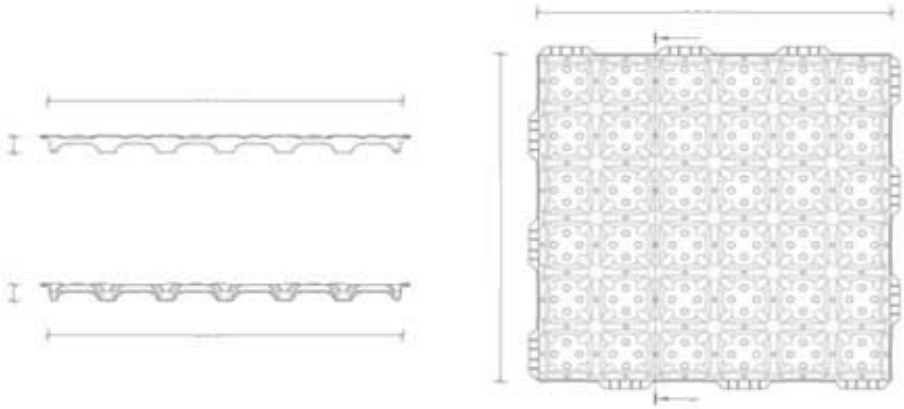
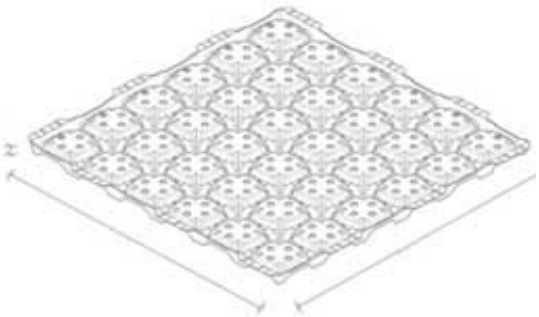
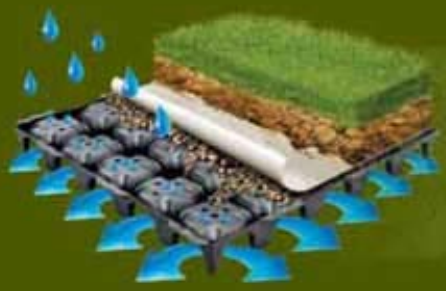
DRAINroof

USER MANUAL

Extensive and Intensive Green Roofs







verde
green

www.geoplast.it

Index

1 INTRODUCTION

1.1 FOREWARD

In recent years green roofs have been regarded with increasing interest amongst the architect and designer community. Roof gardens are seen as a great tool for restoring the environmental footprint otherwise disrupted by the construction of a new building. The advantages to the environmental balance deriving from green roofs are evident, and become greater when these are designed for buildings that permanently alter the landscape: positive effects for environment and human well- being are appreaciable both on a small local scale of the building and the larger scale of the sorrounding area. Green roofs made with the DRAINroof element provide value added to the urban environment, restoring the landscape and ecological balance disrupted by the sprawling urbanization of modern cities.

1.2 DESIGN REQUIREMENTS

Essential requirements for the design of a successful green roof with DRAINroof is the inclusion of all aspects linked to the system: water, biological, chemical, as well as the behaviour under permanent loads and temporary overloads.

DRAINroof was designed to meet these requirements while assuring:

- water storage and drainage capacity of the element;
- capability to aerate the vegetation soil- and drainage-layers;
- resistance to biological attacks.

2 DRAINROOF H6 DATA SHEET

DRAINroof is an element made of non-toxic regenerated polypropylene (PP). The overall dimensions are 50 mm in width, 50 mm in length and 6 mm in height (see figure 1). On the upper side, DRAINroof comes with a plate featuring tapered elements which assures excellent an water storage (20 l/m2): the flat surfaces on each element are 25, each of with 5 holes on the top. The lower side of DRAINroof features crests and flat zones. Each of them is shaped in such as way as to drain water in all directions, thereby assuring maximum dissipation in the minimum time possible: a draining surface of 1,144 cm2/m2 is therefore,provided.

Figure 1 – DRAINroof upper side

The base feet on the lower side are rounded so as to avoid the risk of scraping or breaching the root barrier underneath (see Figure 2).

Figure 2 - DRAINroof lower side

This assures excellent robustness to the entire system, thereby avoiding problems with leakages, and damp spots and mold on ceilings in buildings, which make the domestic environment uncomfortable and unhealthy. DRAINroof undergoes rigorous lab tests, which consist in applying loads onto the material by using a 30x30 footprint. DRAINroof is able to resist a compressive force of 6,000 kg /m2.

Material	Polipropilene rigenerato (PP) al 100%
Dimensions	50 x 50 x 6 cm
Compression resistance	6.000 kg/m2
Draining surface	318 cm^2/m^2
Drain flow volume	40 l/ m^2
Water storage	12 l/m^2 (a raso)
Weight m^2	4 kg/m^2
Package	720 pz (= 180 m2)

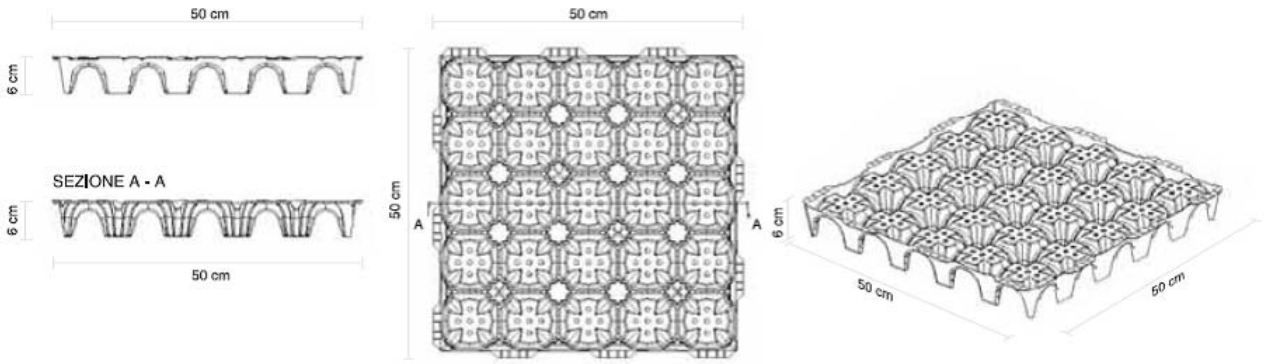
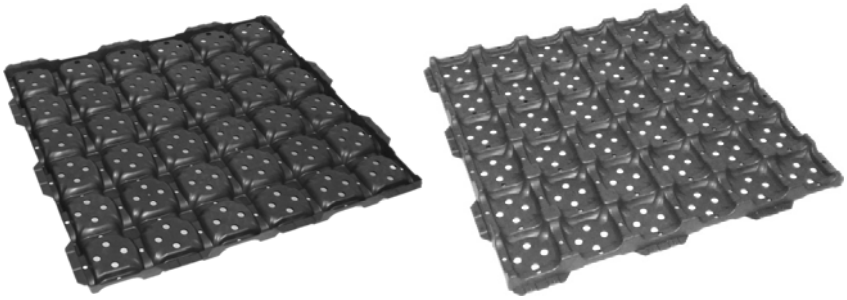
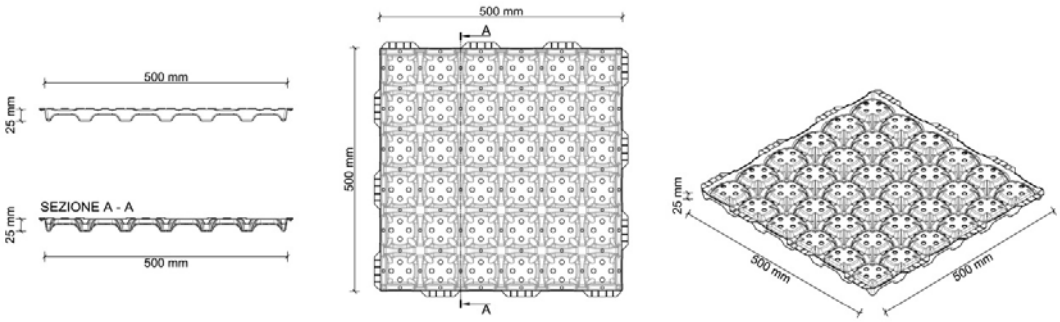


