foundations, reinforced concrete plinths and platforms, packaged with 2 or more inert pieces, in order to obtain a granulometric distribution and a consistency suitable for the work to be carried out, cast with the aid of casings, iron reinforcement and casings separately accounted for. Scaffoldings, work plans, transport, hoisting and vibration with characteristic cubic resistance at 28 days of maturing Rck kg/c sq. m 350 are included. **35 x 2.2 x 0.5**	m^3	38,5	€ 120,00	€ 4.620,00
Supply ad laying of concrete for beams, pillars, flat slabs, staircase and elevator walls in reinforced concrete, packaged with 2 or more inert pieces, in order to obtain a granulometric distribution and a consistency suitable for the work to be carried out, cast with the aid of casings, iron reinforcement and casings separately accounted for. Scaffoldings, work plans, transport, hoisting and vibration d) with characteristic cubic resistance at 28 days of maturing Rck kg/c sq. m 350 are included. **[(0.5 + 0.3)x2.8/2] x 35**	m^3	39,2	€ 120,00	€ 4.704,00
teel bars for reinforcement of concrete aggregate, custom worked and sheared, shaped and put in place, including the rebound, the bindings and the burden relating to legal checks, of type Fe B 44 K with improved adherence, checked in-house.				
rib type 1 2x 167x 0.882x 3.84	kg	1131,22		
reinforcement above foundations 11x 1.201x 35	kg	462,39		
reinforcement below foundations 11x 1.201x 35	kg	462,39		
construction joint type 1 167x 1.201x 3.52	kg	706,00		
upper electro-welded net 9.18x 2.80x 35	kg	899,64		
lower electro-welded net 9.18x 2.80x 35	kg	899,64		
closing type 1 167x 1.201x 3.52	kg	371,05		
closing tools 2x 1.201x 35	kg	84,07		
TOT.	*kg*	*5016,38*	€ 0,90	€ 4.514,74
Wooden straight workforms for concrete aggregate casts, simple or reinforced, with net height from support plan up to 4.00 m, including assembly, the use of suitable disarmings and the dismantling a) for flat foundation work. **foundation: 2 x 0.5 x 35**	m^2	35	€ 18,10	€ 633,50
Wooden straight workforms for concrete aggregate casts, simple or reinforced, with net height from support plan up to 4.00 m, including assembly, the use of suitable disarmings and the dismantling b) for elevation work which walls, elevator shafts, boundary of basements. **elevation walls: 2 x 2.8 x 35**	m^2	196	€ 22,14	€ 4.339,44
				TOTAL € 22.100,11

