Green Walls
An environmental alternative for the city

ARCHITECTE VERONICA HENRIQUES ARDILA[1]
STUDENTS: MARIA CAMILA GIRALDO RESTREPO[2], LUISA FERNANDA ECHEVERRI MONTOYA[3], OSCAR EDUARDO CANO SEPULVEDA[4], ANA CAROLINA RESTREPO ACOSTA[5].

[1,2,3,4,5.] Facultad de Arquitectura, Universidad Pontificia Bolivariana, Medellín, Colombia.

ABSTRACT: We design a prefabricated piece to be used on building envelopes, interior partitions, facades or landscape enclosures. It has the advantage of being self-supported, self-irrigated and self-fertilized by an integrated conduit system. Dissimilar to other pre-existing elements and solutions, in our case the vegetation is integrated within the wall construction instead of being adhered to it. In a tradition wall system with climbing plants, the green wall is directly affected when changing vegetation type or when the plants die or get ill. Our design allows for individual replacement of the vegetation components allowing the permanence and variety of the green elements and species on the wall.
We realize constant tests of the environmental efficiency of this constructive method; and in this article we show the evaluation of sound absorption that we did with a few prototypes.
Keywords: Energy, sound absorption, green envelopes, sustainable envelopes, green skins, vertical gardens, sustainability, environment protection, eco-construction, integrated building vegetation, comfort.

INTRODUCTION
From an architectural point of view, the building facade represents a "skin" which performs similarly to the human skin on its biological processes. It is possible that the skin gives buildings different looks and makes it an exchanging agent with the environment.

In this research, the green closings turn into a constructive and technician method that would allow important benefits from the point of view of the sustainability, as the insulating efficient thermal and acoustic one.

We know that some natural products can be in use like insulating, specially in walls and covers. This constitution is in the habit of including fiber of cellulose, vegetable fiber and wool of sheep. Unlike the insulating artificial ones, the insulating natives contain little built-in energy, are not toxic and do not detach chemical substances that attack the cap of ozone.

In this research we are interested in evaluating the environmental efficiency that can have a green wall or vertical garden. We believe that a constructive system simple to use and with clear advantages, will increase the use of green fronts contributing this way with forceful benefits inside the energetic functioning of the buildings and of the environment.

OUR CONTEXT
Medellin has serious environmental problems today; among them air pollution, pollution by noise, flooding and heat island effect. The causes of many of these problems are related to the construction industry; that is why, it is necessary proposing strategies that lessen the environment impact. We propose the green walls.

Like green roofs, green walls equal cleaner air, cooler cities, absorbs noise, reduced energy consumption, less untreated storm water running into our rivers and streams, and more natural habitat for native plants and animals supporting greater biodiversity.

With the implementation of this development it is possible to formulate new systems of recovery of the urban environment, in this case especially of the metropolitan area of Medellin, and corresponds to the markets of the construction and the architecture to implement in city design forms of environmental sustainable development to generate well-being and balance between the urban inhabitants and his environment.

CONCEPTUALIZATION
ARCHITECTURAL CLOSINGS Architectural closings is that cap that separates the interior of the exterior of a building, acts as a barrier, a protective limit for the

intimacy, to inhabit and the human well-being. But also it is the bridge that joins indoor with outdoor, therefore there is the one who takes charge establishing the relation among them, if it is left to spend the wind, the light and, is left to enter to the nature itself, we grant to our habitat a top quality, a healthy and alive climate.

GREEN CLOSINGS Green closings are leather composed in the main by plant, biodegradable and vivacious elements. The nature itself manipulated to create the above mentioned architectural barrier, leaving major benefits, from the point of view of the sustainability, as the insulating efficient thermal one, with a role on the urban important landscape, and besides saving energy as a tool of social change inside a model of sustainable design.

ADVANTAGES OF GREEN CLOSINGS

Ecological Advantages

- Water retention.

The landscaped surrounding ones are capable of retaining great percentage of the water rain. A great report of this water is returned to the atmosphere, the rest flows of form retarded to the systems of outlet. This way it is possible to diminish the dimension of the conduits and simultaneously costs of outlet diminish.