Figura 3 - DRAINroof : dimensions

2b DRAINROOF H2.5 DATA SHEET





Material	Polipropilene rigenerato (PP) al 100%
Dimensions	50 x 50 x H2.5 cm (= 4 pz/m^2)
Compression resistance	3.200 kg/m^2
Draining surface	547 cm^2/m^2
Drain flow volume	17.2 lt/m^2
Water Supply	6 lt/m^2
Weight	2.39 kg/m^2
Package	1440 pz (= 360 m^2)

2.1 LAYING IN PLACE

The DRAINroof draining layer is extremely easy to install. The elements come with a double-action joint between each other (see figure 3), i.e. the supports are fitted together by interposing the wing on the edge of one element and the void of another.

Figure 4 - Joint

The joint ensure safe a stable laying procedure of DRAINroof even on curved and inclined surfaces.

Figure 5 – Laying on surface

3 DESIGN INSTRUCTIONS

3.1 General information

The choice of GEODREIN for a green roof project is based on various requirements:

a. **Use of the green roof: if the goal is** that of providing a space for open-air activities, it is essential to correctly estimate the wear rate of the vegetation layer, the acting load applied on it and the maintenance work necessary for its upkeep.

b. **Visual benefits: the final result is** intended to blend into the architecture and the landscape.

c. **Environmental compensation: it is** desirable that the green roof and the architectonic elements, understood as a whole, leave an environmental, footprint as small as possible;

d. **Performance of the green roof: a** green roof contributes to the thermal- and noise-insulation values of the roof, improving living conditions within the building;

e. **Changes of the environmental conditions around the building:** it is expected that the green roof created with DRAINroof is capable of absorbing airborn dust, provides an effective sound barrier, manages rainwater and has an ambient temperature mitigation effect.

3.2 Analysis of the environment

The environment is analyzed from a climatic and environmental point of view as regards the functional diagram that illustrates the green covering and the type of vegetation.

An analysis of the environment makes it possible to clearly identify the variables which influence the type of vegetation. The selection of one plant species over another is the result of an analysis of on-site characteristics site such as weather condition, moisture level, sun radiation (light- and temperature-levels), exposure to wind and general weather conditions. A correct green roof design should take into account a 20-year storm.

More into detail, the following items must be checked:

a. **Sun exposure**, paying particular attention to adjacent reflecting surfaces which are may to c change the radiation level on the vegetation;

b. **Winds**, which may produce heavy stress on the vegetation, therefore the shape of the crown, the height of the plant species, the soil anchoring capability of the roots, the flexibility of the trunk and branches shall be considered;

c. **Snow load**, which are likely to produce stress on the plants and covering;

d. Exposure to salt-laden winds which may lead to fast degradation of the vegetation. In fact the plant species should be selected to resist to high saline rate on both the foliage surface and on vegetation layer;

e. **Airborne industrial emissions** from nearby factories may damage the vegetation: it is advisable therefore to use evergreen and frugal species with, an abundant foliage;

f. Presence of coarse- or fine-**dust** concentration which damage the plants. It is advisable to increase the irrigation by sprinkling, also to rinse the dust off the leafs;

g. Plant species should be used which are **compatible** with those currently existing in the environment.

3.3 Designing the load-bearing structure

In order to correctly design a green covering it is important to calculate the permanent load on the building. This value is calculated according to the materials that form each layer of the green roof system, taking into account the fact that they may be water-saturated: this analysis is performed in order to the safety of the green roof system. The project data must therefore include the specific weight of each layer or element of the system when fully water-saturated. The load-bearing structure should be calculated in order to withstand the water load required for the system test.

Quite naturally, the more we move away from the optimal growing conditions of a natural species, the greater is the need to provide energy to the system both during its construction and upkeep.

DRAINroof is the right solution for all types of extensive or intensive roof gardens.

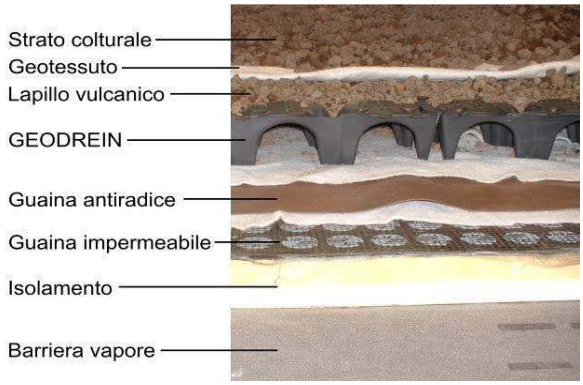


Figura 6 -Stratigrafia tipo

3.4 Designing the thermo-isolating layers

The thermo-isolating layer is not mandatory when designing the green covering with GEODREIN, however its use is recommended. In order to lay the layer in place, locate the load that applies onto the green covering: provide for the deformation rate and reduce thickness according to the decrease in heat resistance. In order to ensure more safety, we recommend designing the thermo-isolating layer considering that the thickness of the sub-soil that must be greater than or equal to 15 cm.

3.5 Designing the sheath as a watertight element

The essential requirement of the sheath is to be fully watertight.
The following considerations must be taken into account:
1 The sealing element must be fully protected from the thermal actions due to solar radiation and the resulting temperature changes (except for the period during the laying procedures);
2 The element, as a precaution, must be considered subject to the action of the roots as well as the chemical biological action of microorganisms.

The sealing coverings that are commonly used are:

1. **1. Bitumen-based membranes:** The latter are normally laid in a double layer to ensure excellent water tightness with local sealing defects. Special attention must be paid to the vertical folds, which can be 15 mm longer than sub-soil layer. If this recommendation cannot be observed, provide draining elements along the folds such as gravel strips **(see figure 7)**. The folds must be fully protected from the “mechanical” action such as maintenance. .

The DRAINroof system provides that bituminous sheath adheres to a rigid support. In this way, leaks are easy to locate, especially when difficult to remove coverings are to be placed.

If the slope of the covering exceeds 5%, the latter must fully adhere by securely fastening the covers in place.

Figure 7 – Gravel strip

2. **Poly-olefin or poly-vinyl chloride based**

membranes: in both case, we recommend following the prescriptions provided for bituminous membranes.

3.6 Designing the root protection barriers

In case that DRAINroof is used to develop a green covering, no special protection should be provided for the root system: DRAINroof already provides for this function. As the DRAINroof element - more than 6 m tall - provides a cavity for the air to prevent the roots from attacking the membrane.
In order to increase the load capacity of the sheath, we recommend two types of protection:

- Mechanical barrier (to be added to the upper protective layer);
- Chemical barrier (an additive is to be mixed to the waterproof mass).

