

Investigation on a Low-Tech green

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ABSTRACT: The main idea behind this projects is trying to exploit the possibilities offered by green surfaces in terms of integration with the building structure. Green Surfaces contain a two-fold property: they are physically useful, primarily being an active insulation barrier against heat and sound. They also increase the quantity of filtered water and the amount of stormwater runoff.

Keywords: Appropriate Energy Technologies; Social And Cultural Context; Thermal Control, Sustainable Growth, Technology Transfer and Local Innovation

1. INTRODUCTION

1.1 LIVING SURFACES: FROM ROOF TO WALL

Green surfaces also act on a less measurable level: they provide a pleasing view to the eye and a sense of ecological integration with a more natural environment.

Therefore, a first interesting premise is to investigate the links between physical properties and perceptives ones, trying to reconcile economy and human sensibility. The research will then follow two parallel paths, economy and physical properties on one side, and sensorial properties on the other one: these means will influence each other sometimes, but could rather be independent.

The process is direct to study the possibility of green surfaces to act the roofs, as inclined planes and also as walls. Rather than being confined in gardens clearly separated from the living areas of the building, the properties of the surfaces will try to be examined in terms of a full integration inside the building.

2. VARIED VEGETATION

The boxes have been differentiated in terms of vegetation in 6 declinations:

- 1 – tomillo, menta y orégano
- 2 - hierba buen: toronjil, poleo, llantén
- 3 - pasto (high transit)
- 4 – Ciboulette, Apio y albahaca
- 5 - Carex green and gold
- 6 - Lechuga

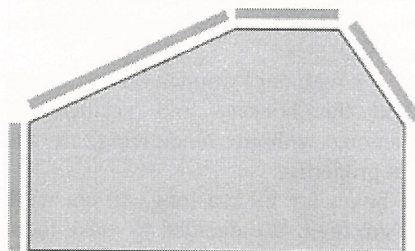


Figure 1: different possibilities of inclination with green surfaces.



Figure 2: Own Standard box .(n° 1)

3. CONSTRUCTION

3.1 Explanation of the boxes' construction: a simple system

The first practical step in our research was to build 6 "test boxes" to start considering the behaviour of green surfaces, in terms of growing medium and the different kinds of vegetation.

Our direction was to establish a simple system. It should be pointed out that was our firm intention to research for something low-tech and simple to build. The European market already faces the diffusion of much more complex system, with an industrial production extended both to the supporting material and the distribution.

Thinking of the Chilean market, rather on the edge of approaching the sustainable architecture, it appeared interesting to propose something more "natural" alongside commercial imported products.

With a small digression, to have a glance at the state of the art in green roofs, would be interesting to look at that different features that distinguish a commercial product. The comparison with our "wooden boxes" would underline the honesty and easiness of construction, without renouncing to the inherent properties.

The boxes are 60 cm long, 40 cm wide and 12 cm high. We decided to make them of a compact size so that we would have been able to move and use them easily. The structure is made of 1 inch thick wood strips. As can be seen from the diagram and the pictures, they are not completely capped. The ground for the growing medium consists of an undulated zinc plate which retains the earth and also simulates the role of a waterproof and root repellent layer in the normal structure of green roofs.



Figure 3 : Longitudinal Section

3.2 EXTENSIVE GREEN ROOF

It does not require any load attention and has a thin growing medium: usually does not require an irrigation system and it's easy to maintain. It's widely used in the conversion of building roofs for its easy installation and cost advantages.

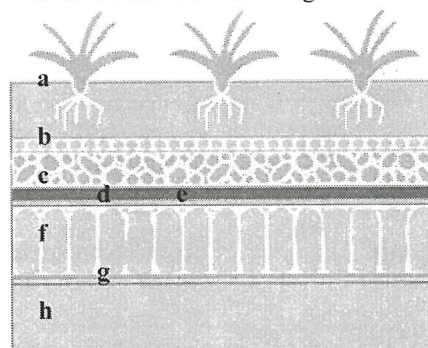


Figure 4 : Typical system green surfaces

- VEGETATION

- a) GROWING MEDIUM

The composition of the green roof is related to the weather where the system is installed. Actually relatively few studies exist about the changing properties related to climate change: there are some publications about Germany, Sweden, Greece, Uk, Tropical and temperate weathers in the Northern Hemisphere.