- Improvement of the urban climate.

The global warming, the increase of sealed surfaces and the heat excess of the residential buildings, the industry and the traffic are giving place to the increase of the temperatures constant inside the urban centers. The difference of temperature between a city and the surroundings heat island is known as the effect. The surrounding green ones reduce the atmospheric warming and moisten the urban environment creating this way a more agreeable climate and better quality of life.

- Reduction of the pollution.

The green closing ones act as a filter for the air, reducing this way substantially the pollution of powder and aerosols. This way they help to reduce toxic elements in the atmosphere, to others to diminish and to control the levels of CO2 emitted by the consumption of fossil fuels and the increasing energetic demand(lawsuit). The substrate in turn leaks(filters) the water of the rain, so that the landscaped covers help to reduce the load of the water with harmful substances.

- Protection against the noise.

The plant closing reduce the sonorous reflection up to 3 dB and are capable of improving the soundproofing up to 8 dB. This way, they are ideal for buildings surrounded by noisy areas. In addition, the electromagnetic waves of the stations broadcasting can be effectively protected by the vegetable cap.

- Additional living space.

The landscaped walls compensate great part of the green spaces lack due to urbanization. Under maintenance, wide zones of green covers can foment the biodiversity, species of insects and birds can find food and I shelter there.

Economic advantages

- Prolongation of the useful life of the waterproofing.

Under a vegetable cap the waterproofing and the materials of front are protected against the ultraviolet radiation, the hail, the heat and the cold. The tensions caused by the thermal differences are reduced so that the useful life of these elements extends.

- Saving of energy.

The systems of gardens with insulating function have a calorific recognized factor. The insulating value of the surrounding one can be added to that of the construction, being able to come to a reduction in the energetic consumption.

- Free usable surface.

The use of the vegetable closings can turn into an alternative of economic maintenance from culturing or urban gardens.

SELECTION OF SPECIES FOR OUR GREEN WALL

For the incorporation of the vegetation (bio/element) in the surrounding architectural ones it is necessary to study the vegetable kingdom to know the morphology and the characteristics of which they can take advantage for our purpose.

SOME PLANT SPECIES SELECTED FOR THE EXPERIMENTAL STAGE.

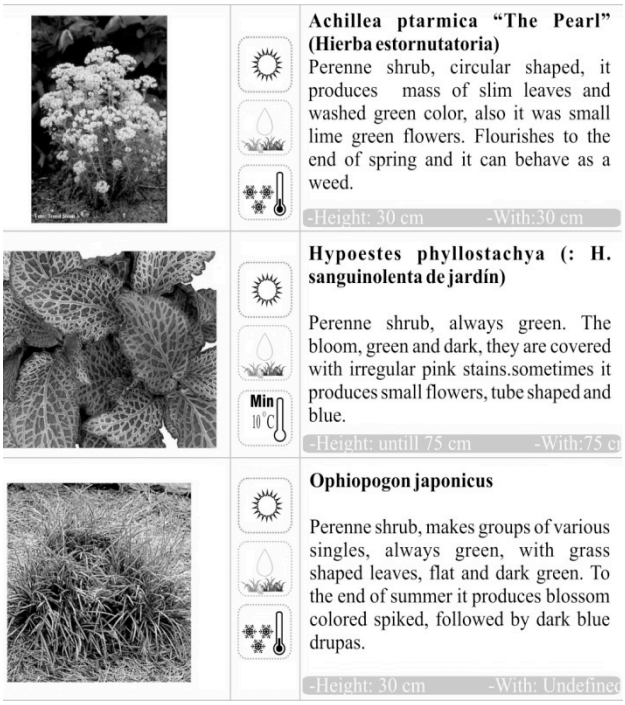

Figure 1: Specification sheets of some species of plants that might be in use.

DESIGN OF PROTOTYPES

The system consists from a module of four fixed pieces, which can be repeated as many times as it is necessary, to the fixed pieces they there is inserted a mobile piece that will be the manager of sheltering the plant.

