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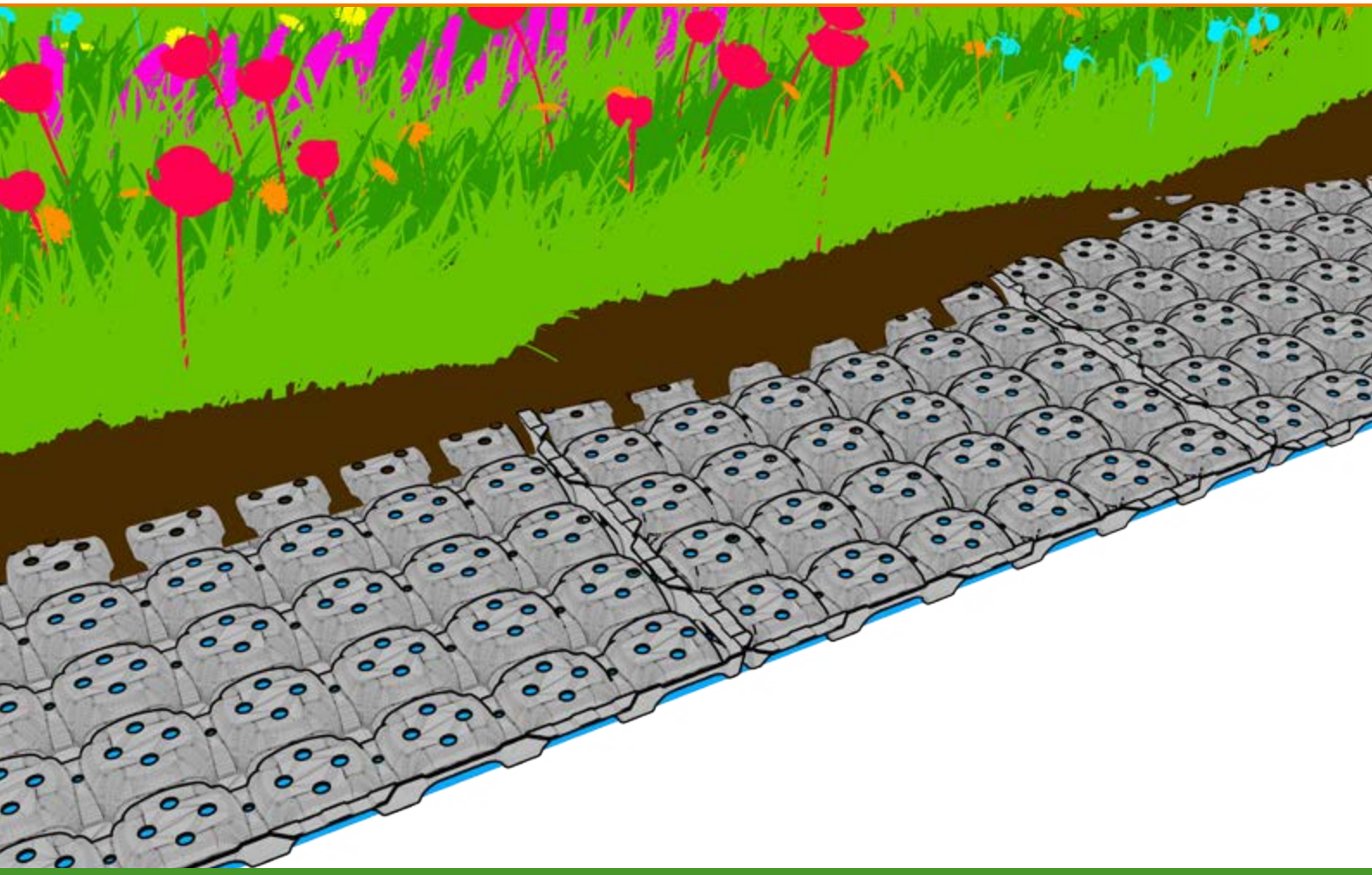
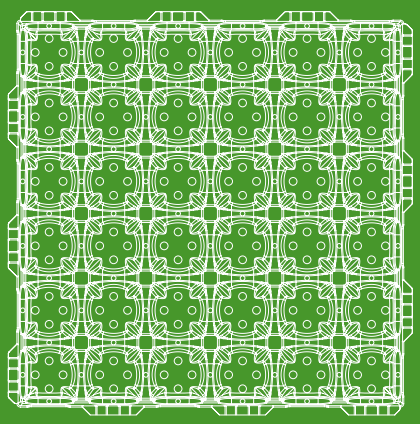


DRAINROOF TECHNICAL MANUAL

HIGH-PERFORMANCE GREEN ROOF DRAINAGE BOARD



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INDEX

DRAINROOF TECHNICAL MANUAL

1. **Introduction** P. 5
1.1 **Generalities**
1.2 **Use of the product**
1.3 **Functionality**
1.3.1 Protection of the covering
1.3.2 Rainwater accumulation
1.3.3 Rainwater drainage
1.3.4 Reduction of the outflow coefficient
1.4 **Elements** P. 6
1.4.1 DRAINROOF h6
1.4.2 DRAINROOF h2,5

2. **Material and manufacturing** P. 7
2.1 **Material**
2.2 **Manufacturing process**

3. **Technical characteristics** P. 8
3.1 **DRAINROOF h2,5**
3.2 **DRAINROOF h6**
3.3 **installation method**
3.4 **Safety measures**

4. **Transport and storage** P. 10

5. **Design instructions** P. 11
5.1 **Context analysis**
5.2 **Design of the supporting element**
5.3 **Thermal insulation layer**
5.4 **Sealing sheath**
5.5 **Rootproof barrier**
5.6 **Rainwater accumulation and drainage**
5.7 **Design of the vegetation anchoring element**
5.8 **Cultivation layer**

6. POSSIBLE TYPES OF GREEN ROOFS ACHIEVABLE WITH DRAINROOF P. 14
6.1 EXTENSIVE or INTENSIVE roof gardens with DRAINROOF
6.1.1 Characteristics
6.1.2 Stratigraphy and manteinance of an extensive green roof with DRAINROOF with temperate climates
6.1.3 Inclined extensive roof garden
6.2 LIGHT INTENSIVE roof garden with DRAINROOF for temperate climates
6.3 INTENSIVE roof garden for temperate climates
7. Plants P. 20
7.1 Plants suitable for extensive roof gardens
7.2 Plants suitable for intesive roof gardens
8. Additional technical specifications P. 21
8.1 Rainwater accumulation systems
8.2 Inclined roofs
8.3 Technical details: angles or similar
8.4 Environmental laying conditions
8.5 Irrigation system project
8.6 Green system maintenance
9. Testing P. 24
10. Maintenance P. 24
APPENDIXES
APPENDIX A – MATERIAL SAFETY DATA P. 26
APPENDIX B – STANDARD LEGISLATION P. 28
APPENDIX C – TEST CERTIFICATES P. 29

TECHNICAL DATA

1.INTRODUCTION

1.1 GENERALITIES

DRAINROOF is a moulded panel in PP, studied for the construction of green roofs and green coverings. The element is installed on the waterproofing membrane of the slab and acts as a rainwater drainage and accumulation system.

1.2 USE OF THE PRODUCT

DRAINROOF is used for the creation of the following systems:

- Extensive roof gardens
- Intensive roof gardens

For the above solutions, DRAINROOF guarantees:

- Element storage and drainage capacity;
- Ventilation of the the cultivation layer;
- Resistance to biological attacks.

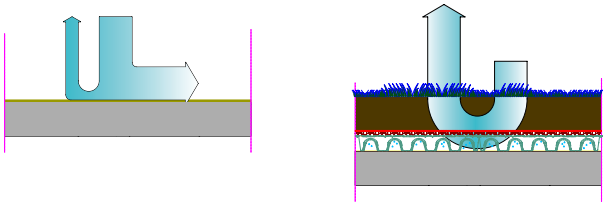
1.3 FUNCTIONALITY

1.3.1 – PROTECTION OF THE COVERINGS

DRAINROOF ensures the protection of the covering insulation system from thermal and mechcanical stresses, thus extending the lifetime of the entire roof structure and keeping it ventilated. The presence of the rounded feet guarantees the safeguard of the sheath from possible engravings.

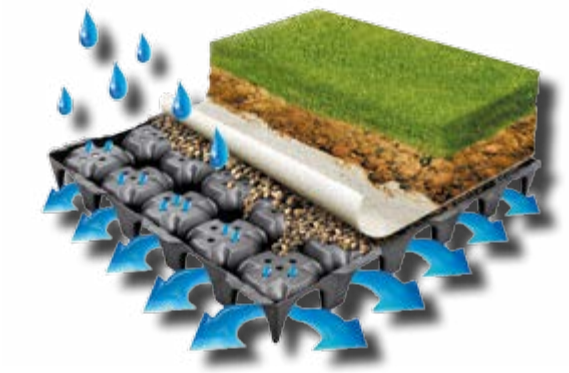
1.3.2 RAINWATER ACCUMULATION

DRAINROOF cones allow the accumulation of rainwater in excess, guaranteeing a water reserve for the cultivation substrate. The collected water is then reused by the vegetation and returned to its natural cycle.