It is clearly evident that the composition and the survival of growing mediums and plant species are closely related to the climatic region they belong to: therefore is necessary to deepen the research about what species and what mediums would be more suitable for a certain country.

On the other hand, being Chile a rich country in terms of climatic variation and plant species, the study could be reduced to a climatic environment similar to some known studies, and apply the tested results in terms of vegetation.

The composition of the growing medium consist of a variable percentage of heat expanded slate (which constitutes the structural soil for the vegetation) plus a percentage of controlled release fertilizer.

The substrate varies between 1000mm and 150mm

- b) FILTER MEMBRANE

Prevents fine particles from being washed out of the growing medium substrate; in this way it increments the efficiency of the drainage layer.

- c) DRAINAGE LAYER

Its role is to retain rainwater for dry periods in troughs on the upperside. The water is drained off through the channel system on the underside. Special holes ensure evaporation and the necessary ventilation.

- d) WATERPROOF/ROOT REPELLANT LAYER.

It provides the necessary waterproofing to the layers underneath, so that water cannot damage or infiltrate in the structure. It can also provide a retention against root damaging, in case this task is not addressed to a different panel. It should always be 150 mm above soil level. Follows the composition of some solutions:

- Built-up bituminous membrane systems
- Polymer modified mastic asphalt systems
- Polymeric single ply systems
- Hot melt systems

- e) VAPOUR CONTROL LAYER

- f) THERMAL INSULATION

- g) SUPPORT PANEL

- h) STRUCTURAL SUPPORT

3.3 INCREMENTAL LOW TECHNOLOGY

The “test boxes” built so far were intended to be a starting point. We thought it would have been interesting to study some irrigation system and to relate their feasibility to the different inclinations (in a range from the completely horizontal to the completely vertical).

What we actually found out proceeding in our reserach was that our system could not exploit the range of the completely

vertical: infact we had problem with the drainage system and the gravity force acting on the terrain. In fact, after the inclination of 50 degrees, the pressure and the erosion caused by irrigation and possible rain, caused the fall of ground and the general sliding of the growing medium.

This of course would have greatly reduced the isolating properties as well as the efficiency of the system.

Therefore, we decided not to exceed in the inclination and limit the tests on temperatures and sound to test boxes with an angle to the ground smaller than 40° (the interval between 50 and 40 was intended as a safety measure).

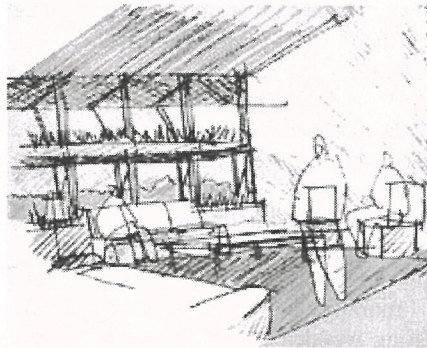


Figure 5 : Target Image, livingroom

In the case of inclined boxes, the system assumes a terraced shape, as can be seen in the diagrams. we eliminate the feature of the box (intended as a test) and lay wooden barriers to keep the ground, parallel to the directed inclination. The “strips” of this surface are inclined no more than 40°, as previously pointed out, and are no more than 50cm deep. This measure is consequent of our evaluation of sliding soil in the case of strong irrigation (which woul simulate rain).

This scheme is common to all the positions from 40° to 10°. For an angle smaller than 10°, the case can be assimilated to the horizontal

one. Therefore we no longer need separating strips with a period of 50 cm, but just a continuos extension of green soil. There is a difference still when the system is used

inside: in fact, it could be still useful keep a system of boxes, both for replacing opportunities and to keep the system still handy. It could be more easily cleaned and a box replaced (if a vegetable is no longer needed in the house, for example!).

Another component that needed to be integrated was the system is the drainage layer, and its relation with the zinc base. We revised different options, between them some much or less technological. We thought that even if our construction system would be low-tech, it was important to evaluate the necessity of some machinery. The only differences are the introduction of two layers: a drainage layer under the soil and a waterproof layer under the zinc plate (to face the possibility of infiltrations underneath).

