

## 225: Green Walls and their Contribution to Environmental Comfort: Environmental Perception in a Residential Building

Mariene Valesan (1); Miguel Aloysio Sattler (2)

*Programa de Pós-Graduação em Engenharia Civil /NORIE  
Universidade Federal do Rio Grande do Sul, Porto Alegre, RS  
(1) [valesan.arg@gmail.com](mailto:valesan.arg@gmail.com); (2) [masattler@gmail.com](mailto:masattler@gmail.com)*

### Abstract

This is an exploratory study which intends to discuss the advantages and disadvantages of the use of green walls. Interviews with dwellers of a residential building in Porto Alegre were conducted. The questions, related to the satisfaction of residents with the building and the flat, also evaluated the influence of climbing plants on the following aspects of the building: temperature in summer and in winter, thermal and acoustic insulation, humidity, presence of bugs, aesthetics and maintenance. The residents are satisfied with their homes, which were been considered comfortable, spacious and well located. There were different opinions on the usage of green walls. Some of the users consider it interesting, beautiful and capable of making the building remarkable in the neighborhood. One of the residents, however, said climbing plants give a derelict aspect to the building. The residents believe the green wall influences in a positive way the thermal comfort of the rooms, mainly reducing the environmental temperature in summer. Maintenance and the need to prune the climbing plant are the main reasons for dissatisfaction among householders, but humidity and the presence of bugs were considered irrelevant.

Keywords: vegetation, buildings, green wall, environmental comfort, environmental perception.

### 1. Introduction

The diversity of characteristics and benefits attached to vegetation indicate its versatility as well as the advantages of its application in environment. Among the possibilities of greening cities, there is the use of green walls: vegetation covering facades of an building, wall, or other vertical element. Some advantages of this technique are: thermal insulation, the reduction of energy consumption for air-conditioning, the reduction of the incidence of sunrays in the facades of the building, as well as psychological well-being and aesthetical benefits.

It is claimed that this system creates problems for its user, such as constant maintenance; the presence of unwanted animals, especially bugs; and humidity, which is capable of damaging the constructed elements. However, these opinions are unconfirmed by scientific studies, and cannot be considered true.

Considering the potential advantages of the usage of green walls and the little knowledge documented about its application, this paper purpose is to discuss the performance of green walls as building covering.

It aims at evaluating the perception of application of green walls in buildings in the subtropical humid climate, typical of the south of Brazil, and also to identify the possible advantages of disadvantages of its usage, as well as the receptiveness of this practice in the view of the dwellers of a building with green walls.

### 2. Vegetation and Environmental Comfort

Vegetation acts over climate elements and urban microclimates, contributing to the control of solar radiation, temperature and air humidity and softening the climate extremes.

Plants can also control the action of wind and rain, and ameliorate the effects of pollution. Besides that, the improvement of physical characteristics of urban soils and urban hydrology were verified. Moreover, the increase in diversity and quantity of urban fauna and improvements for the human well-being were also observed [1, 2 and 3].

The benefits of its usage vary according to the kind of vegetation, its size, age, phytosanitary state, period of year, forms of association among different plants as well as their relationship with buildings and urban spaces. Besides that, vegetation may reduce discomfort caused by excessive daylight, creating transition zones across the areas with different shadowing and allowing a better visual accommodation to the environment lightning [4].

Concerning the climate benefits, the usage of vegetation, as a microclimate modifier is a system that does not require any advanced technology. It is simple and applicable in any part of the world. The rational and intelligent usage of vegetation, intending to allow better climate conditions is vital for future generations and for sustainability [5].