However, special consideration must be given to all details, i.e. the corners, fillers, drains, junctions in order to ensure gap-free continuity of the water-proof layer and adequate root protection system.

3.7 Designing the draining element (lapillus).

The essential requirement of the DRAINroof system is the ability to accumulate and drain the water resulting from irrigation and rain. It is required that all over the covering, above all on the areas where the water load is greater (in particular, along the perimeter edges) where the draining element is provided, i.e. volcanic lapillus. This granular aggregate is highly resistant to compression, is porous and fully responds the recommendations provided. The lapillus, located inside tapered elements and the cavities provided in the DRAINroof system facilitates water drainage and while plenty of water has built up, helps raise water by capillarity.

The choice of the volcanic lapillus has been dictated by the need of having a pervious material that is frost resistant which fully complies with pH values in accordance with UNI EN 13037 standards and that responds fully to electrical conductivity values according to UNI EN 13038.

3.8 Designing the DRAINroof system

The main function of DRAINroof is to store rain water as well as the water deriving from irrigation, giving out the water intake in the periods of need.

The need to accumulate of DRAINroof is dictated by its geometry: the water moves inside the element by diffusion and capillarity thanks to the presence of volcanic lapillus.

The DRAINroof system and volcanic lapillus combine together to ensure that water accumulation is always provided with at least 60% of air passing through the draining element up to the sub-soil layer. In addition between the water surface gap and the filtering layer, there must be at least 30% of the water accumulated with a minimum of 1 cm in order not to cause damage to the root system of the vegetation.

With 6 cm DRAINroof elements, max. water accumulation, in relation to the minimal amount of water required of 30%, can be 4.6 cm with 1.38 cm of air.

3.9 Designing the filter element

With the DRAINroof system, the filter element is made out of “geo-fabric” (TNT = Non-woven material) of 130g/m2 as recommended by current specifications UNI 11235:2007. The material prevents fine particles from seeping through the subsoil layer to the filter element in order to ensure long dependable service over long time. Geo-fabric has permeability 10 times greater than that of the sub-soil layer.

3.10 Designing the anchor elements for the vegetation

Certain areas may be subject to high winds that cause the vegetation to be dislodged with serious problems with the safety of people present.

For this reason, adequate safety measures should be adopted to anchor the vegetation for transitory and permanent periods of time.

For providing the green covering with DRAINroof, in the event that the system needs to be anchored in place, the angle between the bracing and the ground must be greater than 60° if the trunks need to be guyed.

The fastening must take the wind action over the exposed surface under consideration. The wind action must be amplified with a coefficient equal to 1.5. The latter shall be counteracted by the gravity anchors.

3.11 Designing the sub-soil layer

The sub-soil layer made with DRAINroof ensures full control of the agronomic capacity.

The type and the thickness of the vegetation depend on the type of vegetation itself, the use of the characteristics of the covering and the climatic environment.

Seeds, parts of plant, roots or parts of root (rhizomes) cannot be planted in order not to grow undesired vegetation.

The main features of the subsoil layer is the pH kept under control according to the UNI EN 13037 provisions and electrical conductivity in accordance with the parameters established by UNI EN 13038.

4 TYPES OF ROOF GARDENS MADE WITH DRAINROOF

DRAINroof is the optimal solution for all types of roof gardens, which can be divided into EXTENSIVE, LIGHT INTENSIVE and INTENSIVE.
The limit, which normally determines the difference among the three types of garden, is the amount of maintenance required every year - the threshold value is two.

Figure 8 - Example of extensive roof garden on a factory roof

4.1 EXTENSIVE roof garden made with DRAINroof

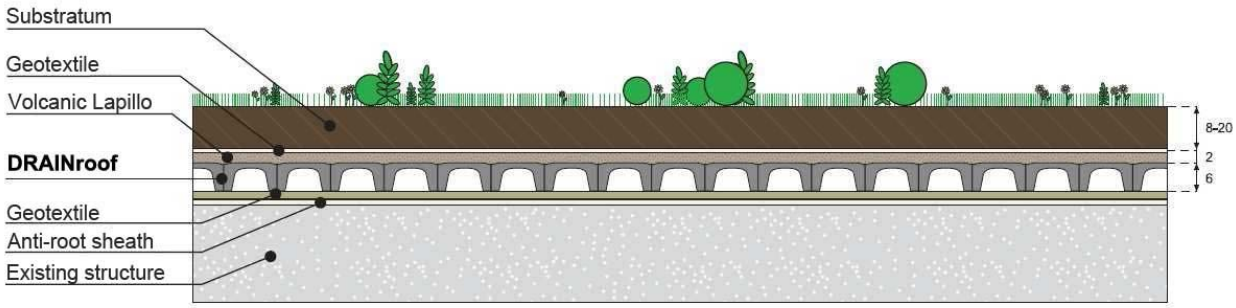


Figura 9 -Sezione tipo pensile ESTENSIVO

4.1.1 Caratteristiche

EXTENSIVE (see photo 9) refers to a roof garden with low energy requirements and little maintenance. Extensive gardens are all the high-pitched green roofs that must be autonomous because they are difficult to get at. We often refer to extensive to indicate a roof garden featuring low stratification and limited vegetation in height. The definition is based on the degree of upkeep required for the selected greenery.
The extensive type of DRAINroof is particularly suited to certain environments such as:

1. Sites where vegetation with reduced stratification are required;
2. Heavily urbanized areas (such as handicraft and industrial sites) where it is necessary to compensate for the presence of green areas.
3. Places where low plants and bushes can be used with low maintenance requirements;
4. Zones to be allocated to the coverings (from 70 to 250 kg/m2);
5. Places to create irrigation systems has been designed only for water shortage emergencies;
6. Places of little use (pitched roofs that can easily reached by the maintenance people) even if footpaths can be provided around the extensive roof gardens.

Thickness of subsoil layer (cm)	Suitable vegetation	Maintenance requirements (h/m2/year)	Drain coefficient	
			Inclination < 15 °	Inclination >15°
8	sedum	< 0.02	0.4	0.5
10	Perennial and low- development weeds	< 0.02	0.4	0.5
15	highly developed perennial weeds, low perennial bushes , low trailer bushes	< 0.02	0.4	0.5
20	Lawns	0.021 – 0.06	0.3	> 0.5

4.1.2 STRATIGRAPHY AND MAINTENANCE REQUIREMENTS FOR ROOF GARDENS MADE WITH GEODREIN IN MILD CLIMATES

An extensive roof garden is “made green” by using DRAINroof. This system needs little maintenance except for the 1st and 2nd year operation resulting in one or two annual treatments aiming at removing undesired, overgrown species and fertilization is not always necessary. In certain cases, when weather conditions permit, irrigation can be avoided

The vegetation used consists of plants that take root quickly, resist frost, dryness and can easily reproduce by themselves.

The species mostly used are those belonging to the Sedum species but other species or associations provide good results and excellent performance. Stratification thickness is reduced (<15 cm), the weight ranges from 75 and 150 kg/m2 under maximum-saturation conditions.