Thanks to the scheme in squared pattern, our vegetable wall, it allows more possibilities in the design, using every piece as a "pixel" or small fraction of the global drawing, and taking advantage of the pigment of the leaves and colors of inflorescences for the creation of an image or landscape.

Figure 2: Photomontage on urban landscape, using our green wall system.

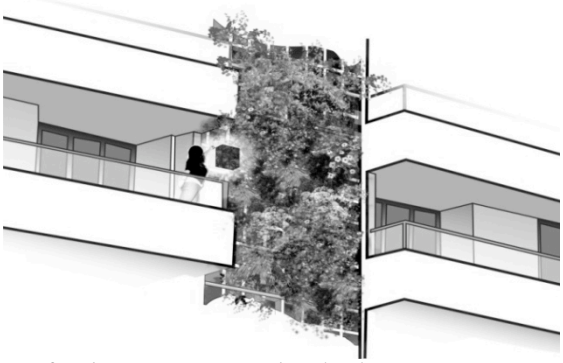

Figure 3: Photomontage on urban landscape, using our green wall system.

ADVANTAGES OF THE SYSTEM

- Easy installation: The modules come in different dimensions that are very practical for manipulation. It is installed in the same way as a wall of masonry is made.
- Multifunctionality: These elements can be in use in public or private buildings, in urban or rural spaces and in spaces for different uses.
- Easy maintenance: The fixed pieces do not need a specific maintenance and the mobile pieces are of very easily replaced.
- System of irrigation: The system of irrigation consists of a pipeline that travels across the pieces and a small water-sprinkler of water that works for every 4 pieces and graduates according to the need of every climate and / species.
- Independent Plants: This one has big differences with other green walls that are known. The mobile pieces are small baskets each one sheltering a plant, hereby infinite designs can be done, vertical gardens can be set up and in case a plant dies or decays, the whole wall does not meet affected since it can be replaced individually very easily and in an independent way.

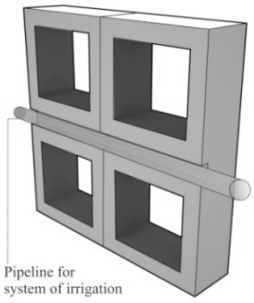

Figure 4: Basic module with system of irrigation.

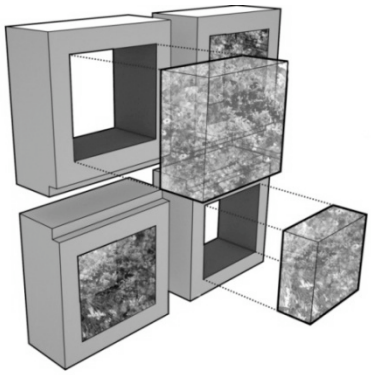

Figure 5. Basic unit of design to build vegetable walls that can be changed according to the plant species and / or of the building requirements.

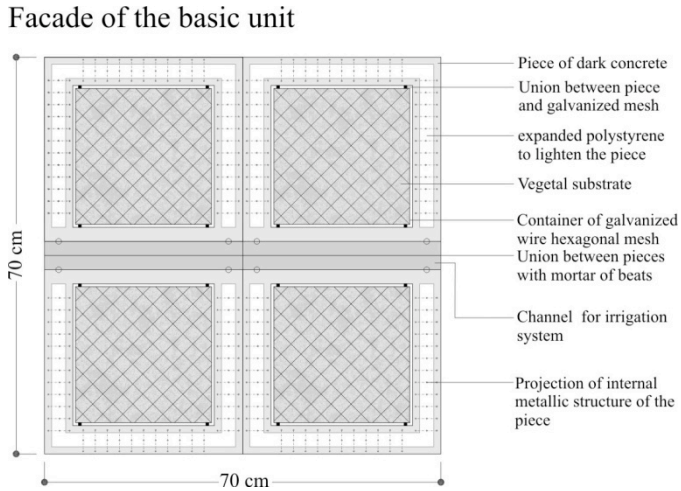

Figure 6. Plan of façade of the basic unit.