The usage of vegetation is also translated into benefits for human well-being. There are some theories that provide explanations on why the

man feels comfortable in the presence of vegetation. One of these theories, developed by Roger Ulrich, deals with biophilia and biophobia hypothesis. According to this author, biophilia is the set of positive sensations that vegetation and natural elements arouse on human beings. As well as biophobia is manifested in negative sensation, such as fear or aversion, related to some natural elements, including some animals. Both manifestations possessed, according to their authors, an innate partial genetic basis [3]. For human beings, parks with green complexes can be seen as a refuge from daily stress and are used as a place for recreation and rest. Spending time close to nature is used in some health institutions in order to promote patients' healing process. This sort of contact with nature is also extreme important for children's development mainly in the areas of motor skill and social interaction, being therefore largely used in schools. Moreover, contact with green and nature result in tangible benefits for the development of students, especially in terms of promoting environmental awareness. Besides that, vegetation in disadvantaged neighbourhoods can perform additional functions when compared to formal cities: besides ambient and composite, there are medicinal and feeding ones [1]. Landscaping also can contribute to the maintenance of a balanced ecosystem, provided that, there is the usage of native species and existent plants of a site, which are adapted to climate and nature of the region and integrated to natural landscape. Draining and erosion control are also favoured with the implementation of green areas, in detriment of paved areas.

## 2.1 Green Walls

As well as other ways to use vegetation near buildings, it is established that green walls can contribute significantly for environmental comfort. In studies conducted by McPherson, Simpson, Holm and Livingstone, softer temperatures were observed during day and night related to vegetal covering in the facades. This vegetal covering works as skin wrapping the building, capable of reducing the amount of energy necessary for heating or cooling the indoor spaces. The climate performance of the building can be significantly affected by green walls, besides the noticeable changes regarding temperature, the solar gain by direct solar radiation and long-wave heat as well as convection. Besides that, changes in the humidity levels are also perceived [5].

In summer, climbing plants shading reduces the gain of solar radiation, due to the angle of the perpendicularity of their leaves to the sunrays.

It might, as well, create wind barriers, change the wind direction and make the hot air be conducted faster to the top of the building. The evaporation and transpiration are responsible for an additional cooling power. In addition to this fact, in winter, evergreen species create a layer of air between the masonry and the environment, reducing the heat loss by convection.

Besides that, contrary to popular thinking, facades covered by vegetation can be used as

barriers for extreme humidity in winter, because leaves work in the avoidance of direct contact of rain water with the masonry [6 and 7].

Considering possible problems of building deterioration caused by climbing plants, the opposite is usually verified. In several cases, vegetal covering works as a masonry protection, making its deterioration considerably slower than the one of as wall exposed to extreme climate conditions [6]

### 2.1.1 The species *Parthenocissus tricuspidata*

The popular name of the species found on the studied building is Boston Ivy, whose scientific name is *Parthenocissus tricuspidata* and its a member of the Vitaceae family. Such species is an herbaceous climbing plant, native from Japan and China. Its branches have octopus suckers, with a gluelike substance which allows the climbing plant to attach on any surface. Its dark green shiny leaves of variable size have three points and irregular boards. In temperate climate, the leaves acquire red and purple coloring in the autumn and fall in the winter. They have a continuous growth and easily multiply by stakes [8].

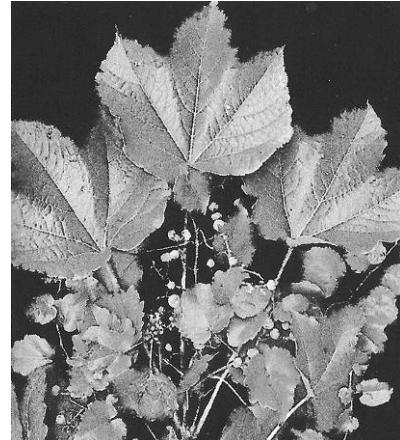


Figure 1: leaves and fruits of the Boston Ivy (Lorenzi e Souza, 2001).