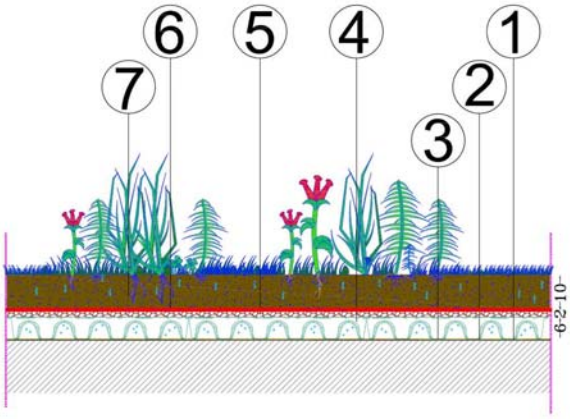
Extensive green are used on large coverings with mild climate and environmentally friendly design.

With Sedum-based surfaces or perennial weeds, the substrate thickness can be reduced up to 8 cm only if weather conditions permit and according to certain rules.

With extensive green, the plants must be selected among species that resist water shortness. The capacity to self-generate the root apparatus favors the formation of stable vegetation over time. It can be advantageous to combine quickly growing but short-lived species with plants that, during the first years, grow up slowly but survive longer. As far as competition and strength of the plants is concerned, these features should be preferred. The local wild plants need consideration as they adapt themselves easily to climate conditions compared to cultivated plants and non-authochtonal species.

Stratification

1) The layers which separate the roof barrier from the water-proof ground slab (e.g. PVC and bitumen) protect from mechanical stress;
2) The roof barrier protects the water-proof slab from eradication;
3) The protective layers provides further protection for the root barrier;
4) The draining layer, made up of loose granular inert material of the volcanic lapillus type increases the development of the root system, accumulates water and nutritive substances while providing an extensive distribution of rain water;
5) The filter cloth prevents the fine particles in the substrate from seeping through the draining layer causing serious problems.
6) DRAINroof features optimal storage capacities for the nutritive substances. The latter help to work out the most appropriate solutions for making your garden completely green while ensuring durability and reduced maintenance costs.
7) The vegetation to be planted again.



Mostly diffused vegetation

Achillea millefolium: widespread in the whole European Continent, Siberia, Himalaya and Italy, this plant is unaffected by dryness and cold weather but fears standing water and excessive humidity. This plant can be infesting and grows in clayish soil, take root in dry prairies, pastureland, uncultivated lands and at the margins of paths and along roads. Flowering takes place from May to October up to 2,000 m altitudes

Allium roseum: widespread over the entire Mediterranean region and Italy where is commonly diffused in Liguria and Romagna up to central southern areas and on the islands The plant grows in the "garighe" sunny slopes, dry uncultivated land at altitudes ranging from 0 to 700 m, in April – May.

Sedum album: This plant is particularly widespread over the mountain areas in hot and mild climates in Europe, Asia, North Africa and North America.

4.1.3 Inclined extensive roof garden

Inclined coverings can be theoretically made green with considerable slopes. Practically, it can be used to operate up to 45° (100% gradient) even if 30% gradient is not normally exceeded (57,7%). Over 10°, you can check the structural features of the overhead retaining beam. When 15° gradient is exceeded, apply the erosion resistant grids before laying the substrate. Over 20°, according to the length of the waterbed, breakwater must be placed to stop and break the avalanche in order not to apply all the weight on the head retainer.
The distance between the lines and the thrust crossbar normally goes from 10 m (at 25°) approx to 8 m at 25° and 5 m (at 30°). The distance is determined by the weight of stratification. When 30° are exceeded, it is advisable to make the area green by using non-slip elements.

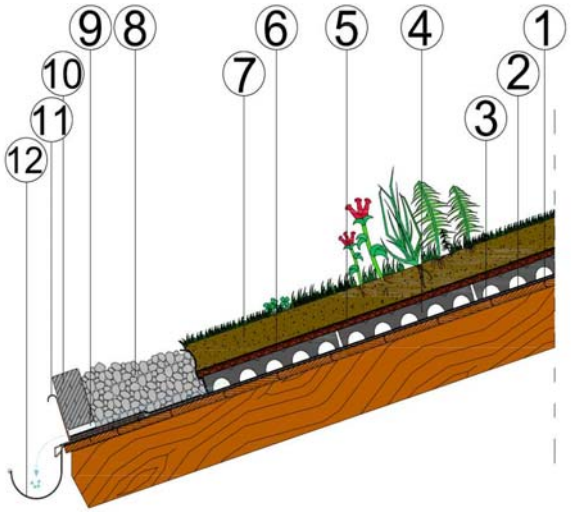


Figura 11 – Inclined extensive roof garden

Vegetation

According to certain features of the roof and the surrounding environment, the following vegetation can be provided:
SEED BEDS: It is essential that the seeds are genetically pure. This feature can be guaranteed by using wild plants such as weeds or certain types of perennial plants. .

WATER SEEDING: A mixture consisting of water, seeds and adhesive agents is sprayed over the substrate. This is particularly recommended for inclined surfaces that need a good protection against the erosion resulting from the action of the rain and wind in conjunction with the adhesion
PLANTING: The more the plants are developed, the less they adapt themselves to the conditions present in a new location. Younger plants should be preferred, even if this means that the effects are not seen in a short time.

4.2 LIGHT INTESIVE roof gardens made with DRAINroof suitable for mild climates

LIGHT INTERSIVE roof gardens, which can be made with DRAINroof, are the most advantageous solutions when you need to have a green area such as a lawn combined with medium-size bushes and by observing the stratification thickness and low weight limits.

The light intensive system allows for green coverings which cannot be classified as “intensive systems” that require reduced cost-effective maintenance work.
The final maintenance depends on the presence of larger or smaller lawns.
The purpose of using the type of roof garden basically relates to the environmental adaptation, compensation and mitigation still prevails over the use. According to the type of vegetation and thickness, the intensive light system is certainly suited to protect biological diversity provided that the creation of ecological paths does not exceed certain levels. Its agronomic capacity permits the product to be laid and sheltered to grow lawns, perennial weeds, herbs and small trailing plants. The system is suitable for intensive vegetation with greater requirements than those needed for making extensive roof gardens green.

A green covering should be designed by applying a number of layers according to the use and the performance required.

The various functional layers are required in such a way that the vegetation planted on the roof can grow and live in a limited substrate without relaying on the intake of nutritive substances if compared to that of the soil.

With the light intensive systems, the draining layer can be created by bringing DRAINroof panels close together.

These elements are lightweight, easy to lay and have good compression resistance. These can also be used to underpin pavements and structural heavy elements, while ensuring accumulation and drainage continuity.

DRAINroof allows roof gardens to be created without damaging the water-roof layers while assuring that good roof gardens can be successfully created. Thanks to the surface provided, great water accumulation and quick drainage of excess water is assured.

The total thickness of the light intensive green system is 25 cm. A 6-cm draining layer and a 19-cm substrate is also provided. The combination fits into the thickness category as provided by UNI specifications suitable for lawn, perennial weeds and small-sized bushes.

The substrate thickness may vary slightly according to the type of vegetation or the need to model the green surface.