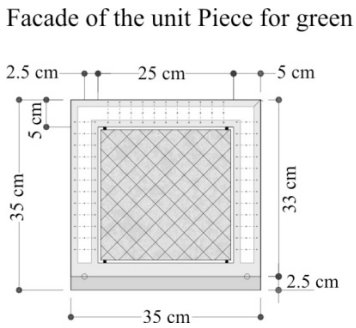

Figure 7. Plan of façade of the unit piece for green wall.

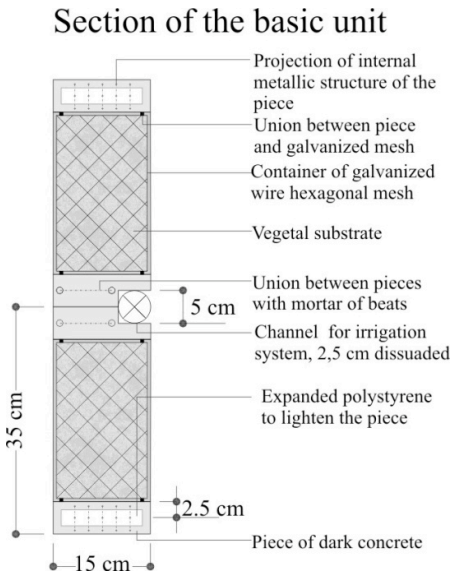

Figure 8. Plan of section of the basic unit.

TYPES OF PIECE COMPONENT Since one of the aims of this design is to be versatile, it can be used in walls and closings in any type of building, for any use and / or in any location, each of four basic pieces can be made in three different ways.
TYPE 1: Allows the vegetation grow in both faces, in the interior as well as in the exterior of the space.
TYPE 2: Allows that the vegetation should grow for an alone face, or only in the exterior of the space.
TYPE 3: Block completely closed to insert in the design as be needed.

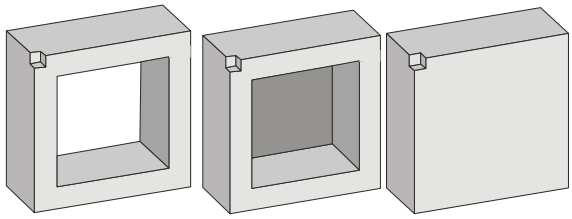

Figure 9: Piece type 1,2 and 3.

CONSTRUCTION OF PROTOTYPES
We construct a wall of 1,00 x 0,70 m to which different species of plants were sowed. The wall was located in the campus of faculty of Architecture of the UPB, in order to do the follow-up to the growth of the plants, and to the general functioning of the system.

What we have observed till now, is that the wall expires with the raised expectations. The plants grow well inside its basket, and the system of irrigation had not generated dampness. The research even continues.

Figure 10: Photo of experimentation with prototypes.

ACUSTIC EVALUATION OF PROTOTYPES
INSTRUMENTS OF MEASUREMENT For this research there was pertinent the accomplishment of a special box that was making simpler the acoustic valuation of the prototype of vertical garden.

This box has a few special conditions of soundproofing. The box is constructed by MDF and polystyrene expanded of high density. Due to the properties of the sound and its form of spread, this box has the same conditions in each of its sides, two MDF's sheets of 12 mm and in the way a sheet of 3 cm of polystyrene expanded, making this way easier the valuation of acoustic absorption of the panel.

The measurement of the tests was in use as instrument a sound level meter BK PRECISION SOUND 732A, with RS232 detection. This instrument of measurement catches from 30 to 130 dB, in three measures: high place, average and low, with a precision of + - 1.5 dB; besides a rapid or slow measurement.

For the tests realized, the sound level meter was programmed in a speed of slow measurement and with 30 to 130 dB detection.

Figure 11:BK Precision Sound732a

METHODOLOGY OF MEASUREMENT The test was realized placing an industrial stamp in one of the short sides of the box, and the instrument of measurement in another side, so that the prototype stays in the way checking the sound quantity that it absorbs.