It is a species of fast growth, that do not require much soil care. Its branches can growth to a height of 15 meters. It is also used as a fountain for nectar and pollen for bees, besides being used by some bird species as a nest construction area, as long as it is supported by a trellis [6]

## 2.2 Porto Alegre Climate

Porto Alegre is located in 30°S latitude and 100 km away from Atlantic Ocean west. It is considered a region of humid subtropical climate, in which there is a wide range of weather changes along the year. Average temperature is 19.5°C and extreme temperatures can oscilate between 40.7°C and -2.4°C. The relative humidity is high across the whole year and has an annual average humidity of 75.9%. Abrupt changes in the weather are frequent and related to the movement of air masses. The main ones are: the Maritime Tropical Mass, Maritime Polar Mass and the Continental Tropical Mass. Phenomena known as "mugginess" and "veranico" (Indian

summer) frequently occur. "Mugginess" is characterized by 3 or 4 days of high temperature and hygrometric level along the year. "Veranico" happens in the autumn and is characterized by hot days, with clear sky and soft wind. During autumn and winter, the low temperatures are associated with the Maritime Polar Mass. This mass is responsible for abrupt falls in temperature, lasting 3 to 9 days and reaching a minimum that varies between 0°C e 3°C. Precipitation is uniform along the year, with a monthly average between 90mm and 190mm. Strong winds are common in December and January. In winter months, wind can be cold and humid (when associated with Maritime Polar Mass movement) or cold and dry (when associated with Continental Polar Masses). This last combination is called generally as "Minuano" [1 and 9].

### **3. Method**

This is a preliminary study of exploratory and investigative character. It is exploratory, because it is a subject so far almost unexplored, aiming at offering hypothesis and research proposals for future papers [10]. The investigative approach was chosen, due to the intention of discovering, in depth, the opinion of users. The study object was chosen for being a multifamiliar building with green wall in all facades.

As for the evaluation format of this object, the choice was environmental perception, which is the technique responsible to investigate the interaction between humans and the environment, using theories and methodologies of different knowledge areas, such as environmental psychology, geography, sociology and architecture [11]. The interdisciplinary capacity of environmental perception along with its recent surging (in architecture, the first studies are dated from the end of the 50's [12]) result in a diversity of methods that can be adapted according to the objectives of the research.

In this work, interviews structured in a questionnaire were the main tool of investigation, once a higher comprehension of the need and values of users of green walls is needed.

As a complement to such interviews information on the project building and its history were also researched, using a data gathering process in the city hall of Porto Alegre, and also information collected with apartment owners. Besides that, several photos were taken to record the different stages of the green wall, and other pertinent details.

The interviews were based on a mixed questionnaire, composed of open and close questions. The questions were divided into themed groups: general data (date, hour and weather characteristic on the day of the interview), subject data (gender, age, monthly family income, education, number of inhabitants/apartment and time of residency), owner satisfaction and, finally, green wall characterization. The questions related to owner satisfaction intended to analyze the satisfaction

with the building and with the apartment, including their opinion regarding environmental comfort. Last but not least, the questions about green wall characterization investigated the owners' opinion on the vegetal cladding and if that was an influent factor in the choice of their apartment as their home. Besides that, it was also questioned its influence regarding the factor: summer and winter temperature, thermal and acoustical insulation, humidity, animal presence, maintenance and aesthetic.

To each of these items, each subject was requested to define the influence of the green wall as being positive, negative or indifferent, and to justify their choice.

One inhabitant from each of the three occupied apartments was interviewed. The questionnaire was also applied to the building caretaker. However, considering the specific nature of the caretaker's activities in the building, in the final analysis of the interviews, his considerations were only taken into account regarding green wall characterization. After the interviews, their recordings were tape scripted and afterwards the analysis of the answers was conducted.

### **4. Results**

#### **4.1 The building**

The building is located in an upper class suburb in Porto Alegre. The terrain has an area of 852m<sup>2</sup>, with approximately a 20X42m dimension. It is located in a corner, with a slope of 5m. The studied building is exclusively residential. According to its inhabitants, this building was constructed to be used by one family: a couple, and their three children. In the total, four apartments were planned, in which the family carried on living for several years. However, due to the death of the patriarch, the remaining members of the family gradually sold their houses. None of the initial owners reside in the building today.