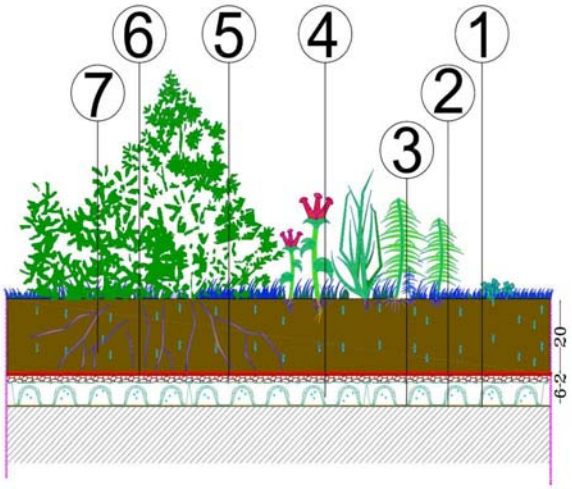


Figura 12 – Stratigrafia intensivo leggero

Irrigation systems

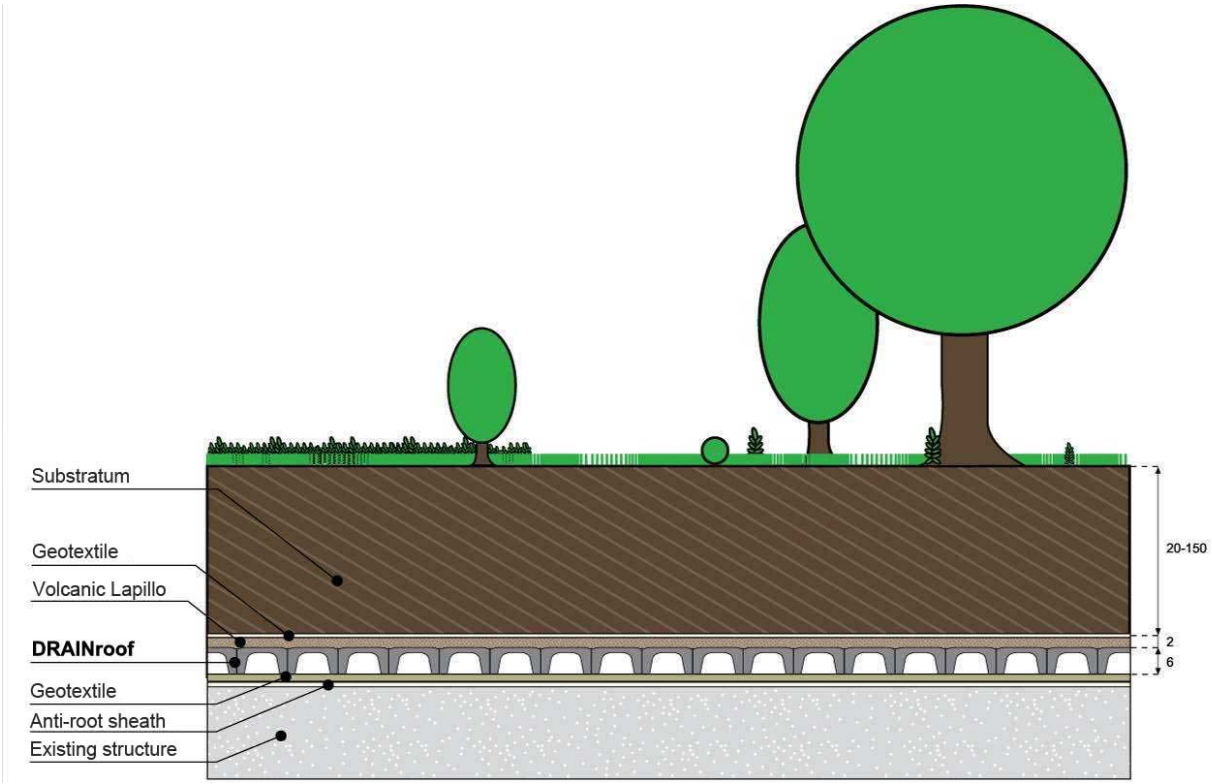
The light intensive system by using DRAINroof can utilize drip irrigation by drawing water from below. This type of irrigation is suited to lawns, flowerbeds, and

bushes with limited growth below the treading path. The distribution water from below for sub-irrigation ensures excellent wind resistance, compatibility with the foul water, no environmental compensation, low laying cost, low maintenance requirements and long-term efficiency and the system provided cannot be dislodged or damaged in any way.

Sub-irrigation systems use a fully underground dripping wing or piping made of exuding geo-fabric The water is uniformly distributed over the entire surface regardless of water “quality”.

4.3 INTENSIVE roof gardens in mild climates

INTENSIVE refers to roof gardens that require maximum energy consumption and high maintenance. Its specific feature is that it can be used in full, i.e. it is exploited as if it were a normal garden.



The green covering involves the typical “roof garden” where use can be extremely important characterized high maintenance work similar to conventional gardens on soil and more or less complex landscaping.
The agronomic capacity allows the development and sheltering of vegetation including lawns, perennial weeds, herbs and large-sized plants.
The small and large sized trees are basically excluded even if their development can be regarded as large bushes. The fields of application are numerous: commercial centers, public and private roof gardens on coverings or underground garage, terraces, balconies, residential housings and school buildings.
Thanks to the vegetal mass and the layers of material used, microclimate and refrigeration benefits can be obtained around the areas and inside the buildings. Otherwise the protection of biological diversity could be limited to the entropic presence and more frequent maintenance work.

Spessore dello strato colturale (cm)	tipo di vegetazione adatta	Manutenzione (h/m2/anno)	Coefficiente di deflusso	
			Inclinazione <15°	Inclinazione e >15°
30	arbusti di grande taglia e piccoli alberi	0.021 – 0.06	0.2	> 0.5
50	alberi di altezza < 10 m	> 0.06	0.1	> 0.5
80	Alberi di altezza tra 10 e 16 m	> 0.06	0.1	> 0.5
> 100	Alberi di altezza > 16 m	> 0.06	0.1	> 0.5

Figure 14 – Esempio di pensile intensivo

The total standard thickness of the system is 35 cm, with a drainage system made of loose inert material such as lapillus 10/12 cm in thickness (approx.) and substrate of approx. 19/23 cm. These parameters are liable to change according to the type of vegetation adopted or the need to model the green surface. Such combination falls within the provisions of UNI 11235 standards dealing with lawns, perennial weeds and bushes.

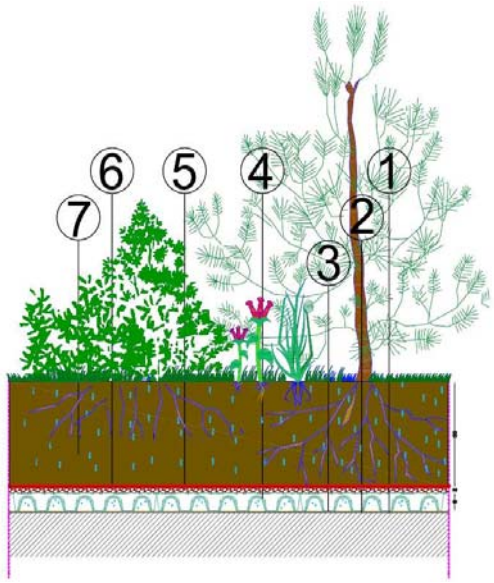


Figura 15 – Intensive green roof stratification

1) DRAINroof separates the root barrier from the waterproof ground slab in case of incompatibility (for instance with PVC and bitumen) and protects from mechanical stress.
2) The root barrier protects from eradication while guaranteeing that the ground slab is fully waterproof.
3) The protective layers serve to provide further protection thanks to the root barrier.
4) The draining layer, including granular inert material, develops the root system, store water and nutritive substances and distributes rainwater extensively.
The filter element prevents the fine particles of the draining layer from seeping through by affecting proper operation. .
6) The brought-in soil has good storage capacities, provides the best solutions for a safe growth of the vegetation and the green areas ensuring long duration and low maintenance costs.

