Green Walls: Environmental Quality in Buildings

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ABSTRACT: The use of creeper in building walls is an important tool for architecture and engineering professionals, in the search of thermal comfort and energy efficiency. Creepers used as facade elements minimize the heat gain indoors, provide a better thermal condition and refinement performance of the construction. If green walls are thought of since the preliminary design stages - elaboration of necessity program, through even the stage of post-occupation evaluation, they can improve the performance of the built environment. In this paper information is being obtained in the evaluation of the thermal performance through measurements in two identical buildings, one of them with creeper and the second without creeper in the facades. The field work is being realized with the creeper Parthenocissus tricuspidata (ivy-japanese.,) In order to get information about the performance of the buildings, the environmental parameters were measured indoor and in the external area: air and globe temperature, relative humidity, wind speed, surface temperature of the internal and external walls. Results show differences in the performance of the two buildings. It can be concluded that the use of the vegetation at the facades can contribute in specific interventions in the development of practical instruments for the programs of thermal comfort and improvement of the performance in the built environment.
Keywords: thermal comfort, vegetation - creeper, environmental comfort.

INTRODUCTION

Researches about the urban environment in different climates are being carried out in several regions of the world, with the concern about the needs for well-being, life quality, and urban environmental comfort. The aspect of comfort deals with subjective aspects, people's sensation and their relationship with the environment. These aspects are represented by acoustic, lighting, visual, thermal and psychological comfort [1]. The present study has focus in thermal comfort in buildings, which involves a relation between indoor and outdoor spaces and the intervention exercised by the man, in other words, the internal environment is influenced by the exterior through man's activities [2].

The growth of the cities without urban planning, illegal constructions and great concentration of high-rise buildings reduce the ventilation in the urban spaces, bring the well-known urban climate problems - warming, poor ventilation, air pollution, intense and noisy traffic. There is also the problem of soil permeability, strong absorption of solar radiation, decrease of green areas diminishing evapotranspiration and air humidity levels. These are the characteristics of urban heat islands [3].

By observing the role of vegetation in the control of the incident solar radiation and as a regulator of the urban climatic changes, the importance of quantifying the influence of green areas not only on outdoor urban spaces but also on indoor environments. In Brazil, it is known that more pleasant temperatures occur in mild winter. In summer periods high temperatures are common, so the vegetation is a natural element for the control of solar radiation and to decrease the energy consumption for cooling purposes.

The aim of this work is to evaluate the contribution of the vegetation in walls, in particular the use of creeper in building facades, in order to attenuate the heat gain in the indoor environment. It aims to show the possibility of developing more coherent projects using this mechanism to solve and to minimize thermal discomfort in existing constructions, for people's well-being, creating a larger climatic balance in a thermally adequate and comfortable indoor environment.

THE INFLUENCE OF VEGETATION IN THE COMFORT OF BUILDINGS

The presence of vegetation in the urban centre contributes to microclimate mostly as thermo-regulator, soothing the solar radiation, temperature, relative humidity, modifying the direction, air speed, acting as acoustical barrier and providing shading [4, 5].

The vegetation minimizes the precipitation incidence in the soil, and modifies the humidity content in the air. Professionals of the built environment should use this tool for environmental functions as climatic control, temperature and air humidity balance.

The lack of vegetation caused by human interference causes larger energy consumption in the constructions. There are several studies about energy savings through the utilization of passive forms of climatization [5].

The study accomplished by Alexandri&Jones [6], reveals that green walls and roofs cool the environment and the microclimate around them. Their effect is to decrease the energy consumption depending on the climatic region and the quantity of vegetation in building facades. Besides, green walls improve the temperature conditions of the urban areas known as "heat islands" through passive cooling techniques, obtaining from 90% to 35% of energy economy.

According to Olgyay [7], shading through the vegetation is a fundamental element to the attainment of thermal comfort, mostly by decreasing the surface temperature of the soil and building facades.

There is an important point in the construction which keeps the relation between energy gain and loss through the wall or *skin*, regarding the permeability or barrier capacity between interior and exterior as resistance for the heat flow, depending on the internal and external temperatures.

The construction can benefit of thermal comfort through the vegetation with shading as a protection of direct solar radiation or using as a second *skin*. The creeper can be this second skin, mostly in places where there is little area for tree planting.

The innovative possibility to use the creeper at the facades for attainment thermal comfort as a natural element is easy to access and has low maintenance cost. They are powerful tools following the principles of bioclimatic architecture, but to Bunnett and Kingsbury [8] the creepers can reduce dramatically the temperatures of the building due to shading of this element. The effectiveness of this result is related mostly with the total extension of the shaded area and the thickness of the creeper, but it can be reduced up to 50%. The other important factor is the reduction of the speed of cold wind in the winter, through interlacing of the creeper. The thermal isolation is related to the age of the plant, thickness and the growing period.