Before realizing the tests corresponding to the prototype of the green wall, the box and the stamp were submitted also to the acoustic pertinent valuations for the comparison and analysis. Three evaluations were realized by two stamps, each one composed by five evaluations of five seconds each one. These proofs were:
1. Stamp got in the opened box and the sound level meter on the outside.
2. Stamp got in the sealed box and the sound level meter on the outside.
3. Stamp got in the box sealed together with the sound level meter.
The box is sealed whenever a proof is realized.

ACOUSTIC TESTS For the prototype of the green wall there were realized 10 tests of 5 seconds each one, with two different stamps. The tests were realized by the prototype sowed with plants, to verify the absorption of them. The prototype is introduced in the box, staying in the middle of the stamp and the sound level meter. The box is sealed whenever a proof is realized.

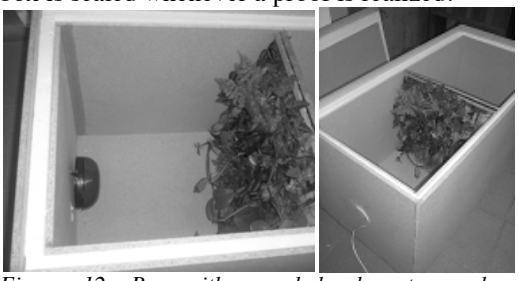

Figure 12: Box with sound level meter and green wall prototypes.

ANALYSIS OF RESULTS

- Measurement of the box without the prototype of green wall:

Table 1: Results of box with stamp 1 and 2.

TEST STAMP 1	Stamp to the interior with the opened box and the sound level meter on the outside.	Stamp to the interior with the sealed box and the sound level meter on the outside.	Stamp to the interior with the box sealed together with the sound level meter
	MAX dB	MAX dB	MAX dB
1	109.4	79,7	119,3
2	112.6	77	118,7
3	114.3	79	118,1
4	114.3	82,8	117,8
5	115.3	80,7	117,9

TEST STAMP 2	Stamp to the interior with the opened box and the sound level meter on the outside.	Stamp to the interior with the sealed box and the sound level meter on the outside.	Stamp to the interior with the box sealed together with the sound level meter
	MAX dB	MAX dB	MAX dB
1	111	85,6	106,6
2	111,8	72,6	117,6
3	111,4	73,9	116,3
4	111,3	73,2	117,2
5	111,1	72,6	117,2

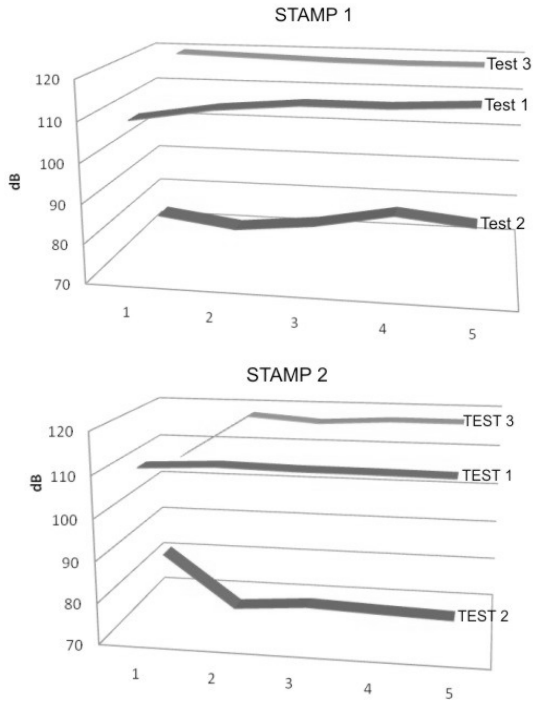

Fig. 13: Comparative graphs among the results of the stamp 1 and 2.