According to files of the Municipal City Hall of Porto Alegre, the approval of this project was issued in 1980 and the inhabitance letter in the year of 1982. The constructed area sums up to a total of 1.211m<sup>2</sup>, divided in four floors. In the ground floor deposits are located that belong to the condominium, the caretaker apartment and the garage. The second floor has two apartments, with a constructed area of 193m<sup>2</sup> and 182m<sup>2</sup>. The third and fourth floor has two other duplex apartments, with a constructed area of 322m<sup>2</sup> and 291m<sup>2</sup>. Each of them has a broad living room; three bedrooms (one of them a suite); kitchen; service area; maids room and study. Besides that, the duplex apartments have a second floor composed of recreation room, with a place for barbecue and a terrace with pool. Few alterations were perceived regarding the dimension and arrangement, when compared to the original project.

It was related by the residents that the green wall was a part of the original project and that the family appreciated a lot the presence of the

climbing plants in the building. The young climbing plants were brought from Germany and planted in all facades, as soon as the civil work was ended. That is the reason why there is no other covering external to masonry, except render.

The climbing plant is responsible for the covering of the different facades, in all aspects. As their leaves fall in the autumn and winter, the building has two different visuals across the year, as seen on figure 2.

As for the householders, one apartment is occupied by a couple and a son; the other, by a couple and two children and the third one by a woman and her three sons.



(a)



(b)

*Fig 2: Different visual of green walls: in the end of the winter (a) and the beginning of summer (b).*

#### 4.2 Analysis of the Interviews

The interviews were conducted in October 2007. The weather in those days was sunny, with considerable high temperature (approximately 30°C). The interviewees were in the number of three, a male and two females. Their ages varied between 44 and 53 years, with a secondary or higher educational degree. Family incomes varied approximately 3 to 15 thousand euros. Last but not least, household owning time is 1, 5 and 9 years.

Regarding the questions related to the opinion of the householders on the building and the apartment, it was perceivable that they were satisfied with the location, which they considered to be highly convenient. Two of the subjects

considered the building beautiful, however, the third one disagreed with this view. In his opinion, this was positive, because the region was highly aimed by thieves and he believed that it was safer to live in a more discrete building and that "does not attract so much attention".

About the condominium area, the householders claimed that there were not many leisure options. One of them mentioned that he fulfilled this need for physical activities in a sports club and the householder in the second floor, who did not have a recreation room, suggested the construction of a common room, with a place for barbecue. The remodeling of the garden that surrounds the building and the desire for a lift were also mentioned.

Regarding the apartments, the residents considered them to be broad and none of them suggested any changes. Regarding the comfort, the householders were also highly satisfied. The sun orientation was considered good, since both flats in each floor had good sunlight along the day. One of the householders added that the usage of air-conditioning was really rare, because the inner temperature was generally satisfactory. Just one of the rooms, facing west, was considered problematic, too hot in summer, and too cold in winter. In general, summer temperature was considered to be very pleasant, and winter, just a little below comfortable, however, not enough to change the positive opinion of the householders.

Regarding green wall, it was noticeable that there was a conflict of opinions. One of the householders was enthusiastic about the Boston Ivy and was also involved in its conservation and the consciousness of other owners:

*When people came, they did not do it due to the vines, they came because the apartment is huge, located in a good area, with a reasonable price and with an inexpensive condominium. Because it does not have any expensive infrastructure (...) But that is attractive! So, they look and say: this has to be removed [referring to the green-walls].*

*It is awful! This apartment was already sold three times. And the new householders, when they arrive, they think about taking it out. I had lots of trouble, as soon as they arrive, they think it is bad. So, I imagine that the real estate agent, in the time of selling, says something like: do not worry, they are thinking of removing it, they are remodeling the façade. They end up buying and there were no changes being made at all. When one of the owners bought, before coming here, before signing the deed, I remember that I talked and had an argument with him, because he said that he was going to remove it from his part. And I told him no, you can not remove it because it is the facade and it was like this, awful. (...) Some people said: in the winter the building is ugly, it can get creepy sometimes, it has just branches in the wall, without leaves,*

*looking like an abandoned house. But it depends on your focus, on your way of thinking. In my opinion, it is interesting to live in a place that has different facades along the year, in summer, you have one, in the winter another, and yet another in the autumn. It is not always the same and I like that.*