By starting with the intensive roof garden, it is possible to use the sub-irrigation system with waterbed integration. With an intensive roof garden, wide varieties of vegetable species can be used. Tall trees and trailers (for covering walls) trellis and pergola, perennial and decorative plants which may create visual connections. From an esthetical point of view, the latter respond to seasonal changes while maintaining their freshness.
Bulbs can be planted which are appreciated for their use under the zones free of deciduous shrubs that are excellent in lawn and plants that blossom every year or two for obtaining intense esthetical effects thanks to their foliage and rich blossom.
You can play with a wide variety of vegetables providing a number of effects generating accurate compositions over the different layers while providing a protective covering for the soil.

5 STANDARDS

The roof gardens has started developing in Italy approximately twenty years ago especially for embellishing buildings and as an essential tool to relieve the effects of large-scale urbanization with the prime aim of increasing environmental benefits Unfortunately, the projects of roof gardens have been performed in the past without any specific reference standards. Reasons of language, climate conditions and different construction traditions have led to unsatisfactory results from an economic point of view

Finally, in May 2007, UNI (the Italian Organization for Standardization) has published “Instructions for designing, executing, controlling and maintaining green coverings” where the main criteria for creating roof gardens were established. This is an invaluable guide that assists designers in all stages of design, from inspection to maintenance requirements.

The UNI 11235: 2007 standards set out the procedures for the construction of roof gardens with complex stratifications giving special consideration to the modular elements, the agronomic and draining capacity, water storage, aeration and resistance to biological attacks

The standard includes the initial part, which provides the terms and definitions to be used with roof gardens, a part is devoted to the designer and the green composition, and the designer must draw to. Finally, UNI 11235:2007 standards conclude with instructions related to building sites and the construction of covering, the inspections as well as the testing parameters and maintenance procedures required.

UNI aims at guaranteeing maximum safety for the users of the roof gardens, its service life, quality and product safety in order to increase the reputation of roof gardens providing added qualifications for the insiders.

Thanks to precise rules, the standardization of the design and control procedures help facilitate the definition of the specifications thereby making the technical documentation easier to understand

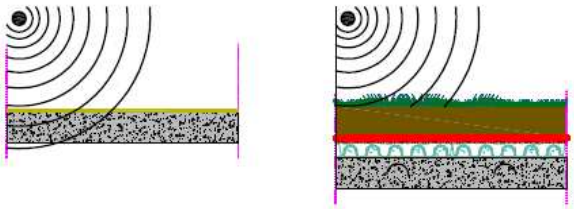
The UNI 11235:2007 standards deals with water-proof layers in the overall system: each project stage takes into account the performance of all the elements used to create the roof garden starting from the substrate. This is an aspect of extreme importance if compared with present standards currently in force in Europe.

6 ADVANTAGES OF A ROOF GARDEN MADE WITH DRAINROOF

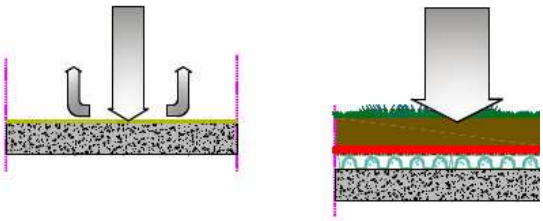
The use of DRAINroof for creating roof gardens offers a number of advantages such as:

- Protection of the **insulation** from **thermal and mechanical stress**, thereby extending the service life of the entire roof.

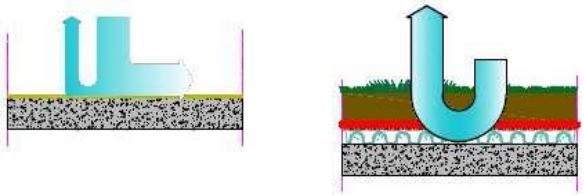
- Reduction of **noise** The noise levels are notably reduced all over the reflecting surfaces depending on the vegetation present, the space provided and in relation to the noise emission source



- Air is cleaned up by removing **dust**: the green covering cuts down on environmental pollution. In fact, the dust load in the air is directly proportional to the foliage. This “cutting-down” effect results from the perspiration-evaporation of the thin vegetation layer. The sprinkling irrigation systems help increase the beneficial effects of dust separation proportionally to the action exerted on the foliage system. The vegetal layer combined with the presence of winds has a soothing effect on dust.



- **Rain water can reused** in its natural cycle as the tapered elements that characterize DRAINroof allows rain and water source to be provided and drained through irrigation;

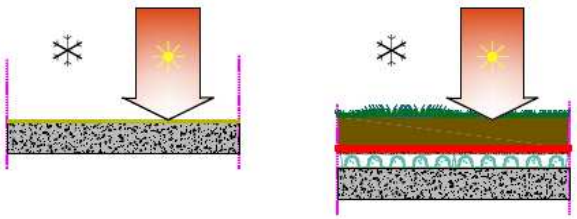


- **The outflow coefficient** is reduced thus helping decrease the amount of water toward the underground disposing system. The effect of retaining rainwater is directly proportional to the thickness of the subsoil layer and the capacity of retention of the actual vegetal mass present.

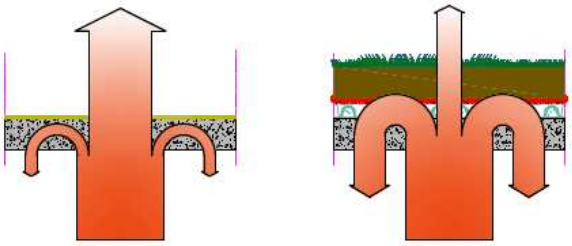
Stratification thickness (S)	Outflow coefficient Ψ	
cm	Covering inclination < 15°	Covering inclination > 15°
8 < S < 15	0.4	0.5
15 < S < 25	0.3	> 0.5 *
25 < S < 50	0.2	> 0.5 *
S > 50	0.1	> 0.5 *

* To be defined individually according to the type of material used as layers and elements

- **Mitigation of the “heat island” phenomena** i.e. the temperature fall by a few centigrade in the urban areas in relation to the countryside, with all the problems connected. With a green covering, the maximum summer temperatures is maintained around 25° C as well as the energy absorbed for the vegetative processes and the reflected radiation decreases which help limit the rise in temperature.

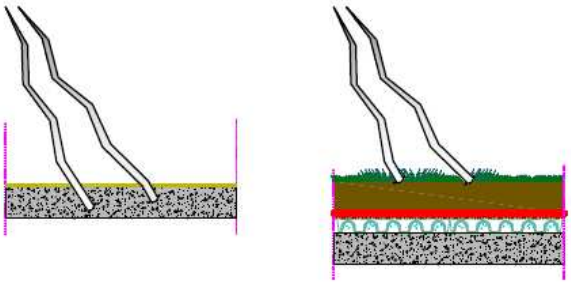


- The green roofs give rise to winds that bring air to the base of the building while sweeping away pollution and refreshing the structural walls.



- New useful environments are created for the animals and the plants around the city.

- **Electro-magnetic pollution** is notably reduced



- Green roofs improve a building's appearance, increasing its **commercial value**

According to all this, the roof garden is no longer a costly embellishment to be created in wealthy houses but can be considered as an improvement to environment conditions. Its execution and use can be numbered among the most advanced techniques of environment protection engineering and can be added to the projects as a valuable tool for determining the Environment Impact Estimation (VIA) as it is optimal tool as a compensation.