Solar heat gains through opaque components in a building, depending on latitude, orientation and surface color, can strongly contribute to undesirable heating indoors. To achieve thermal comfort in buildings during hot periods it is necessary to control the elements of microclimate to prevent the excess of solar gains. The studies in the area of thermal comfort in built environments seek elements of nature; one of them is vegetation, the use of which is on the basic principles bioclimatic design. According to Givoni [9], "green areas, both public open spaces like parks and private planted areas around buildings, can have a marked effect on many aspects of the quality of the urban environment and the richness of life in a city. The environmental conditions within a public urban open space may have significant impact on the comfort conditions experienced by persons using them, and consequently on their utilizations by the public, especially in places or seasons of stressful climate".

METHODOLOGY

This work consists in a case study in the city of Campinas, located in the SE region of the State of São Paulo. The city has an area of 800 km², characterized by high rates of urbanization and industrialization. The latitude is 22°53´20´´S (South), Longitude 47°10´15´´ (West) and Altitude 694m above sea level.

The climate of Campinas is classified as tropical continental. In summer period, the maximum temperatures vary from 28,5°C to 30,5°C in November, December, January, February and March. In winter period, the maximum temperatures vary from 11,3°C to 13,8°C in June, July and August. So, there is a longer summer than winter, with a predominance of hot season. [10].

Two identical buildings were analyzed, one of them with creeper at the external wall and the second was painted with clear yellow, without vegetation in the corresponding facade.

In this paper, a comparative analysis of creeper influence in the buildings and the comfort degree reached realized in winter period is presented.

The residential building is used by university students. It is well-known in the city as student's dwelling. The apartments have 21,00m² in total, with 19 cm walls in ceramic block, tow, fine tow (figures 1 and 2). The external area was painted with clear yellow and inside the apartments with white color. Inside the apartment, there is ceramic floor, flagstone between levels, and the last floor is covered with ceramic tiles.

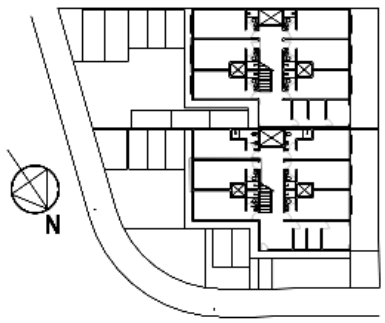

Figure 1 – Implantation of the construction in study.

Figure 2 – Facade of the construction in study.

Figure 3 – Facade without creeper (block 01).

Figure 4 – Facade with creeper (block 02)

Legend: ⟶ *Apartments in studies.*

The building consists of apartments with two blocks and two levels. The first block has no creeper in the facade, but in the second block external walls have the creeper *Parthenocissus tricuspidata* (ivy-japanese) (figures 3 and 4). The characteristics of creeper are very branchy stem, semi-woody, long thin and flexible branches, which grow high, supporting themselves in walls, façades or trees by means of their adventitious roots. They have aerial roots in staple form with the function to fastening the plants in supports or walls (figure 5.) The leaves are brilliant green with variable sizes. In winter the leaves fall down, but, before that, in the temperate climate the leaves edges become reddish and purple [11].

Figure 5 – Parthenocissus tricuspidata (ivy-japanese).

Collected data were air and globe temperatures, relative humidity, air speed, outdoor and indoor. Surface temperatures of the internal and external walls were also measured. The equipment is as follows:

- air temperature and relative humidity: two digital thermometers Testo, with automatic data recording, at 10 minutes interval.
- globe thermometer, with a sensor inside, for measurements of globe temperature and calculation of mean radiant temperature.
- thermoanemoter Testo, for measurement of air speed.

- surface temperatures of the walls through a probe fastened in the wall, for evaluation of the influence of vegetation on the wall surfaces.

RESULTS

The equipment was installed below the window, due to dimension of the apartment, in the facade frontal to southeast. Measurements occurred simultaneously in the two apartments, in the conditions explained above.
They were accomplished in the winter period from 08/07/2008 to 08/11/2008.

It was verified for the measured period in relation to air temperature:
- external area of construction reaches the maximum temperature 26,3ºC; inside the apartment without creeper the maximum temperature was 25,8ºC, and in the apartment with creeper, 24,5ºC. So there is a difference of 1,8°C in temperatures at the external area to the apartment with creeper. (Fig. 5)

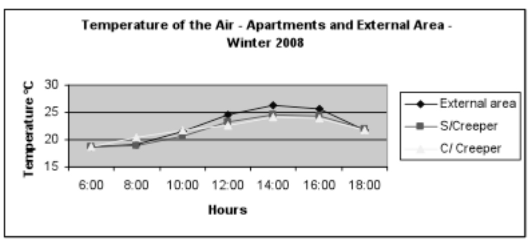

Figure 5 – Results of Temperatures of the Apartments and External Area of the building.
Average at period from 08/07/2008 to 08/11/2008.