1.3.3 RAINWATER DRAINAGE

The perforated surface of DRAINROOF allows the optimal drainage of rainwater.



1.3.4 REDUCTION OF THE OUTFLOW COEFFICIENT

DRAINROOF allows the reduction of the outflow coefficient, helping also to reduce the amount of water channelled to ground disposal systems. The effect of stormwater retention is directly proportional to the thickness of the cultivation layer, its retention capacity and the present plant mass.

Thickness of the cultivation layer (cm)	Vegetation type	Outflow coefficient	
		Covering inclination < 15°	Covering inclination > 15°
8 < S < 15	Sedum, green surfaces	0.4	0.5
15 < S < 25	Green surfaces, large trees	0.3	> 0.5 *
25 < S < 50	Small trees with height <10m	0.2	> 0.5 *
S > 50	Tress with height > 10m	0.1	> 0.5 *

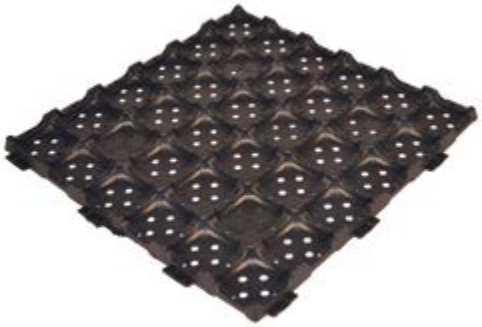
1.4 ELEMENTS

1.4.1 DRAINROOF H6

Drainroof is a polypropylene element for rainwater drainage and accumulation in roof gardens. The panel is 50x50 cm and 6 cm high.

1.4.2 DRAINROOF H 2,5

Drainroof is a polypropylene element for rainwater drainage and accumulation in roof gardens. The panel is 50x50 cm and 2,5 cm high.



2. MATERIAL AND MANUFACTURING

2.1 MATERIAL

Drainroof is made of 100% regenerated polypropylene (PP). The material is chemically inert and does not release substances into the environment. The material does not release substances into the stored water. It may suffer from prolonged exposure to UV rays. Material properties are shown in the table below.

CHARACTERIS-TICS	METHOD	U.D.M.	VALUE
MFI (190°C / 2,16 kg)	ASTM-D-1238	g/10'	5±1
Izod resistance	ASTM-D-256	J/m	70-90
Elastic flexural modulus	ASTM-D-790	MPa	1200 - 1300
Settling temp b/50n	ASTM-D-1525	°C	70-80
Density	ASTM-D-792	g/cm^3	0,89-0,92

Information about the materials safety use is provided in Appendix A.

Figure 5 - Regenerated polypropylene granules

2.2 MANUFACTURING PROCESS

DRAINROOF is manufactured by injection moulding at the Geoplast plant in Grantorto (PD), Italy.
Geoplast Spa is a company with UNI EN ISO 9001:2000 quality certification.

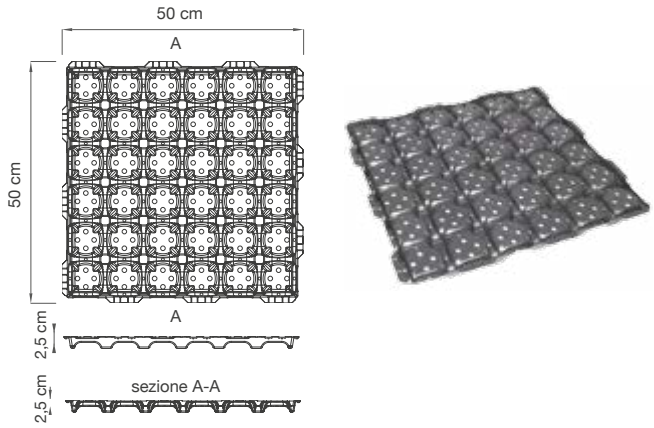
Figure 6 - Geoplast Spa Headquarters

3. TECHNICAL DATA

3.1 DRAINROOF H 2,5

Technical data of Drainroof H2,5 are reported in the table and in the dimensional drawings (Figure 1). The product is black.

Product code	FDRAIN5002
Dimensions	50x50xH2,5
Weight	2,39 kg/m²
Draining surface	547 cm²/m²
Outflow volume	17,2 l/m²
Compressive strength	3,2 t/m²
Water reserve (at level)	6 l/m²
Material	PP 100% regenerated Chemically inert
Color	Black



Figur 7 - Dimensional drawings h2,5

3.2 DRAINROOF H6

Technical data of Drainroof H6 are reported in the table and in the dimensional drawings (Figure 2). The product is black.

Product code	FDRAINR5006
Dimensions	50x50xH6
Weight	4 kg/m²
Draining surface	318 cm²/m²
Outflow volume	40 l/m²
Compressive strength	6 t/m²
Water reserve (at level)	12 l/m²
Material	PP 100% regenerated Chemically inert
Color	Black

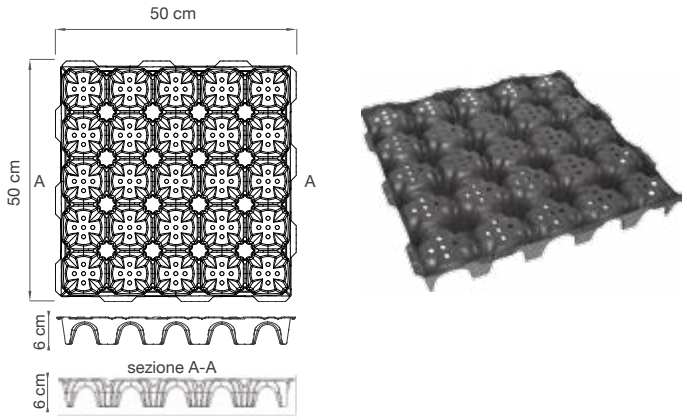


Figure 8 - Dimensional drawings h6

3.3 INSTALLATION METHOD

The article is equipped with a double action coupling between the elements (see Figure 3), i. e. the interlocking between the supports takes place thanks to the overlap between the tab present in the edge of one element and the complementary void of the other.

Figura 9 - Coupling

DRAINROOF can be safely and securely installed even on inclined and curved surfaces.

3.4 SAFETY MEASURES

The product must be installed manually. The installation can be carried out by a single operator because the weight of the elements is less than the maximum liftable weight in optimal conditions (ISO 11228).
When handling Drainroof elements, attention should be paid to the following risks:

- Risk of crushing during the mechanical handling of material pallets;
- Risk of crushing during break-up operations;
- Risk of elements detachment from an inclined roof, if not properly fixed;
- Risk of falling during installation, especially at heights that require means or tools for the operator lifting.

Figure 10 - Installation on curve surfaces

Figure 12 - Drainroof Installation

Figure 11 - Drainroof, on-site installation

4. TRANSPORT AND STORAGE

DRAINROOF is stored and transported in pallets; the characteristics of the packaging are as follows:

	DIMENSIONS cm	ELEMENTS n°	SURFACE m²
DRAINROOF H 2,5	105 x 120 x H=230	1440	360
DRAINROOF H 6	105 x 120 x H=240	720	180

For the load and handling of the pallets it is possible to use mechanical means like forks, or cranes provided with lifting straps. For a roper storage, it is recommended to choose stable surface, as regular as possible; The product needs to remain protected from contact with fuels, lubricants, chemicals or acids. Once the elements are removed from the pallet, the following operations must be avoided:

- Improper storage (superimposition of pallets, stacking of elements in bulk,…);
- Improper handling (throwing the elements, dragging them,…);
- Contact or impact with blunt or sharp bodies (stones, blades,....)

IMPORTANT: Before installation, it must be checked that the elements are not damaged or defective (the characteristics described in paragraphs 3.1 and 3.2 must be observed). Avoid installation if there is any damage or defect in the product.