In this testimonial, it was noticeable that, for some, the presence of green wall is considered to be positive, and, for others, it is negative. It is an interesting issue to be raised, because it goes against biophilia theory, which claims that vegetation has a positive impact of human beings' physical and mental well-being. Besides that, some consider that its presence decreases the value of the building, producing an undesirable visual, of an abandoned building. Complementary to this point of view, the caretaker said that there is a difficulty for the sale of the unoccupied apartment, due to the climbing plants and quoted some commentaries made by a few that were interested:

*It is because of that [referring to the green wall]. It is simple: people think that is bad. There are several who dislike it, who wanted all to be taken off (...) A lot of people came to look at this apartment [referring to the vacant apartment], but when they went to look inside, they were already disappointed it. It is on sale for years now, and just does not sell. They are almost closing the deal and then, when they turn the corner, they see something that just is derelict.*

The third subject considered the green wall beautiful, in spite of admitting that, when she moved in, she thought about removing it. What is perceivable in this case, is the change in the opinion along the time of permanency in the building. This owner also added that, in general, the green wall is highly appreciated by visitors and friends. In spite of receptiveness, the existence of buildings with this kind of cladding system is rarely seen.

*Even when we came here, we said: let's see what we can do to remove the Boston ivy, to paint, to improve the visual, but once you get used to it, it is so nice, that you just want to have it there. Everybody loves it, it is pretty cool. It is just different! In the winter it is not so nice, because the leaves fall, looks like an abandoned building, but afterwards, in the summer, it is beautiful again. At the end of September, the sprouts begin to grow; and in October, everything is covered. (...) There is a bunch of people sharing the same opinion. When I tell them that I live in a building covered in ivy: they all love it! It is curious, because you are used to see lots of houses looking like these, but just few buildings with vegetation.*

This is an issue that requires further studies for its comprehension, because it is important to know what percentage of users consider green walls as an interesting solution and why it is not

more often used. This variation of receptivity to the technique should be known, to avoid unsatisfactory application, in spite of its comfort benefits. Perhaps this technique aims at a specific user, who holds a strong bond with nature and vegetation. To people with a practical viewpoint, green walls can be unattractive. A good example is the subject who dislikes trees, because leaves in autumn cover the ground and can cause accidents making it slippery.

There are some factors that could be considered a problem and might explain the uncertainty regarding the use of green walls. They are mainly the presence of bugs and humidity. In spite of this common assumption, owners claimed that there were no bugs or other animals in a high number that could be noticed in comparison with other buildings and they considered that the green wall does not exert influence in such aspect. It was observed that none of the apartments had net on the windows to avoid the entrance of insects. One of the owners considered the presence of birds as positive, in spite of the commentary of another owner that said that the birds do not build their nests on the green wall. Therefore, their presence in the region is due to other factors. As for the humidity existent in parts of masonry, which was the cause of mould and spots, the residents did not believe them to be related to the green walls. The building had some infiltration problems, next to the windows, which was considered by the owners to be caused by the low quality of frames and other construction problems.

According to the interviewees, maintenance was the factor highlighted as the one which demanded the highest care. It was considered as a negative aspect, by one owner and unimportant, by the remaining two, because, in their view, the necessary prune was equivalent to the repairs in the painting that would be needed in the absence of the vegetal covering.

*It is a lot of work, because you have to maintain it pruned, it grows very fast in this period; you have to be always pruning; it starts to get attached to the windows. But you do not have to paint the walls, so it is indifferent. The hardest work is to cut around the windows, because it grows, starts to get attached and I can not take it away, then I have to work my way around or to call for help.*



*Figure 3: In spring and summer, the prune should be frequent to avoid the hardening of the openings.*

This same owner completed his opinion referring to the damage cause by green walls due to inadequate maintenance. In general, new owners are used to prune the branches in a way that harms the vegetal composition on the facades, mainly in the openings.

There was one gardener hired to do the maintenance of the Boston Ivy and other garden species. However, this care seemed to be insufficient in spring and summer, when the green wall prune became a daily activity of the caretaker. Otherwise, the branches would cover the window, hardening its opening and damaging its painting, because the suckers used for its fixing keep attached to the shutters, when the undesired brunches are removed.