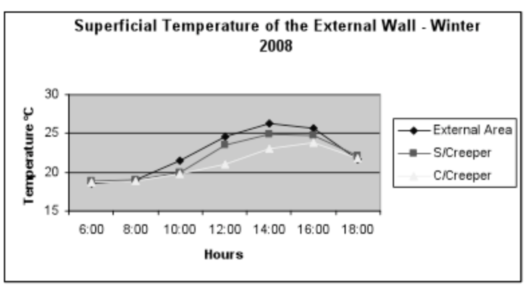

Figure 6 – Results of Superficial Temperature of the external wall of the apartments.
Average at period from 08/07/2008 to 08/11/2008.

During the day, the external wall surface temperature in the apartment without creeper showed a maximum 24,9°C, and for the apartment with creeper the maximum was 23,7°C. (Fig. 6)

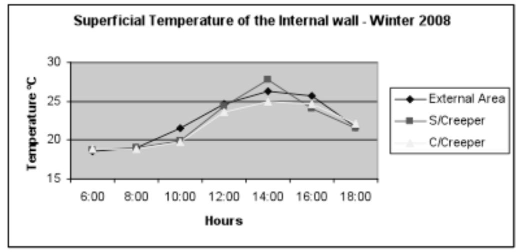

Figure 7 – Results of Superficial Temperature of the internal wall at the apartments.
Average at period from 08/07/2008 to 08/11/2008.

Inside the apartments, the surface maximum temperature of the walls was 27°C in the apartment without creeper, and 25°C in the apartment with creeper, but at the end of the day (18:00) for the apartment without creeper the temperature was 21,6°C, and in the apartment with creeper it was 22,1°C, bringing a pleasant temperature to the user at the nocturnal period. (Fig. 7)

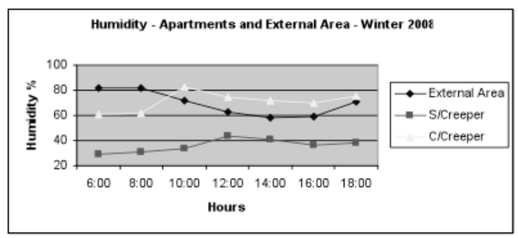

Figure 8 – Results of Humidity of the External Area at the Apartments.
Average at period from 08/07/2008 to 08/11/2008.

In relation to relative humidity, the area with vegetation, wall with creeper, it was verified that it reaches 75% in comparison to the area without creeper 43,8%, bringing a comfort to the environment. (Fig. 8)

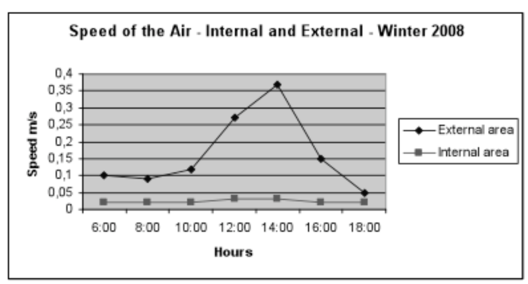

Figure 9 – Results of Speed of the Internal and External Air.
Average at period from 08/07/2008 to 08/11/2008.

In the measured period, the air speed reached at most 0,37m/s, and inside the apartments its value was 0,03m/s, resulting in days of soft ventilation. (Fig. 9)

From there results, it is possible to verify that the apartment with creeper, mostly in the afternoon period, keeps the temperature at most 25°C, and in the apartment without creeper had the value of 27°C demonstrating the efficiency of the creeper to minimize heat gain in the built environment.

In relation to the results for surface temperature of the internal and external wall, it was verified that the apartment without creeper in the facade, accumulates in its interior a higher temperature than the temperature of the exterior. For the apartment with creeper in the facade the results are more favorable, since the internal temperature is almost the same as the external temperature.

In the winter period this external temperatures varied from 15ºC to 32°C. In the apartment without creeper the variation was from 18°C to 27°C, while for the apartment with creeper the variation was from 18°C to 25°C. So the results demonstrate that the creeper in the diurnal period maintain the lowest temperatures.

The results obtained demonstrate that the foliages of the creepers act like insulating material, helping to keep lower temperature in the internal environment. At the nocturnal period when the wall returns the radiation received from the external area, it occurs slowly staying in the internal environment with a pleasant temperature. The first stage of this research shows that creeper has a potential of minimizing the heat gain.

CONCLUSION

It was verified a difference between internal temperature in the apartments with two arrangements in the facade: one facade with creeper and the other one without creeper.

The leaves of the creeper form a layer of thermal isolation helping to keep low temperature during the day and more pleasant environment during the night. It also allows the daily temperature to be kept in balance with the built environment bringing quality in the condition of thermal comfort. In the contest of urban environment, the introduction of green facades in the future constructions can soothe the effect of heat island, recovering the balance of the urban area and improving life quality.

To conclude, the research proposes to comprehend the operation of the vegetation with the environment in many aspects of thermal comfort, and to pay attention to the users' needs. The observations and evaluations accomplished hitherto show the possibilities of arguing some indicators for the improvement of the quality of the built environment.

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