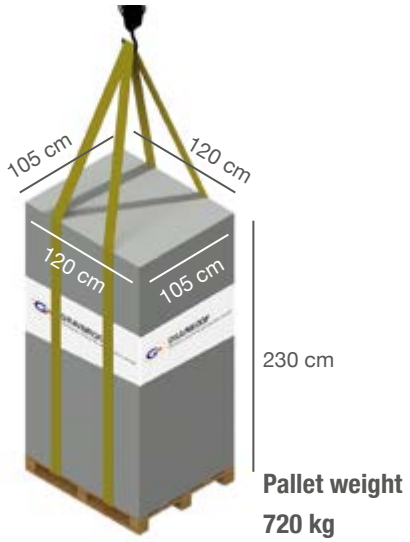


Figure 13 - Handling in the worksite

Figure 14 - Drainroof pallet and packaging

5. DESIGN INSTRUCTIONS

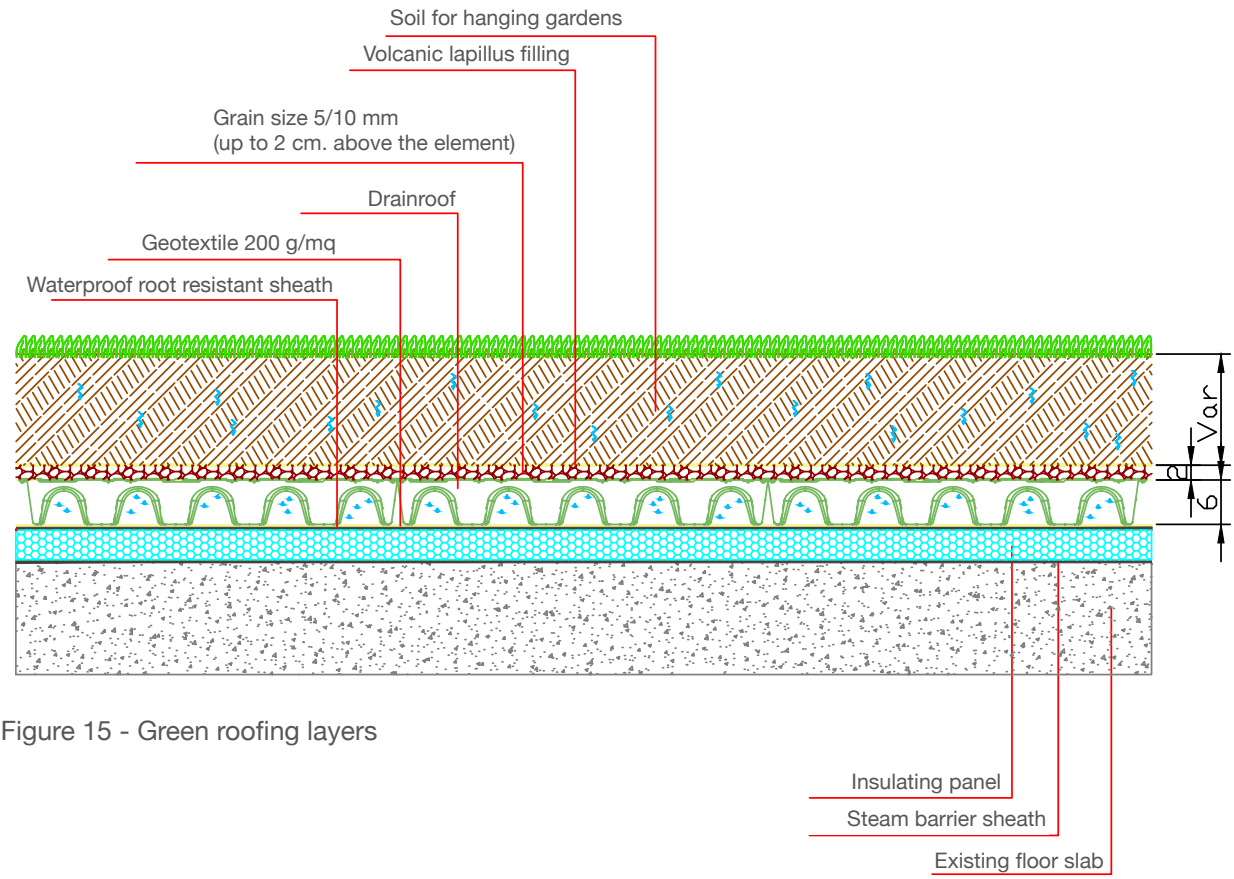


Figure 15 - Green roofing layers

5.1 CONTEXT ANALYSIS

Analyzing the context allows to identify the variables that can influence the type of vegetation to choose. Choosing one plant species rather than another is the result of an analysis of site characteristics such as rainfalls, humidity, solar radiation through the light and thermal effect, wind exposure and general atmospheric conditions, all of which are necessary for proper design and should be evaluated over a return time of 20 years.
It should therefore be checked in detail:

- **a** Solar exposure with particular attention to the presence of possible contiguous reflective surfaces which can cause variations in the radiation of plant species;
- **b** Winds, which can produce strong stresses on the plant species, and therefore the characteristics of the canopy, their height, their ability to anchor the roots, the stem elasticity and branches must be evaluated
- **c** Snow loads, which can produce stresses on plants and roofing;
- **d** Exposure to saltiness, that can cause a fast degradation of the plants, which must therefore have a strong resistance both on their leaves surface and in their cultivation layer.
- **e** Emissions of air or fumes from nearby plants can cause deterioration of plant species, so it is necessary to think about the use of evergreen, frugal typologies, with consistent foliage;
- **f** Presence of coarse or fine dust concentrations that facilitate the deterioration of the plants: an increase of the system's biomass should be evaluated
- **g** Increase the prinkler irrigation and the leaves washing;
- **e** Plant species compatible with those already present in the context, must be included.

5.2 DESIGN OF THE SUPPORTING ELEMENT

This load shall be assessed in relation to the materials that form the individual layers and elements which can be completely saturated with water. This analysis shall be carried out to guarantee the coverage security.

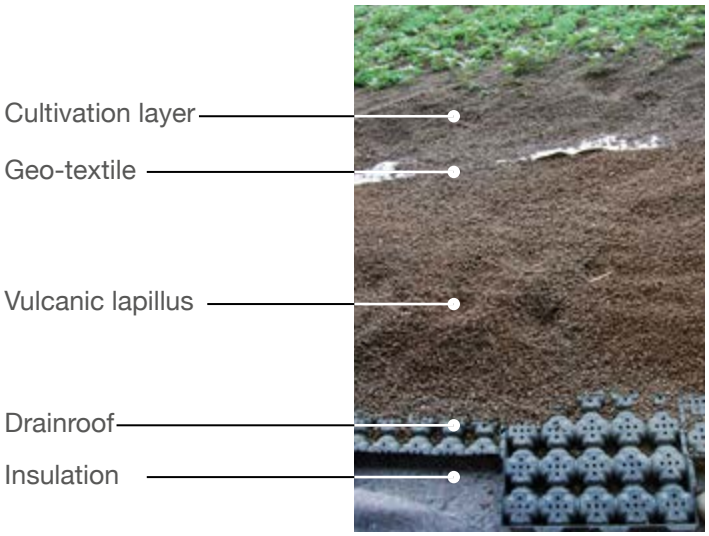


Figure 16 - Example of stratigraphy

5.3 THERMAL-INSULATION LAYER

The thermal insulation layer is not required when designing a green roof with DRAINROOF, but its use is recommended. In order to install the layer, it is necessary to correctly identify the load on the green roof. Moreover, in order to enure safety, it is recommended todesign the thermal-insulation layer taking into consideration the thickness of the cultivation layer, which needs to be higher or equal to 15 cm.

Figure 17 - Thermal-insulation layer

5.4 SEALING SHEATH

The basic requirement for the sheath is that it is watertight. The following characteristics must be taken into account:

1. The sealing element shall be protected against thermal actions due to sunlight and the resulting temperature change (excluding the period during which installation takes place);
2. The element, for precautionary purposes, must be considered as subject to roots action, chemical, biological and micro-organisms actions.

The most widely used types of sealing elements are:

1. Bituminous membranes: the application of these membranes must be carried out in two layers to guarantee the water resistance to any local welding defects. Particular attention should be paid to the vertical folds, which must reach a height of at least 15 cm higher than the cultivation layer. If it is not possible to comply with this prescriptions, additional draining elements should be provided along the folds, like gravel corridors (see figure 6). The folds need to be protected because they could degradate due to mechanical actions, like the maintenance. DRAINROOF system provides a rigid support of the bituminous membrane, in total adhesion. In this way, it is easier to identify any leakage especially with coverings which are difficult to remove. If, on the contrary, the inclination is higher than the 5%, the total adhesion, integrated with the mechanical fixing of the textiles, is recommended.

Figure 18 - Gravel corridor

2. Polyolefin membranes and polyvinyl chloride membranes: In both cases, it is recommended to follow the requirements for bitumen membranes.

5.5 ROOT-PROOF BARRIER

In order to increase the load-bearing capacity of the sheath, it is reommended to use the following types of protection:

- Mechanical barrier (adding an upper layer of protection);
- Chemical barrier (an additive is mixed to the waterproofing mass).

In all cases, special care must be taken for the details, i. e. corners, conduits, drains and joints, in order to obtain the perfect continuity of the waterproof covering and therefore of the root barrier.

Figure 19 - Root-proof barrier

5.6 RAINWATER DRAINAGE AND ACCUMULATION

DRAINROOF main function is to accumulate the water of rainfalls and irrigations, in order to subsequently release it in case of long periods of drought. Through the combination of DRAINROOF and the volcanic lapillus, a 60% of air is always present in the water accumulation system, this air is free to flow from the draining element to the cultivation layer. It is recommended the use of a geo-textile (TNT = non- vowen fabric) of 150g/m2 which can guarantee, as required in the regulation UNI 11235:2007, the passage of the fine particles from the cultivation layer to the filtration element, in order to keep intact over time the system's functionality.