Support structure in reinforced concrete

TeMa services

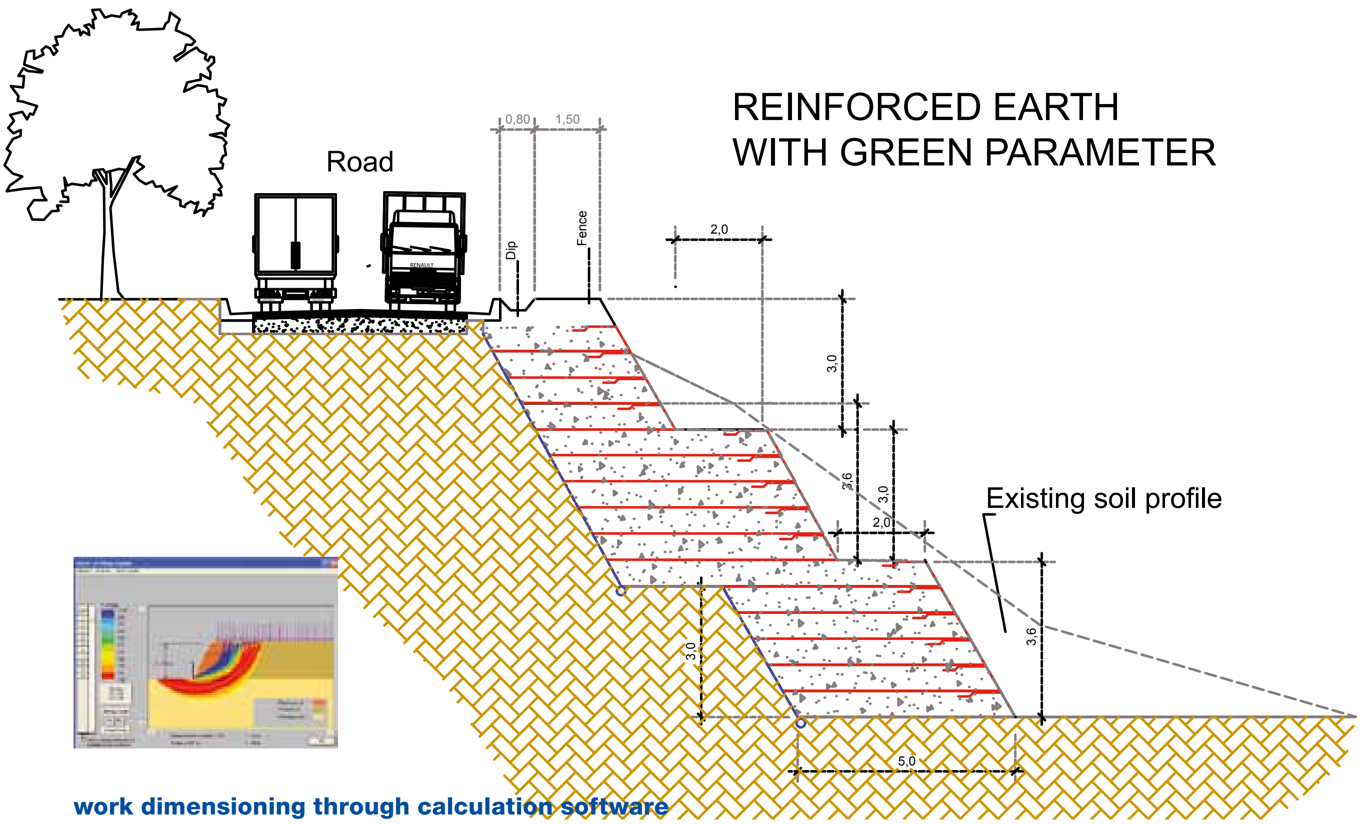
TeMa has an internal technical office able to support clients from product choice to laying modalities.

Through in-depth analysis and through the use of state-of-the-art software, the TeMa technicians are able to propose suitable solutions, complete and reliable for any type of problem, within the geosynthetic products field.

The dimensional analysis, the structural verifications and the specifications of the products to be used, constitute an essential support not only for the designer or the company wanting to qualify for the realisation of reinforced earths, but even for the more expert operators of the sector wanting to develop their experience in a continuously evolving field, to propose versatile and modern solutions.

The dimensioning of the work is carried out through the study of the sections of the slope, the internal stability analysis and the dimensioning of the products, customising and specifying the results at every individual intervention.

- **site inspections**
- **work dimensioning**
- **technical reports processing**
- **specification entries editing**
- **laying indications**



work dimensioning through calculation software

TeMa laboratories

The analysis laboratory is provided with modern equipment and qualified technicians that daily test the products, in order to maintain high quality standards and performance of maximum level.

The comparison with the most reliable external laboratories, pushes to a continuous improvement of the test and verification procedures carried out during all phases of the production processes.

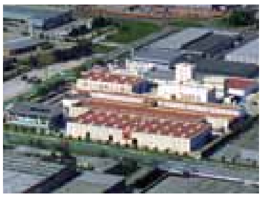
- **test on raw materials**
- **research and development support**
- **qualitative and performance verifications on finished products and prototypes**
- **product technical sheets editing and updating**
- **quality control**
- **certifications**
- **supervision and control of the production processes**
- **sample test on production batches and conformity verification**

Specific equipment for the testing of materials in the laboratories

Testing activity

TeMa
Technologies and Materials

Tema: technologies and materials for the building sector and the environment.



There are two fundamental aspects in the realisation of building works and environmental engineering interventions: the visible one, mainly aesthetical, and the non-visible one, involving structural, protection, maintenance and safety elements. Tema has been dealing with the latter aspect for over 10 years, distinguishing itself for the original application solutions (often very competitive) and for the technological innovations and the use of new materials.

Tema uses a modern production system with establishments in Italy, Spain, Turkey, Romania and Russia. It works daily in over 60 countries where it is a market protagonist with solutions and products for drainage and insulation in the residential and civil building sectors.

Also very important are the innovative solutions conceived for large environmental intervention work: Tema proposes the widest and most complete range of draining geocomposites and antierosion three-dimensional geomats.

Tema also distinguishes itself for the continuous research of new products, the active involvement of designers and companies, the support to clients during the designing and realisation phases.

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