Therefore, we selected among the different options a simple pipe system to irrigate the plants. It works quite the same way for all the inclination, except the horizontal position.

As shown in the diagrams, there are pipes running in the direction of the separating wooden strips: this pipes feature little holes intended for the homogeneous irrigation of the soil. They are positioned in the upper part of the inclined strip. On the other hand, a simple drainage layer is positioned under the soil, right above the zinc plate. The drainage layer lets just the water to pass, going down along the curves of the zinc plates (oriented to the normal of the wooden strips) and letting the water running along a collecting pipe.

This collecting pipe is inclined, and every 4 modules (60cm long, so 120 cm) two pipes end in the same draining pipe, running through the boxes collecting all the water related to the adjacent modules. In the end, the drainage pipe end in a collecting chamber, connected to a little pump.

The pump pushes the water to a cleaning chamber with earth and dust filter, then is recollected above the ground at the top of the roof, ready to be reused.

The question might rise about where is the water taken from in the first place. It could be raining water collected from a pool, could be the black waters of housing consumption already cleaned (shower, kitchen, flush water), just as examples of feasible and sustainable ways of solving this problem.

In the case of the horizontal solution, the irrigation and drainage system is quite similar, apart from the fact that is organised as a grid on the same level, and although the soil is no longer inclined, the pipes still are.

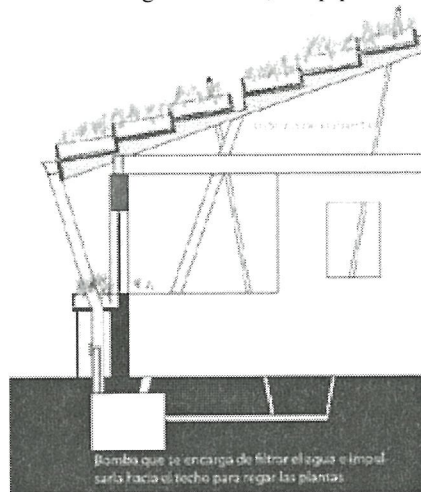


Figure 6 : Water filter bomb, that push-up on the roof, for the vegetation

4. TESTING THE PERFORMANCE OF OUR GREEN ROOF

As clarified earlier, the investigation is going to follow two rails, physical experiment and sensorial considerations. About the first field, we are going to concentrate around heat and sound transmission.

Test sound insulation, in dB, looking at the differences in the different species and growing mediums.

Test heat reduction, in °C, regarding the different species and growing mediums.

Test stormwater retention capabilities along different lengths of time and through the different mediums.

Test temperature variation in the immediate air substrate, to evaluate the creation of a microclimate.

Test the possibilities of water filtration and water evaporation, compared between the different plant species and growing mediums.

12:00 hrs.	ENVIRONMENT TEMPERATURE	VEGETATION	T: INSIDE	T: OUTSIDE	VEGETATION	T: OUTSIDE	T: INSIDE	VEGETATION	T: OUTSIDE	T: INSIDE
	33,3	PASTO	20,0	17,0	CAREX	20,0	16,0	CIBOULETTE	22,0	16,0
	32,0		21,0	18,0		21,0	17,0		23,0	17,0
	33,0		20,0	18,0		19,0	15,0		22,0	15,0
	32,5		19,0	16,0		21,0	16,0		21,0	15,0
	33,4		22,0	18,0		20,0	15,0		22,0	16,0
	32,8		21,0	15,0		20,0	14,0		21,0	15,0
	31,9		22,0	16,0		22,0	15,0		22,0	16,0
	33,4		21,0	17,0		20,0	16,0		22,0	15,0
	32,7		20,0	16,0		20,0	15,0		22,0	15,0
	33,0		21,0	18,0		20,0	14,0		21,0	15,0
	33,2		20,0	16,0		21,0	16,0		22,0	17,0
	33,4		22,0	17,0		20,0	15,0		20,0	16,0
mediana	33,0		21,0	17,0		20,0	15,0		22,0	15,5
media	33,0		20,8	16,8		20,3	15,3		21,8	15,7

Figure 7 : Heat Reduction log n°1.

4.1 Heat reduction

Heat reduction was indentified as the most important property for our investigation. We took different many sets of measures, where the first ones were not really systematic. The results presented in the following pages are aggregated ones, summarizing all the different measurements.