Figure 20 - Combined use of Drainroof and the volcanic lapillus

5.7 DESIGN OF THE VEGETATION ANCHORING ELEMENT

Some areas may be subjected to high-intensity winds and this can cause the movement of the vegetation with consequences also to people safety. For this reason it is necessary to adopt anchoring measures for the vegetation, designed both for temporary and permanent periods. In case of anchoring of DRAINROOF, it would be usefull that the angle between bracing and the ground is higher than 60°, especially if shaft anchorage systems are used. The anchoring design needs to take into consideration the wind action on the surface, considering the plant species: the wind action, carefully amplified with a coefficient equal to 1.5, must be counterbalanced with a gravity anchor element.

5.6 CULTIVATION LAYER

The choice of the type and of the thickness of the layer depends on the type of vegetation, the intended use, the characteristics of the covering and the climate. It is not possible to plant seeds, plants parts or roots parts (rhizomes) which can possibly generate unwanted vegetation. The main characteristics required for the cultivation layer, in order to guarantee the correct functionality, are pH under control according to UNI EN 13037 and electrical conductivity is aligned with the parameters set by UNI EN 13038.

Figure 21 - Cultivation layer

6. EXTENSIVE ROOF GARDEN WITH DRAINROOF

DRAINROOF is the ideal solution for all types of roof gardens, which can be divided into EXTENSIVE, LIGHT INTENSIVE and INTENSIVE. The limit that conventionally determines, from a regulatory point of view, the difference between the three types, is the number of maintenance operations per year, whose threshold value is two per year.

Figure 22 -Example of extensive roof garden on an industrial building

An EXTENSIVE roof garden (see figure 8) is a garden that uses a minimal amount of energy both with the installation and with the manteinance; Generally, all green roofs with an high inclination are extensive. This happens, because of their hard accessibility, they need to be as independent as possible. At the bottom of the definition we have the green manteinance grade. The extensive green roof with Drainroof is particularly suitable for specific types of environments, such as:

1. Sites where vegetation with reduced stratigraphies is required;
2. Strongly urbanized areas (e. g. industrial and craft areas) where it is necessary to compensate the strong cementification with the presence of “green”;
3. In sites where it is possible to use herbs or small plants, with a low grounding and manteinance;
4. Zones where you do not want to burden on the covering (from 70 to 250 kg/m2);
5. Locations where the construction of an irrigation system is designed only for emergencies of water shortage;
6. Places that are not very accessible (roofs that are inclined and can only be used by who will take care of maintenanance), even if it is possible to create pedestrian paths around the extensive roof garden.

6.1 ROOF GARDEN

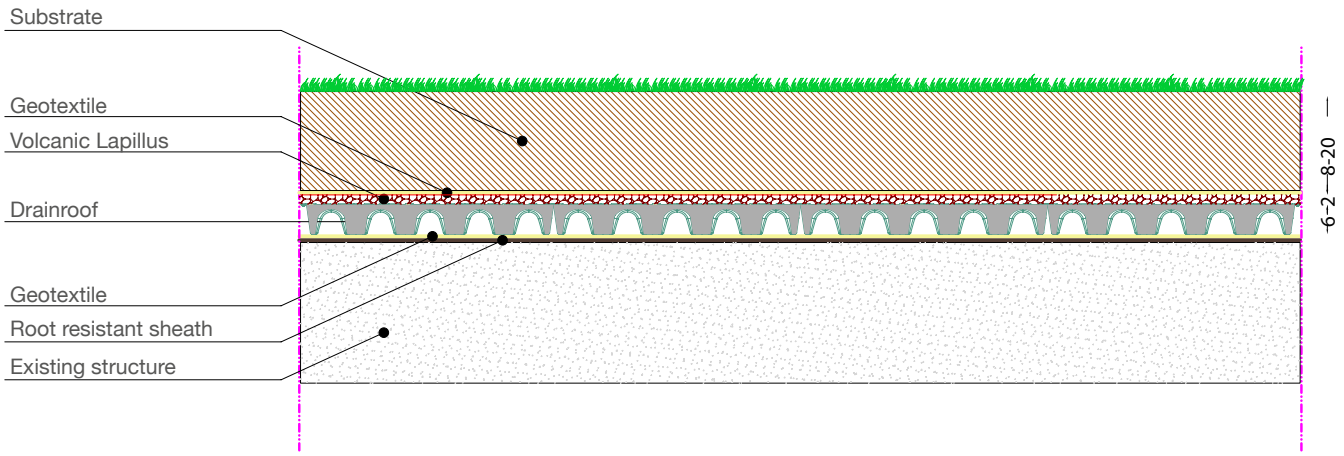


Figure 19 - Typical section of an EXTENSIVE roof garden

Cultivation layer thickness (cm)	Suitable type of vegetation	Manteinance (h/m²/anno)	Outflow coefficient	
			Incli-nation <15°	Incli-nation >15°
8	Sedum	< 0.02	0.4	0.5
10	Perennial small development grass	< 0.02	0.4	0.5
15	Large herbaceous perennials, small groundcover shrubs	< 0.02	0.4	0.5
20	Grass surfaces	0.021 – 0.06	0.3	> 0.5

6.1.2 STRATIGRAPHY AND MANTEINANCE FOR EXTENSIVE ROOF GARDENS IN TEMPERATE CLIMATES

Extensive green roofs with DRAINROOF, after the first or second year of operation of the plants, require:

- Reduced maintenance results in one or two operations per year, mainly aimed at removing unwanted or oversized species and fertilizing, which is not always necessary;
- In some cases, when it is permitted bt the climatic conditions, irrigation can be avoided.

The vegetation used is made up of plants characterized by fast rooting and covering, resistance to drought and frost and good self-healing capacity. The most commonly used species are those belonging to the genus Sedum, but many other species and associations can provide excellent, if not better, performance. The thickness of the startifications is reduced (< 15 cm), the weight is between 75 and 150 kg/sqm under conditions of maximum water saturation. Extensive greening is particularly used on large, environmentally friendly coverings with ecological value. In the case of Sedum surfaces, or particularly rustic perennial herbaceous surfaces, the thickness of the substrate can be reduced to 8 cm, but only if climatic conditions permit it and always in accordance with the norm. For extensive green roofs, the plants choice must fall on plants that:

- Able to resist to long period of droughts.
- A high self-healing capacity, especially in the root system, facilitates the formation of stable plant associations over time.

The combination of fast-growing, but not very long-lived species may be advantageous, with species that are slower to grow in the early years but survive longer. With regard to the competivity and robustness of the plants, priority should be given to these characteristics. It is advisable to pay attention to local wildlife species that are better suited for the location and climate than cultivated or non-native plants.

REFERENCE STRATIGRAPHY

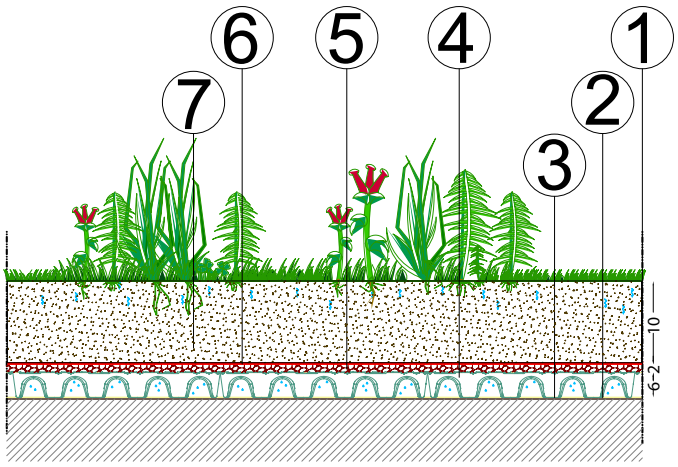


Figure 23 - example of EXTENSIVE roof garden stratigraphy

1 The dividing layers separate the anti-root membrane form the slab, also in case of incompatibility (for example PVC and bitumen) and protect the roof from mechanical stresses;
2 The root-proof membrane protects the waterproofing of the slab from grounding;
3 Geotextile for additional sheath protection;
4 The draining layer, consisting of bulk granular inert material such as volcanic lapillus, guarantees the safe drainage function, increases the development of the root system, accumulates water and nutrients, ensures a capillary distribution of rainwater;
5 DRAINROOF has excellent nutrient storage capacity. They provide the best solutions for safe plant growth and successful greening, ensuring durability and limited maintenance costs;
6 Protection of the drainage package by applying a 150 g/m^2 non-woven fabric.
7 The filter fabric prevents fine particles from infiltrating into the drainage layer, which would compromise its functioning. The substrate must be of 10 cm to guarantee the growth of vegetation. It is recommended that the correct plant species are selected according to local climatic conditions.