In the first proof, both the stamp and the sound level meter got to the box, but this one was not sealed, doing a checking of the scope in decibels that the stamp can have. In this case the stamp 1 produced less regular results with an average of emission of 113,18 dB, in comparison to the stamp 2 with an average of 111.32 dB. In the second proof, the stamp was introduced in the box, which was sealed and the instrument of measurement was left in the exterior of this one, to verify the efficiency in acoustic isolation of the box. In case of the stamp 1 the information was less regular like in the previous test, with an average of 79,84 dB, in comparison with the stamp 2 with an average of issue of 75,88 dB.

In the third case, both the instrument of measurement and the stamp were introduced in the box, which was sealed to verify the conditions of noise to the interior of

this one, to which the prototype would be submitted and with which it was compared. The stamp 1 unlike in the previous tests, it had more regular results with an average of 118,36 dB, in comparison with the stamp 2 that it emitted in average 114,98 dB.

-.Measurement of the box with the prototype of green wall:

To prove the acoustic absorption of the prototype of green walls, two tests were realized by two different **stamps, each one by 10 evaluations. The prototype was** introduced in the way of the stamp and the instrument of measurement, verifying the sound quantity that is absorbed by the prototype.

Table 2: Results of green wall prototype. Stamp 1 and 2.

	STAMP 1	STAMP 2
TEST	MAX dB	MAX dB
1	105,8	93,8
2	105,3	93,7
3	101,4	93,8
4	100,9	94
5	104,7	94,2
6	101,4	93,8
7	100,6	93,4
8	100,7	93,3
9	105,2	92,2
10	104,2	93,3

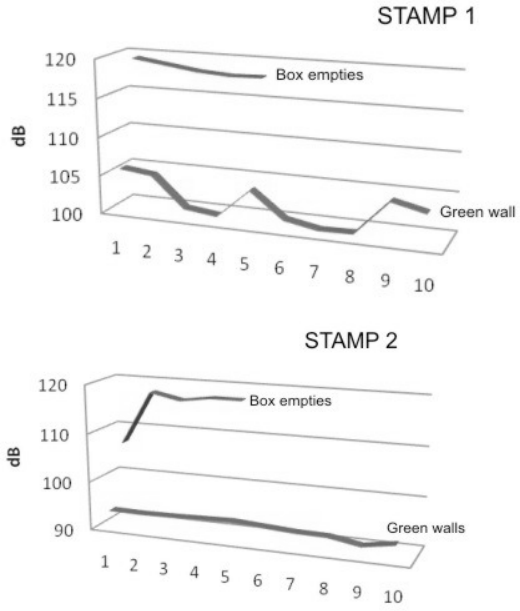

Figure 14: Comparative graphs among the results of green walls absorption with the stamp 1 and 2.

These graphs show the sound quantity in dB that passes across the panel and is measured by the sound level meter. In case of the stamp 1 the sound quantity that manages to pass across the prototype goes from 105, 8 dB maximum up to a minimum of 100,9 dB. In case of the stamp 2 with a few results with major regularity the sound level meter reaches a maximum measurement of 94,2 dB and a minim of 92,2 dB.

In average the sound quantity that manages to catch the instrument of measurement in case of the stamp 1 is of 102,42 dB and in case of the stamp 2 it is of 93,2 dB, in comparison with 118,36 dB of the stamp 1 and 114,8 dB of the stamp 2 without the prototype.

CONCLUSIONS

The prefabricated system allows its use in any type of building. The design is very versatile which allows innovating with the use of the vegetation and the interaction of the people and it. Green walls would be very efficient in acoustic absorption, and it would be of great utility for exposed spaces to very much noise.

For this research, it was important to check simultaneously the absorption that has the box of proof, to guarantee that the prototype was exposed in a homogeneous way and without oppositions to the noise emitted by the stamp. This box of proof reach an isolation of 32.55 % of noise of the stamp 1, and 34.3 % with the stamp 2, while this one was inside the box and the instrument of measurement in the exterior. In case of the absorption of the prototype, the proofs helped to corroborate the acoustic qualities of this one. Of 118,36 dB to which the instrument of measurement was exposed, the prototype managed to absorb 13.47 % of the noise emitted in case of the stamp 1 and 18.95 % in case of the stamp 2. The research even continues. Measurements will continue done to see the long-term response.

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