Being questioned about the relationship between the green wall and temperature, the subjects said that the climbing plant had a positive influence on temperature during the summer. One of the owners added that he did not know if there was an effectively change in the indoor temperature or if the climbing plant just had a psychological impact. Regarding the temperature during the winter, two of the interviewees said that the green wall had no influence on it; one of them pointed out that the absence of leaves allowed sunrays to reach the masonry, heating the wall as it happens in other building without it. The third one said that there was a negative influence, because the ivy did not let the apartment receive the sun warmth. Referring to thermal insulation, two subjects mentioned a positive influence and the other disagreed. Two owners did not notice difference in acoustical insulation, and the third one perceived a positive, although subtle, influence.

## 5. Conclusion

This paper tries to shed a light in the need of continued researching related to green walls and environmental comfort.

In the case of the studied building, the residents were satisfied with indoor space and comfort. However, the green wall was not viewed as positive by all of them. In spite of the fact that two subjects had a favorable opinion regarding the green wall, the third one think that it gave the building an anti-aesthetical aspect. The prune was the main cause of conflict between the residents and aspects, such as the presence of bugs and humidity, were not considered relevant. Concerning the influence of the green wall on the apartment comfort, it was affirmed that it was positive.

It is understood that this study should proceeded, in order to investigate, among other aspects, the variability in the degree of satisfaction related to the use of evergreen or deciduous species as wall covering.

It is also believed that the same questionnaire should be applied to the users of other buildings covered with green walls, aiming at obtaining a sample with statistical relevance. It would also be

important to gather the data of the climate conditions of the studied building. So, a comparison can be held between the findings and the answers given by the householders about environmental comfort.

## 6. References

- 1 - Mascaró, L. *Ambiência Urbana*. 2<sup>a</sup> ed. Porto Alegre: +4 editora, 2004.
- 2 - Sattler, M. A. *Arborização Urbana e Sustentabilidade*. In: X Congresso Brasileiro de Arborização Urbana – Anais. Sociedade Brasileira de Arborização Urbana. Centro de Eventos Araucária. Maringá, PR. 2006.
- 3 - Schanzer, H. W. *Contribuições da vegetação para o conforto ambiental no campus central da Pontifícia Universidade Católica do Rio Grande do Sul*. Dissertation presented at "Programa de Pós-Graduação em Engenharia Civil" / UFRGS. Porto Alegre, 2003.
- 4 - Weingartner, G. *Levantamento sobre os aspectos relativos à influência da vegetação no desempenho térmico dos edifícios*. Dissertation presented at "Programa de Pós-Graduação em Arquitetura" / UFRGS. Porto Alegre: PROPAR, 1990.
- 5 - Cantuária, G. C. *Microclimatic impact of vegetation on building surfaces*. Master Thesis – Environment and Energy Studies Programme. London: A.A. School of Architecture, 1995.
- 6 - Johnston, J. e Newton, J. *Building Green: a guide to using plants on roofs, walls and pavements*. London: The London Ecology Unit, 1992.
- 7 - Dunnett, N. e Kingsbury, N. *Planting Green Roofs and Living Walls*. Portland: Timber Press, 2004.
- 8 - Lorenzi, H. e Souza, H. M. *Plantas ornamentais no Brasil: arbustivas, herbáceas e trepadeiras*. 3 ed. Nova Odessa, SP: Instituto Plantarum, 2001.
- 9 - Menegat, R. (org.). *Environmental Atlas of Porto Alegre – condensed version*. Editora da Universidade – UFRGS: Porto Alegre, 1998.
- 10 – Gil, A. C. *Métodos e técnicas de pesquisa social*. 5. ed. São Paulo: Atlas, 2006.
- 11 – Whyte, Anne. *Guidelines for Field Studies in Environmental Perception*. Technical Notes 5. Paris: UNESCO, 1977.
- 12 – Bonnes, Mirilia and Secchiaroli, Gianfranco. *Environmental Psychology: a psycho-social introduction*. London: Sage Publications Ltd, 1995.