6.1.3 SLOPING EXTENSIVE ROOF GARDEN

Theoretically sloping green roofs are possible up to steep slopes. In practice, it is possible to work conveniently up to the limit of 45° (100% slope) even if, in the norm, we do not exceed 30° (57.7%).
Options:

1. Over 10° it is necessary to verify the structural characteristics of the head restraint beam;
2. Over 15° it is advisable to apply anti-erosion gratings before laying the substrate;
3. More than 20°, and depending on the length of the stratum, it is mandatory to insert in the load-bearing structure breaker elements to intercept and fragment the slipping thrust of the system and to avoid bearing the entire weight on the head restraint element.
   As a guideline, the distance between the lines with thrust crossbar is as follows: from about 20° 10 m, from about 25° 8 m, from about 30° 5 m. The distance is determined by the weight of the stratification. More than 30° is recommended to green with anti-slip elements.

VEGETATION

Depending on the particular characteristics of the roof and the surrounding environment, they are possible:

1. **SEED:** it is important to ensure that the seeds are of the necessary genetic purity. This guarantee is obtained by using wild plants such as grasses or certain types of perennials;
2. **HYDROSEMINE:** a mixture of water, seeds and adhesive is sprayed onto the substrate. Particularly recommended for strongly sloping surfaces which, in connection with the adhesive fixing, need a good protection against erosion caused by the action of wind and rain;
3. **PLANTING:** The more plants are developed, the less easily they adapt to the conditions of the new location. Young plants should be given priority, even if this means that you cannot see the effect quickly.

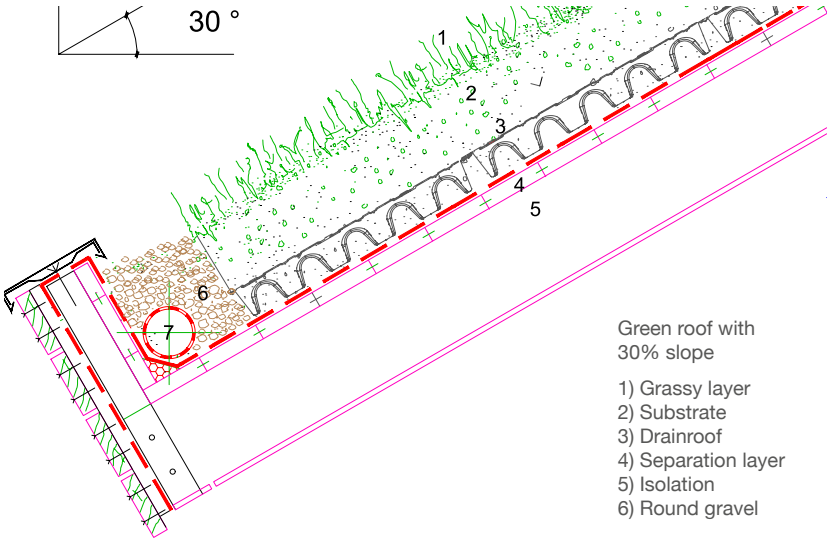


Figure 24 – Sloping extensive roof garden

6.2 LIGHT INTENSIVE ROOF GARDEN WITH DRAINROOF FOR TEMPERATE CLIMATES

The lightweight hanging green systems attainable with DRAINROOF are the most advantageous solution when you want to take advantage of a green space such as, for example, a grassy carpet combined with medium-sized bushy species respecting layer thicknesses and relatively limited weights.
The light-intensive design requires a relatively low level of maintenance and guarantees a good price/performance ratio.
The final level of maintenance depends essentially on the greater or lesser presence of turf. Its agronomic capacity allows the planting and development of vegetation consisting of grassy carpets, perennial herbaceous, aromatic and small shrubs upholstery.

The total thickness of the light intensive greening system is 25 cm, equipped with a 6 cm draining layer and a 19 cm substrate: a combination that falls within the category of thickness required by UNI standard suitable for grassy carpets, perennial herbaceous and small shrubs. The thickness of the substrate may vary slightly depending on the type of vegetation used or the need to shape the green surface.

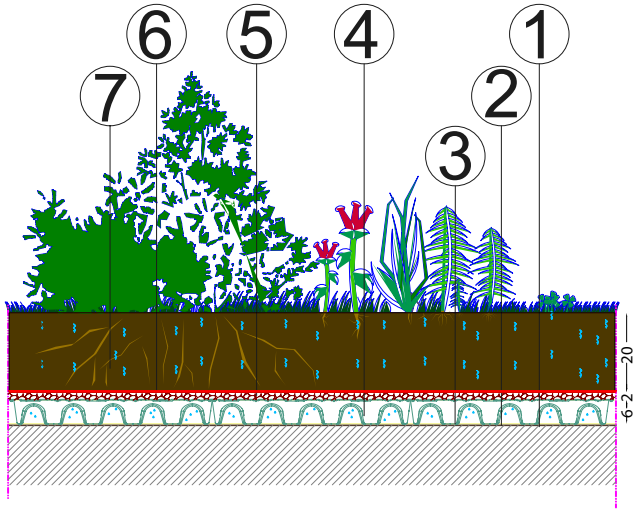


Figure 25 – Light intensive stratigraphy

1 Floor waterproofing;
2 Root resistant sheath;
3 Separation geotextile layer (grammage 200 g/sqm);
4 Drainroof for drainage and stormwater accumulation;
5 Drainroof with high porosity volcanic lapillus;
6 Geotextile for separating the volcanic lapillus from the vegetable substrate;
7 Vegetable substrate.

DRAINROOF's light intensive irrigation system can take advantage of the dripping wing sub-watering system, with a supply of water from below. It is an irrigation type suitable for grassy carpets, flower beds, bushes and shrubs, with limited operations for working under the floor. The distribution from below by sub-irrigation allows complete wind resistance, compatibility with waste water, no environmental compensation, low installation costs, low maintenance and efficiency over time, no possibility of moving the lines and remote possibility of damage.
The sub-irrigation may use a fully underground drip stream or exuding geotextile piping. Dispensing along the entire surface ensures maximum uniformity regardless of water quality.

6.3 INTENSIVE ROOF GARDEN FOR TEMPERATE CLIMATE

With the INTENSIVE typology we indicate a hanging garden that requires the maximum consumption of energy in both construction and maintenance: its specific characteristic is its usability, or rather it is exploited as if it were a normal garden on the ground.

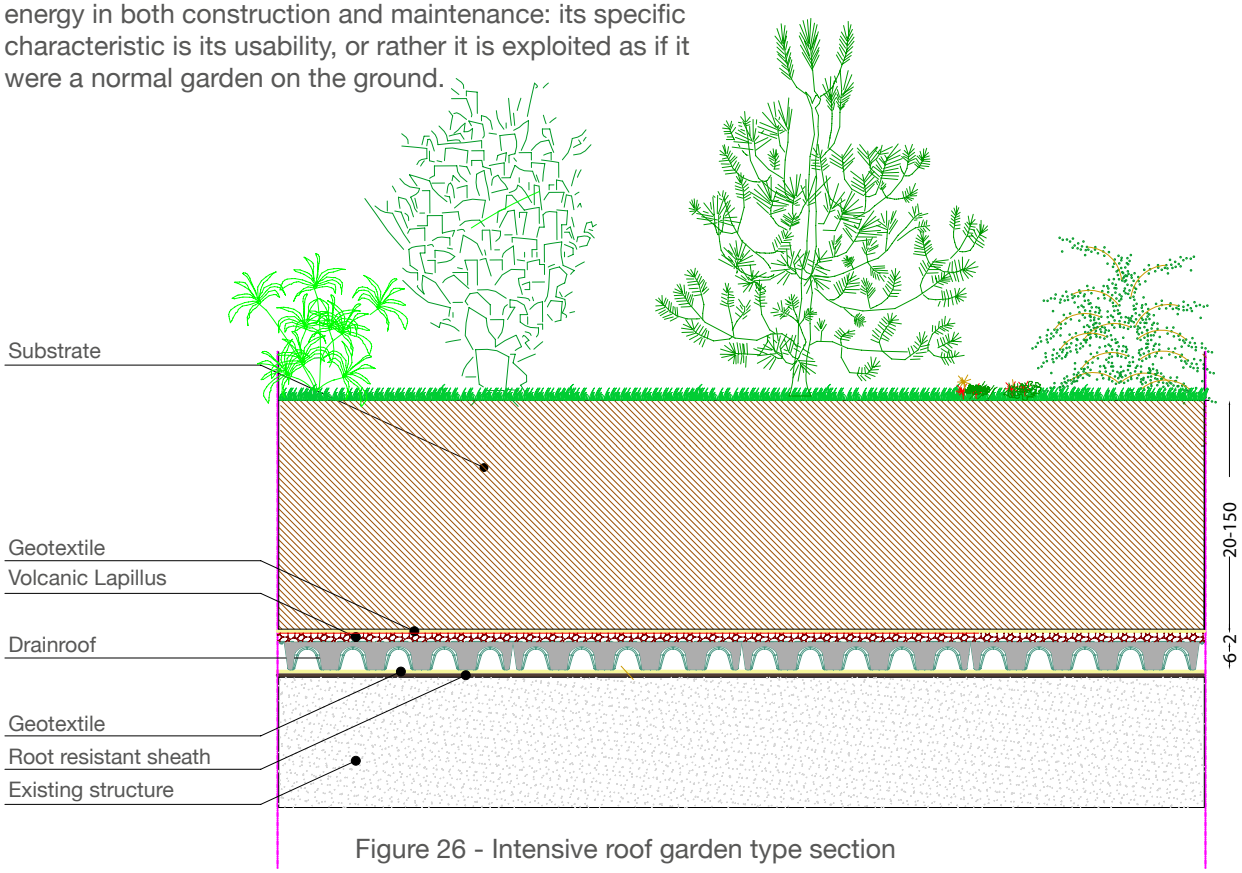


Figure 26 - Intensive roof garden type section

Intensive greening requires the classic “roof garden”, i. e. a construction in which usability can take on priority value, characterized by a tentatively high level of maintenance, similar to that required by a traditional garden on the ground and a more or less articulated landscape design. Its agronomic capacity allows the planting and development of vegetation consisting of grassy carpets, herbaceous perennial and aromatic herbs and large size shrubs. Only small and large trees are practically excluded, although many small trees can be technically considered as large bushes, depending on their developmental characteristics.
There are many fields of application: shopping malls, private and public hanging gardens on roofs or underground garages, terraces and balconies, residential complexes, school buildings. Thanks to the greater plant mass and thickness of material used, the microclimate and refrigeration benefit is very important in relation to the surrounding area and the building envelope.
On the contrary, the protection of biodiversity can be limited by the high human presence and the greater frequency of maintenance interventions.