The temperatures measured are of three kinds:

- ambiantal temperature, measured with a normal ambiantal thermometer.
- temperature on the "external" box surface (the one with the vegetation, supposedly exposed outside). Taken with a laser surface thermometer.
- temperature on the "internal" box surface (the one with the base and the zinc plate, supposedly exposed inside). Taken with a laser surface thermometer.

For each set of measures there are 12 samples, followed by the statistical median value (indicated in the tables as "mediana") and the statistical average value (indicated in the tables as "media").

About the setup, we measured both ambiantal and surface temperaturas always in the same moments of the day: at 12.00, when the heat it's going towards the peak of the day, and at 20.00, when the heat it is greatly reduced and preceeding night cooling.

We had already selected 4 types, of which we thought of using 2 indoor (the vegetables types) and 2 outdoor (the turfs types). We also evaluated the temperature of the simple zinc plate, simple registering its great heat transmission property.

It has to be said that the tests just evaluated the difference between the internal and the external surface. Although the results show us the isolation property of the boxes, they do not evaluate numerically the potential of establishing a microclimate around the internal surface (that was exposed to the same ambiantal temperature). We can assume, though, that such an event is posible even with the tests we took.

The results show us two main things:

a) in late morning the sun heat up the boxes external surfaces, but the internal surface is still cooler and retains the cool taken during the night.

b) On the other side, in late evening the internal surface it's warmer than the external one, and starts realising the heat assimilated during the day. This is a very interesting results, because it shows the isolating property of our system.

It has to be said that the surface don't isolate too much, but on some levels follow the heating-cooling process in a more natural way, with cycles of accumulation and release of heat.

The differences are constant regarding the different vegetation: the power of realising and accumulating heat doesn't change in the same vegetative type.

The Carex (high density turf) and

Ciboulette where the best performing Vegetation types.

ENVIRONMENT TEMPERATURE	VEGETATION	T-OUTSIDE	T-INSIDE	VEGETATION	T-OUTSIDE	T-INSIDE	VEGETATION	T-OUTSIDE	T-INSIDE
30,7	LECHUGA	20,0	16,0	ZINC ALONE	x	42,0	hierba Buena	11,0	10,0
31,7		20,0	16,0		x	43,0		10,0	10,0
31,0		21,0	17,0		x	43,0		9,0	9,0
32,5		20,0	15,0		x	43,0		10,0	11,0
32,4		21,0	16,0		x	40,0		10,0	10,0
33,7		21,0	17,0		x	41,0		9,0	9,0
32,0		20,0	16,0		x	42,0		10,0	11,0
32,4		21,0	17,0		x	43,0		11,0	11,0
32,5		22,0	16,0		x	42,0		11,0	10,0
31,8		21,0	15,0		x	41,0		10,0	11,0
32,7		20,0	16,0		x	41,0		11,0	10,0
32,8		20,0	16,0		x	42,0		11,0	10,0
mediana	32,4	20,5	16,0			42,0		10,0	10,0
media	32,3	20,6	16,1			41,9		10,3	10,2

Figure 8 : Heat Reduction log n-2

20:00 hrs. ENVIRONMENT TEMPERATURE	VEGETATION	T-OUTSIDE	T-INSIDE	VEGETATION	T-OUTSIDE	T-INSIDE	VEGETATION	T-OUTSIDE	T-INSIDE
24,5	PASTO	18,0	24,0	CAREX	15,0	22,0	CIBOULETTE	14,0	25,0
22,0		17,0	26,0		13,0	22,0		15,0	22,0
22,8		19,0	22,0		16,0	27,0		14,0	25,0
23,8		22,0	21,0		18,0	23,0		15,0	24,0
23,0		21,0	24,0		19,0	24,0		16,0	24,0
24,1		18,0	23,0		18,0	22,0		16,0	23,0
23,7		19,0	25,0		15,0	25,0		17,0	24,0
24,0		17,0	24,0		17,0	22,0		15,0	25,0
23,6		17,0	25,0		14,0	23,0		16,0	24,0
22,9		20,0	26,0		15,0	24,0		17,0	21,0
23,2		20,0	21,0		16,0	23,0		15,0	23,0
23,7		18,0	22,0		15,0	22,0		15,0	21,0
mediana	23,6	18,5	24,0		16,0	23,0		15,0	24,0
media	23,4	18,6	23,6		15,8	23,2		15,4	23,4