7 ADDITIONAL TECHNICAL SPECIFICATIONS

7.1 Rain water collection system

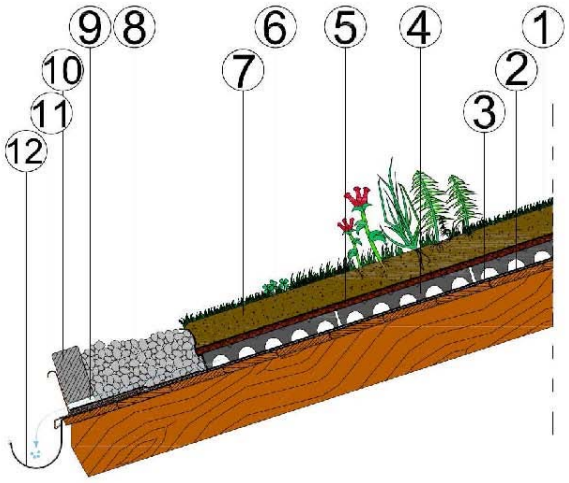
The system for collecting rainwater must be taken into consideration at the design stage.
We suggest dimensioning the rainwater-collecting network without considering the effects linked to water inertia of the covering in view of exceptional events or removal of the vegetation in the past. Each element that forms the rainwater collection system must be easily accessible.
In fact, in accordance with current standards, the fillers must be suitably dimensioned so that they can be held in special gullies and be accessible from the outside without having to handle the elements or the layers. The gullies should be provided with side openings and filters in order to normally control the water flow to the covering.

7.2 Inclined coverings

If a green covering is to be performed with DRAINroof on inclined surfaces, the following considerations are required:

- With inclined surfaces from 10° to -15, check the site for the structural dimension of the perimeter-retaining element in order to avoid dislodgement due to applied loads;
- With inclined surfaces from 15° to -20°, lay non-woven fabrics on the subsoil layer.
- With inclined surfaces greater than 20°, take care to lay crosswise elements to the bed in order to subdivide the thrusting force resulting from the upper elements and the layers.
  The crosswise elements must be provided with openings to permit water passage. Use extreme caution to single element slipping from every single layer from the load-bearing structure as well as other layers (it is possible to turn the percent gradient into inclination degrees of the perspective diagram provided by current standard UNI 11235:2007.

With extensive coverings, in particular in perimeter zones exposed to the depression created by the winds, inert ballast material should be provided (minimal 50 cm in width) Emerging bodies (parameter folds, supports and skylights) can be positioned near service and protection areas at least 50 cm in width. In any case, the material must not be placed above the subsoil layer but above the draining or protection layer. If gravel is used, the latter must be thoroughly washed and dressed.



7.3 Technical details: angles and similar items

The distinctive features of these architectonical details that requires the same care as that given to the waterproof layer. In addition to the angular link, a reinforcement membrane and waterproof canvas must be provided. In fact, the latter must go up to the back-frame below the fixture.

7.4 Ambient conditions for laying the roof gardens

Unfavorable ambient conditions (rain, slow, dew, frost, high and low temperatures) can result in difficult and poor execution of the roof garden.

7.5 Designing the irrigation system

To provide the roof garden with irrigation systems, keep to the techniques recommended for the conventional gardens.

For designing green coverings with DRAINroof, find out the basic requirements according to the vegetation and the dimensions of the different type of irrigation systems required. The main systems adopted so far are listed below:

- Rain irrigation from above or by sprinkling;

- Drip irrigation of the ground;

- Sub-irrigation from below (specific project details are needed to be examined according to the water selected storage systems).

7.6 Manteinance of green systems

The coverings are classified as outlined below:

- Class 1: low maintenance requirement (**extensive**)
- Class 2: medium maintenance requirement (**light intensive**)
- Class 3: high maintenance requirement (**intensive**)

The covering is classified according to the maintenance requirements.

Classi	**Irrigazione**	**Manutenzione**	**M/C**
	m 3/m2	Mdo h/m2/anno	%
1	Solo di soccorso	< 0.02	M/C < 1
2	Prevista	0.021 – 0.06	1 < M/C ≤ 5
3	prevista	> 0.06	M/C > 5

Legend
M = Total annual cost to be borne for routine maintenance
C = Cost to be borne for constructing the green covering excluded the logistic expenses
Mdo = Manpower

The maintenance of the covering must be defined at the design stage as it determined the operating costs and relates to environmental and economic sustainability of the system.

There following maintenance levels are provided:

1 *Low maintenance:* (extensive system) maintenance work is limited to the control of the system elements. As regards the vegetation layer, check the python-sanitary and physiological state of the vegetation, the presence of parasites, which may limit the functionality, as well as the presence of infesting agents.
As far as irrigation is concerned, maintenance can be done occasionally in order not to cause water problems under extra-ordinary conditions.

2 *Medium and high maintenance:* (light intensive system and intensive system) Maintenance work includes the controls of the vegetal layer and the irrigation system as for the extensive system but the agronomic activities should be also included as they are required for the control of green areas.

8 TESTING

The testing procedures, performed to assess the functioning of the green covering with DRAINroof, must ensure that building and agronomic operations fully observe the project recommendations: Such as:

- Control of the support layer in the sealing element
- Final control of water tightness done at the end of work related to the green covering before laying vegetation in place.
- Control of stratification and of auxiliary systems (water and electrical systems).
- Control of green works to be made within a year when they have been completed.

If the covering is to be seen over prolonged periods of time and a lot of people have to tread on it, water tightness should be checked before laying the layers or elements in place on the sealing element.

The green works must be checked at the end of 12 months after laying the vegetal species.
The check procedures should be done on square zones (1 m x 1 m) located in the areas indicated by the inspectors or the work management.

The UNI standards provides for all types of vegetation (perennial weeds, sedum, pre-cultivated mats of perennial weeds, seeded or rolled lawn turfs or pots) the control shall be made according to the measurements taken from the horizontal projection of the epigeous part of vegetal species. The results are positive if all the samples examined have the percentages as well as the presence of infesting agents.

9 MAINTENANCE

Maintenance is divided into three types:

- Green-work maintenance:

  a. Starting maintenance should be checked;

  b Starting maintenance work in case of extensive roof garden;

  c. Routine and extraordinary maintenance in the case of adverse conditions.

  “Routine maintenance” refers to maintaining over time the type of green provided by agronomic treatments.

The agronomic treatments include irrigation, manuring, mowing, containing as well as esthetic pruning and finally sanitary treatments;

- Servicing the draining system (check the build-up and the water supply system drainage);
- Maintenance of the rain water disposal and tightness system (annually before the winter season, inspect the filler to prevent clogging).

10 TESTING CERTIFICATES

TECHNOPROVE Srl

Prove di laboratorio e in sito - servizi per l'industria delle costruzioni - Laboratorio geotecnico e chimico

Viale dell'Industria 22 - 36100 VICENZA
Tel. 0444 966121 - Fax 0444 966129 - Email: techno@technoprove.it - Internet: www.technoprove.it
Cod. fisc. 04636880288 - Part. IVA 01869270245

Laboratorio autorizzato dal Min. LL.PP. - L. 1086/71 - Autorizzato dal Min. Università e Ricerca Scient. e Tecnol. - L. 46/82
Socio UNI - Membro ASTM - Sportello Tecnologico SITEB - Associato AICQ e ALPI

Vicenza, 13/05/05

Certificato n° 175/5/02

Richiedente: GEOPLAST srl
Via Martiri della Libertà, 6/8 – 35010 Grantorto (PD)

Indicazioni del Richiedente:
Geodren

Prova: **PROVA DI COMPRESSIONE SU IMPRONTA 30 x 30 CM**

Norma: Modalità concordate con il Richiedente.