Cultivation layer thickness (cm)	Suitable vegetation type	Maintenance (h/m²/year)	Outflow coefficient	
			Inclination <15°	Inclination >15°
30	Large shrubs and small trees	0.021 – 0.06	0.2	> 0.5
50	Trees height < 10 m	> 0.06	0.1	> 0.5
80	Trees between 10 e 16 m	> 0.06	0.1	> 0.5
> 100	Trees > 16 m	> 0.06	0.1	> 0.5

Figure 27 – Example of an intensive roof garden

The standard total thickness of this system is 35 cm, with drainage system in bulk inert material such as lapillus with a thickness of approx. 10/12 cm and substrate with a thickness of approx. 18/23 cm. These parameters may vary depending on the type of vegetation used or the need to shape the green surface. This combination falls within the thickness category of the UNI 11235 standard, suitable for grassy carpets, perennial herbaceous and shrubs.

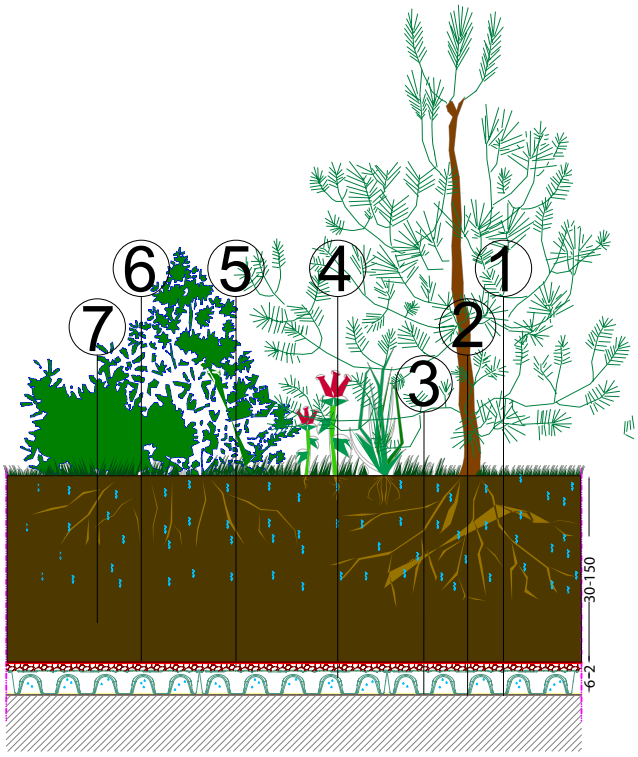


Figure 28 – Intensive roof garden stratigraphy

1 The slab must be waterproofed;
2 The root resistant sheath protects against rooting, ensuring the insoles are waterproof;
3 The protective layers serve as additional protection for the root resistant sheath;
4 DRAINROOF allows drainage and accumulation of rainwater.
5 The drainage layer, consisting of granular bulk granular inert material such as lapillus, guarantees the safe drainage function, increases the development of the root system, accumulates water and nutrients and provides a capillary distribution of rainwater;
6 The filter tissue prevents fine particles of the substrate from infiltrating the drainage layer and thus impair its functioning;
7 The soil provided has an excellent nutrient accumulation capacity, guarantees the best solutions for a safe growth of vegetation and successful greening, ensuring durability and limited maintenance costs.

Starting from the intensive greening of the roof, it is possible to apply the **sub-irrigation system** to replenish the water table. For an intensive roof garden you have the opportunity to use a wide variety of plant species. Trees and shrubs, climbing plants (for covering walls) grilled and pergolas, perennial plants and decorative plants that, starting from the early years, can create visual links.

7 PLANTS

7.1 PLANTS SUITABLE FOR EXTENSIVE GREEN ROOF SOLUTIONS

SEDUM ACRE

ROSMARINUS OFFICINALIS

LAVANDULA ANGUSTIFOLIA

HYPERICUM CALYCINUM

SEDUM ALBUM

7.2 PLANTS SUITABLE FOR INTENSIVE GREEN ROOF SOLUTIONS

ACER PALMATUM

CAMELIA SASANQUA

PITTOSPORUM TOBIRA

CORNUS ALBA

VIBURNUM TINUS

8 ADDITIONAL TECHNICAL SPECIFICATIONS

8.1 RAINWATER COLLECTING SYSTEMS

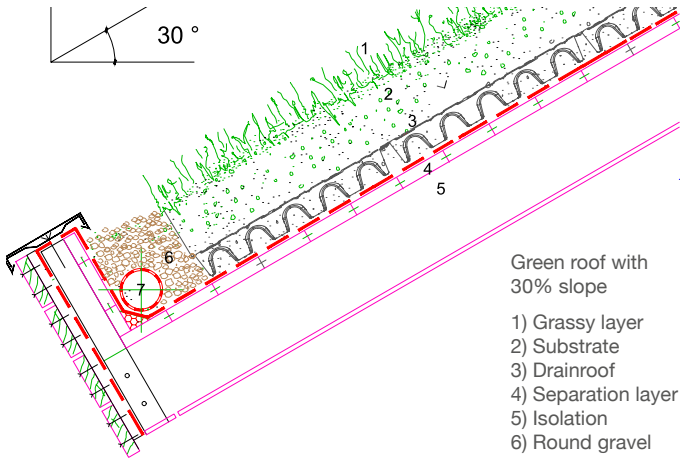
An element to be evaluated during the design phase is the rainwater collection system. It is advisable to carry out the sizing of the rainwater collection network without taking into account the effects of the water inertia of the roof in anticipation of exceptional events or future vegetation elimination.
Every element of the rainwater collection system must be inspectable. In fact, according to the regulations, the receptacles must be dimensioned and contained in special wells in order to be directly accessible from the outside without moving the elements or layers. The wells must be provided with side openings with a filter so that the normal flow of water from the roof can occur.

Figure 40 – - Detail of a roof garden

8.2 INCLINED COVERS

If green roofing of inclined surfaces with DRAINROOF is required, the following aspects must be considered:

- For inclinations between 10°-15° it is necessary to check the structural dimensioning of the perimeter containment element, in order to avoid its dislocation due to the loads acting on it;
- Per inclinazioni comprese fra 15°-20° è opportuno applicare nello strato colturale tessuti geosintetici;
- For inclinations of more than 20°, it is mandatory to insert elements transversal to the water table in order to divide the thrust due to the elements and upper layers;.
- The transverse elements shall be provided with openings for the passage of water. It is necessary to pay attention to the slippage of each individual layer with respect to the load-bearing structure and other layers (it is possible to convert the slope into percentage and gradient in the elevation in accordance with UNI 11235:2007).
  In extensive roofs, particularly in the perimeter areas exposed to wind suction depression, weights of inert material with a minimum width of 50 cm must be provided. Even in the case of emerging bodies (perimeter flaps, supports, skylights) service and protection strips with a width of at least 50 cm can be positioned. In any case, materials must not be placed on top of the crop layer, but on top of the draining or protective layer. If gravel is used, it must be well cleaned and rounded.



8.3 TECHNICAL DETAILS: ANGLES AND SIMILAR

The delicacy of this particular architectural detail requires as much attention in the construction of waterproofing. In addition to the corner fitting, account must also be taken of a reinforcement membrane which, as a waterproof sheet, must climb up the base of the skylight to below the window frame.

8.4 ENVIRONMENTAL LAYING CONDITIONS

Adverse environmental conditions (rain, snow, dew, frost, high and low temperatures) can make it difficult or even poor to build the roof garden.

8.5 IRRIGATION SYSTEM DESIGN

For the construction of the irrigation system, the techniques used for traditional garden systems must be followed. For the design of green roofs with DRAINROOF, it is necessary to identify the vegetation needs and size the different types of plants according to the requirements. The main systems adopted are the following:

- Rainwatering from above or by sprinkling;
- Drop irrigation on the ground;
- Sub-irrigation from below (specific design studies are necessary, depending on the type of water storage element chosen).