Figure 9 : Heat Reduction log n-3 (a)

ENVIRONMENT TEMPERATURE	VEGETATION	T-OUTSIDE	T-INSIDE
23,5	LECHUGA	13,0	20,0
23,0		14,0	22,0
21,8		16,0	19,0
23,6		15,0	23,0
22,8		16,0	22,0
23,1		14,0	24,0
23,7		15,0	23,0
22,0		15,0	22,0
23,6		14,0	22,0
23,5		15,0	20,0
23,6		16,0	21,0
24,0		15,0	21,0
mediana	23,5	15,0	22,0
media	23,2	14,8	21,6

Figure 10 : Heat Reduction log n-3 (b)

4.2 Humidity and water retention

The retention power of the different vegetation was conducted on a more qualitative way than the other tests. We irrigated the boxes with the same amount of water, on three quantities: small amount, bigger amount and complete flooding. After ten minutes, we removed the box and observe how dry was the ground. The results showed

that on smaller amounts the different vegetation types work quite all the same way.

On the other hand, in the case of complete flood Carex and Ciboulette show quite better results: for us the reason is due to the bigger surface on the types, that lead to bigger absorption and retention, and a quicker evaporation.

4.3 Sound isolation

Sound isolation was performed initially on all the vegetation types. We evaluate the sound noise placing the box acting as a barrier against the source of noise. We then evaluate the sound in Db placing the instruments on the external and the internal sides of the box. We measure it on two different conditions, bigger and smaller noise.

The precision of the instrument did not let the outcoming of differences between the difference vegetation types. This is also due to the fact that we didn't isolate the internal surfaces in any means, so the actual reduction is due entirely to the "barrier" effect. It is predictable, though, that isolating the boxes some differences in the various vegetations would come out. It is interesting anyway to register a isolating barrier, that increases slightly from the smaller noise to the higher one.

SOUND LEVEL (Db)	VU, outside	VU, inside	VU, outside	VU, inside
80,0	59,0	64,0	60,0	
62,0	57,0	63,0	58,0	
57,0	54,0	60,0	56,0	
58,0	55,0	59,0	54,0	
60,0	54,0	62,0	59,0	
61,0	56,0	63,0	58,0	
62,0	57,0	65,0	57,0	
63,0	59,0	61,0	60,0	
61,0	58,0	63,0	58,0	
62,0	56,0	64,0	60,0	
58,0	56,0	62,0	57,0	
56,0	57,0	58,0	59,0	
60,5	56,5	63,0	58,0	
60,0	56,4	62,5	57,9	

Figure 11 : Sound Insolation log.

4.4 Tests conclusions

The results on different tests show that Carex and Ciboulette perform slightly better than the other types. This led us to prefer them, where Carex can be used as a turf outdoor and Ciboulette indoor. Actually Carex features a very soft appereance if used as a turf and it's better for inclined surfaces, because its bigger roots retain more ground than the other ones. At the same time Ciboulette it's quite enjoyable as an indoor surface.

It should be remembered that other vegetation types feature other qualities and are more useful on other levels (such as the production of eatable vegetables) and have not such differentproperties.

In conclusion, the box as a green roof performs well.

5. CONCLUSIONS

As clarified at the beginning of this paper, the system was not thought as a complex system. A final remark is that we found out anyway some interesting properties. This demonstrates that sustainable architecture can act on a much simpler scale, closer to laymen and non-professionals.

Our green roof system is very easy to build and very easily maintained, and offers a pleasing solutions on both sides of our aim: obtain a sustainable solution for thermal insulation and offer a pleasing and convenient way to increase any place's visual quality. The experiments testified the opportunity of green surfaces, especially in the way of thermal insulation, sound insulation and water retention.

As shown earlier, our boxes could fit indoor and outdoor, offering a way of vegetable in-house cultivation in the city, or a garden surface to quite densed populated neighborhoods. Above all, it seem very important the possibility to regeneratethepoorly greened areas.