Materiale: N° 2 campioni di altezza 6 cm in materiale plastico.
Data di accettaz.: 03/05/05.
Data di prova: 05/05/05.
Attrezzatura:
- Telaio di carico con cilindro di spinta Enerpac;
- pompa Enerpac P-462, pressione massima: 700 bar;
- trasduttore di pressione Wika tipo 891.23.510, campo 0 – 1000 bar;
- trasduttore di spostamento potenziometrico Penny-Giles HLP 190/FS1, corsa massima: 50 mm, linearità: 0.2%
- unità di acquisizione Telea.

Risultati:

Provino	Dimensioni in pianta cm	Carico massimo raggiunto daN	Carico massimo unitario raggiunto kN/m²
B1	50 x 50	**2480**	276
B2	50 x 50	**2443**	271

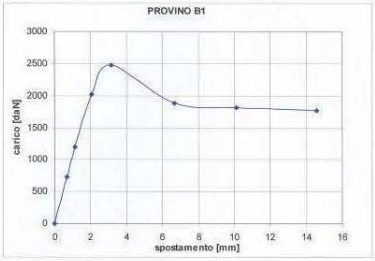
Note: Il carico è stato applicato su un'impronta di dimensioni 30x30 cm.
Il carico massimo unitario è dato dal rapporto tra carico massimo raggiunto e l'area dell'impronta.

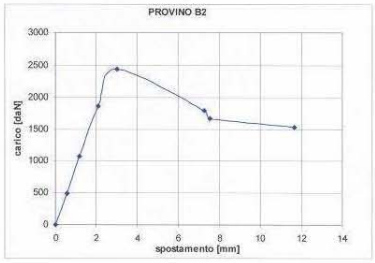
Lo Sperimentatore
Ignazio Sardu

Il Responsabile
Dott. Ing. Alfio Vigilante

TECHNOPROVE Srl
Prove di laboratorio e in sito - servizi per l'industria delle costruzioni - Laboratorio geotecnico e chimico
Viale dell'Industria 22 - 36100 VICENZA
Tel. 0444 966121 - Fax 0444 966129 - Email: techno@technoprove.it - Internet: www.technoprove.it
Laboratorio autorizzato dal Min. LL.PP. - L. 1086/71 - Autorizzato dal Min. Università e Ricerca Scient. e Tecnol. - L. 46/82
Socio UNI - Membro ASTM - Sportello Tecnologico SITEB - Associato AICQ e ALPI

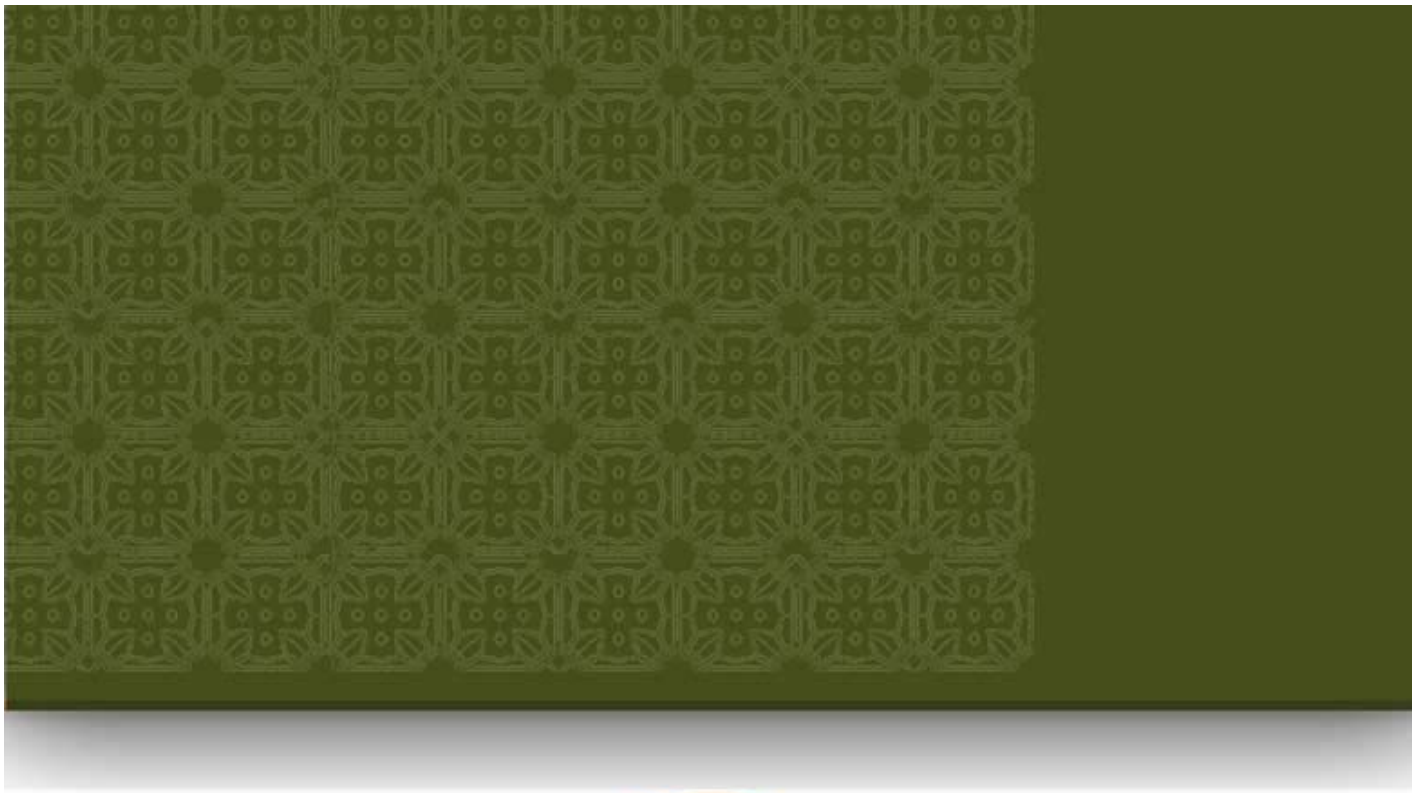
Diagrammi carico – spostamento:





TECHNOPROVE Srl
Prove di laboratorio e in sito - servizi per l'industria delle costruzioni - Laboratorio geotecnico e chimico
Viale dell'Industria 22 - 36100 VICENZA
Tel. 0444 966121 - Fax 0444 966129 - Email: techno@technoprove.it - Internet: www.technoprove.it
Laboratorio autorizzato dal Min. LL.PP. - L. 1086/71 - Autorizzato dal Min. Università e Ricerca Scient. e Tecnol. - L. 46/82
Socio UNI - Membro ASTM - Sportello Tecnologico SITEB - Associato AICQ e ALPI

Documentazione fotografica:



GEOPLAST S.p.A.
35010 Grantorto PD - Italia - Via Martiri della Libertà, 6/8
tel +39 049 9490289 - fax +39 049 9494028
e-mail: geoplast@geoplast.it - www.geoplast.it

Rev. 000