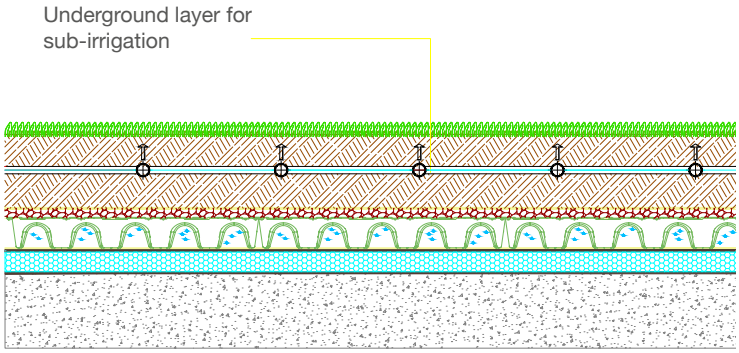


Figure 41 – Underground sub-irrigation layer

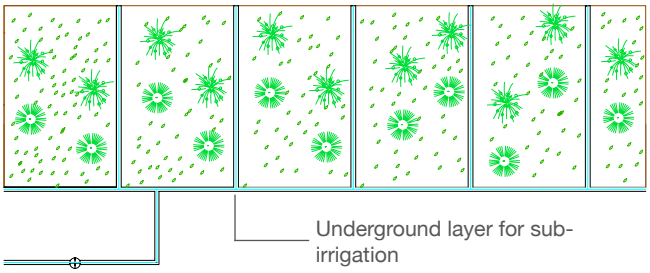


Figure 42 – Plan view of the underground layer for sub-irrigation

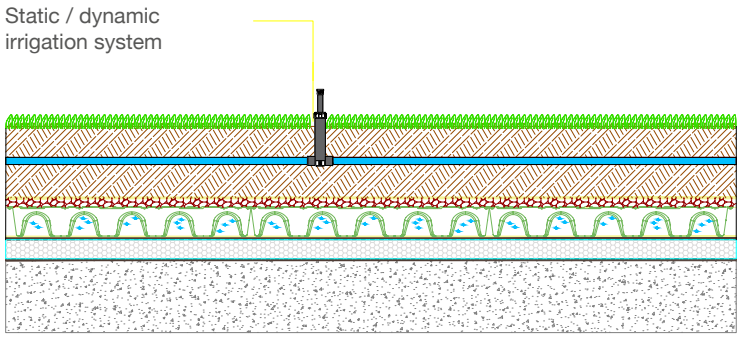


Figura 43 – Static / dynamic irrigation

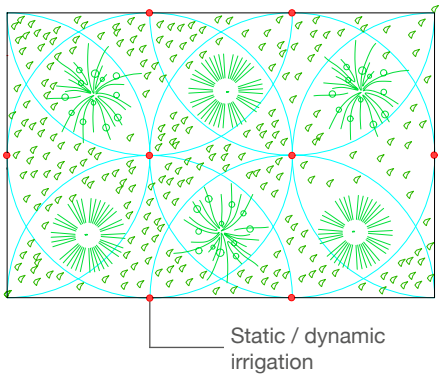


Figure 44 – Static Plan View

8.6 MAINTENANCE OF THE GREEN SYSTEM

The coverage is classified according to the format
- Class 1: Low maintenance (extensive);
- Class 2: medium maintenance (light intensive);
- Class 3: High maintenance (intensive).

The classification of the coverage according to maintenance is shown below:

Classes	Irrigation	Manteiannce	M/C
	m^3/m^2	Mdo h/m^2/year	%
1	Rescue only	< 0.02	M/C < 1
2	Expected	0.021 – 0.06	1 < M/C ≤ 5
3	Expected	> 0.06	M/C > 5

Legend
M = total annual cost of routine maintenance
C = construction cost of green roofing, net of logistical and equipment costs
Mdo = manpower

The maintenance of the roof must be defined during the design phase, as it determines the operating costs and is linked to the economic and environmental sustainability of the system.

TYPE OF INTERVENTION	ANNUAL MAINTENANCE PLAN (MONTHS) 1	2	3	4	5	6	7	8	9	10	11	12
Monitoring and cleaning of drains, monitoring of the calcium carbonate deposit formation	🟠	🟡	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟡	🟠
Cleaning of drainage control wells grids	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢
Cleaning gravel strips from unwanted vegetation	🟠	🟢	🟢	🟢	🟡	🟡	🟡	🟢	🟢	🟢	🟡	🟠
Manual extirpation of woody weeds from green areas	🟠	🟡	🟢	🟢	🟡	🟡	🟡	🟡	🟢	🟢	🟠	🟠
Manual weeding of annual, biennial or perennial herbaceous	🟠	🟡	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟠	🟠
Vegetation control, degree of coverage, consistency of vegetation layer	🟠	🟠	🟡	🟡	🟡	🟡	🟡	🟡	🟡	🟡	🟠	🟠
Containment cutting, reassembling or rejuvenating of perennial herbaceous vegetation	🔴	🟠	🟢	🟢	🟠	🟠	🟠	🟠	🟢	🟢	🔴	🔴
Containment cutting, cleaning or replacement of bushy vegetation	🔴	🟠	🟢	🟡	🟠	🟠	🟠	🟠	🟠	🟠	🟠	🔴
Grass surfaces cutting	🔴	🟠	🟡	🟢	🟢	🟢	🟢	🟢	🟢	🟡	🔴	🔴
Wild meadow cutting	🔴	🟠	🟡	🟢	🟢	🟢	🟢	🟢	🟢	🟡	🔴	🔴
Check of irrigation system functionality	🔴	🟠	🟡	🟡	🟡	🟡	🟡	🟡	🟡	🟡	🟡	🔴
Fertilisation of turf covers	🔴	🟢	🟡	🟢	🟡	🟠	🟠	🟢	🟡	🟡	🟢	🟠
Fertilisation of perennial herbaceous species	🟠	🟠	🟢	🟢	🟢	🟠	🟠	🟠	🟠	🟠	🟠	🟠
Shrub species fertilisation	🟠	🟠	🟢	🟢	🟡	🟡	🟡	🟡	🟢	🟢	🟡	🟠
Phytosanitary treatments	🟠	🟠	🟡	🟡	🟡	🟡	🟡	🟡	🟡	🟡	🟠	🟠
Check of the thickness of the crop layer with possible integration	🟠	🟠	🟡	🟡	🟡	🟡	🟡	🟡	🟡	🟡	🟠	🟠
Reinforcement of herbaceous plants, shrubs and trees	🟠	🟠	🟡	🟡	🟡	🟡	🟡	🟡	🟡	🟡	🟡	🔴
Resemination of failures, filling of failures	🔴	🟠	🟢	🟢	🟡	🟡	🟠	🟠	🟢	🟡	🔴	🔴
Irrigation	🔴	🔴	🟡	🟡	🟡	🟡	🟡	🟡	🟡	🟡	🔴	🔴

Legend: 🔴 Excluded period 🟢 Optimal period 🟡 Possible period 🟠 Not recommended period

9 TESTS

Tests, foreseen to verify the functioning of the green roofing realized with DRAINROOF, must ensure that building and agronomic interventions respond to the design requirements. They are schematizable in:

- Check of the support layer of the sealing element;
- Initial inspection of the sealing element;
- Final inspection of the system's watertightness, carried out at the end of the green roofing work, before laying the vegetation layer;
- Check of stratigraphies and accessory systems (hydroelectric and electrical;
- Verification of the green works, carried out within one year of completion of the works.

If the roof remains visible for extended periods of time or if people and things pass through the roof, it is advisable to carry out a water tightness check even before laying layers or elements on top of the sealing element. The green works must be checked 12 months after the end of the laying of the plant species. Verifications must be carried out on square areas of 1m x 1m located in areas defined by the Testator or the Works Department. The UNI standard provides that for each type of vegetation (perennial herbaceous and Sedum grasses, pre-cultivated mats of perennial herbaceous plants, grass mats sown and sown in rolls or coverings in clods or pots) the control is calibrated according to the measurement of the horizontal projection of the epigeous part of the plant species: the verification is if all samples tested show compliance rates of coverage, rooting and pest occurrence.

10 MAINTENANCE

Maintenance can be divided into three main types:

- Ordinary maintenance means the maintenance over time of the functionality of the type of greening envisaged, through agronomic treatments. These treatments include irrigation, fertilisation, weed eradication, mowing, containment and cosmetic pruning and finally phytosanitary treatments;
- Maintenance of the drainage system (checking the efficiency of water storage and drainage system);
- Maintenance of the rainwater disposal system and the sealing element (annual and prior to the winter season, inspection of the receptacles must be carried out in order to avoid obstructions).

APPENDIXES

APPENDIX A

MATERIAL SAFETY DATA SHEET

COMPOSITION / POLYMER INFORMATION

INGREDIENTS	NO. C.A.S.	%
Polypropylene Random	9010-79-1	97-99
Additives	Not available	1-3

HAZARDOUS COMPONENTS

This product does not fall within the definition of hazardous material provided by EEC 1999/45 and subsequent regulatory measures.
Physical state: Solid.
Problems: If the polymer is subjected to high temperatures it can produce vapours irritating to the respiratory system and eyes.

FIRST AID MEASURES

Inhalation of decomposition products: Keep patient calm, move patient to fresh air and call for medical help.
Skin contact: parts that come into contact with molten material must be quickly brought under running water and the doctor must be contacted.
Eye contact: flush eyes for at least 15 minutes under running water while holding eyelids open. Contact with material particles does not present any particular danger, except for the possibility of abrasion wounds. Fine particles can cause irritation.
Ingestion: No particular measures to be taken.

FIRE-FIGHTING MEASURES

Extinguishing materials: water, foam or dry extinguishing materials.
Unsuitable extinguishing materials: none.
Substances released in the event of fire: carbon dioxide (CO2) and mainly steam. Other substances that may form: carbon monoxide (CO), monomers, other degradation products.
Special protective equipment: Wear breathing apparatus in case of fire.
Other requirements: Dispose of contaminated combustion slag and fire extinguishing material in accordance with local regulations.

ACCIDENTAL RELEASE MEASURES

It is not classified as a hazardous material. It can be recycled, incinerated or disposed of in landfills in accordance with local regulations.

STORAGE AND HANDLING

When the product is ground, the applicable dust regulations must be taken into account.
Keep it in a dry place.

EXPOSURE CONTROL/PERSONAL PROTECTION

Respiratory tract protection: if respirable dust forms, P1 filters (DIN 3181) must be used.
Skin protection: no special precautions.
Eye protection: safety glasses in the presence of free particles.

PHYSICO-CHEMICAL PROPERTIES

Shape	Panels
Color	Dark grey-black
Smell	Soft
Change in physical state	Melting temperature: 140°C Combustion temperature: above 400°C
Flammable properties	None
Density	0.91-0.97 kg/dm^3
Solubility in water	Insolubile
Solubility in other solvents	Soluble in aromatic solvents

STABILITY AND REACTIVITY

Conditions to avoid	Do not overheat to prevent thermal decomposition. The process begins at around 300°C
Thermal degradation products	monomers and other sub-products

TOXICOLOGICAL INFORMATION

Acute toxicity: data not available (no animal experiments due to impossibility related to product conformation).
Insoluble in water

ECOLOGICAL INFORMATION

Degradation in nature: no data available.
Insoluble in water.
Behaviour and environmental purpose: the product is environmentally friendly because it is made of recycled plastic. It is not apparently biodegradable due to its water insolubility and consistency.

DISPOSAL CONSIDERATIONS

Product 100% recyclable. It can be disposed of in landfills or incinerated in accordance with local regulations.

TRANSPORT INFORMATION

It is not classified as dangerous for transport purposes.

REGULATORY INFORMATION

It is not subject to the CE marking.

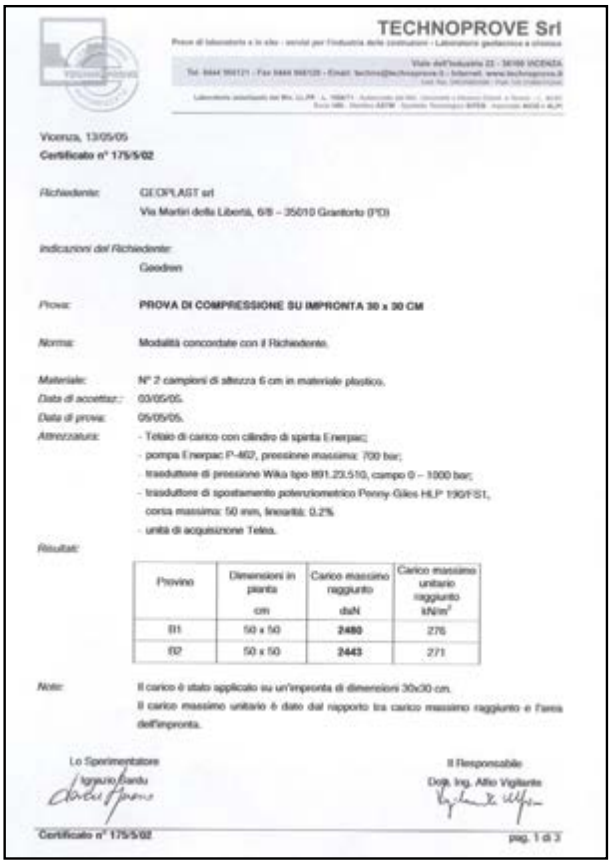
APPENDIX B

REFERENCE LEGISLATION

The roof garden began to spread in Italy about twenty years ago, mainly as a factor of embellishment of buildings and subsequently as a fundamental tool to mitigate the effects of high urbanization, with the precise objective of increasing environmental well-being. Unfortunately, the green hanging designs made in the past have been carried out in total absence of a specific technical reference standard.
The results, for linguistic reasons, of climatic conditions and, last but not least, of different constructive traditions, have been poor and economically prohibitive.
Finally, in May 2007, UNI, the Italian Unification Body, drafted UNI 11235:2007, entitled “Instructions for the design, execution, control and maintenance of green roofing”, which set out in detail the criteria for creating a roof garden. A valuable guide for the designer in all phases of design, from testing to maintenance. UNI 11235:2007 regulates the procedure for the construction of hanging gardens, both in the overall stratigraphy and in the characteristics of the elements that compose it, the requirements of agronomic capacity, drainage, ventilation, water storage and resistance to biological attacks.
The standard is composed of the initial part in which terms and definitions are provided, followed by a part that defines the requirements for green roofing, a part dedicated to the designer and the composition of greenery and a list of the documentation that the designer must draw up. Finally, UNI 11235:2007 concludes with the instructions related to shipbuilding, relative to the execution of the cover, to the controls during the execution by means of test parameters and maintenance. UNI’s aim is to guarantee the users of the roof garden the safety of the result, its durability and quality in order to enhance the reputation of green roofs, qualifying the operators in the sector.

Thanks to precise rules, the unification of design, control and testing methods facilitates the definition of specifications and technical documents. In UNI 11235:2007, the chapter on layers of waterproofing was also included in the overall system: every phase of the project must take into account all the performance characteristics of all the elements that contribute to the construction of the roof unit starting from the substrate, therefore DRAINROOF.
This is an aspect of the standard of considerable value when compared to the current European standards in force. The UNI 11235 standard has recently been updated to the 2015 version.
The new standard (made by the Technical Commission for Products, Processes and Systems for the building body) takes back and replaces UNI 11235:2007 and defines the criteria for the design, execution, control and maintenance of continuous green roofs, depending on the particular climatic context, building context and use.

APPENDIX C
TEST CERTICATES



TECHNOPROVE Srl

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:

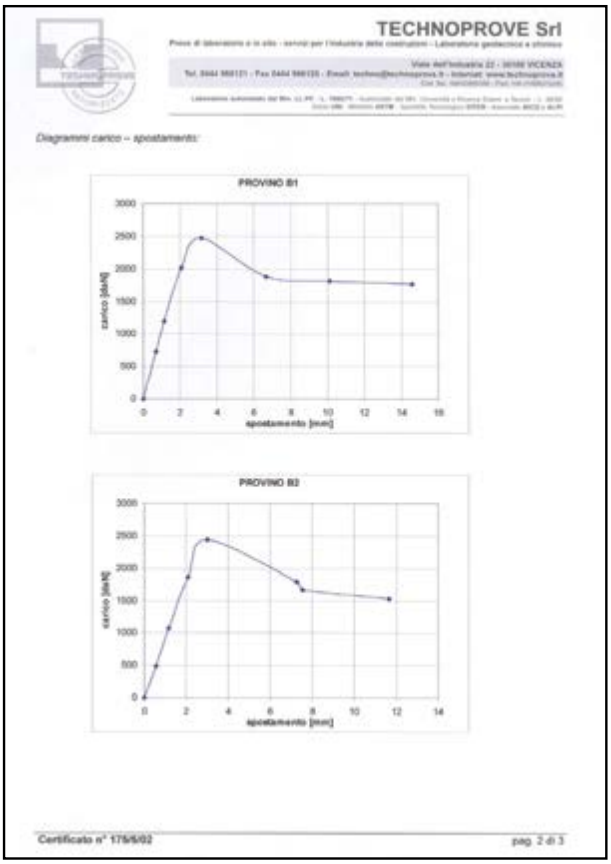
Provino	Dimensioni in pianta cm	Carico massimo raggiunto daN	Carico massimo unitario raggiunto kN/m²
B1	50 x 50	**2480**	276
B2	50 x 50	**2443**	271

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

Certificato n° 175/5/02 pag. 1 di 3



TECHNOPROVE Srl

Diagrammi carico – spostamento:

PROVINO B1

PROVINO B2

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Documentazione fotografica:

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rev.001
11/2017