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Behaviour of green facades in Mediterranean Continental climate

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ABSTRACT

In order to obtain data on the behaviour of green facades in buildings as a passive system for energy savings in dry Mediterranean Continental climate a long-term work has been performed. This paper presents the first results of two actions developed during 2009. First, the growth of four different climbing plants as well as their ability to provide shadow was studied. Second, monitoring for a year of a real green facade was carried out. The results confirmed the great capacity of green facades to produce shade, reducing the heat on the facade wall of the building. It was also verified that a microclimate between the wall of the building and the green curtain are created, characterized by slightly lower temperatures and higher relative humidity. This means that the green screen acts as a wind barrier and confirms the evapotranspiration effect of the plants. On the other hand, these results did not allow withdrawing conclusions about the insulation effect of green facades.

1. Introduction

The use of green vertical systems, well designed and managed, can be a useful tool for thermal regulation for buildings with interested energy savings [1]. But in evaluating the potential of these systems as passive systems for energy savings in buildings the following aspects must be considered.

First, the election of the type of the green vertical system has to be considered, as there are significant differences between systems. The construction system, the type of plants, the maintenance, and the operation, vary between systems (Table 1), and this will affect their behaviour as passive energy saving system [2].

Second, the parameters that influence their behaviour must be considered. Basically, there are four fundamental mechanisms that characterize green vertical systems as a passive system for energy savings: the interception of solar radiation by the effect of the shadow produced by the vegetation [3–6], the thermal insulation provided by vegetation and substrate [3,6], the evaporative cooling that occurs by evapotranspiration from the plants and the substrate [3,5,7], and finally, through the variation of the effect of the wind on the building [8,9]. The parameters that influence each of these mechanisms are summarized in Table 2.

Finally, it is important to consider that for the efficient operation of these systems it is essential to know the behaviour of the different species in local weather conditions, because the end result may differ greatly from one climate area to another, spoiling the expectations of energy savings that had been planned according to theoretical calculations for a given system.

Given the extreme climatic conditions in the area of Lleida (continental part of the region of Catalonia, Spain), it is even more necessary to have more knowledge about the development of these species in local weather conditions. *Lleida* has a climate classified as dry Mediterranean Continental, characterized by its great seasonal variations. It has low rainfall, that is divided in two seasons, spring and autumn and it has a thermometric regime with large differences between a long winter (between the spring and the last frost may take more than 160 days) and a very hot summer. The average annual rainfall of between 350 mm and 550 mm, and the mean annual temperatures oscillates between 12 °C and 14 °C, with thermal amplitudes of 17–20 °C. A special mention must be made to the fog, typical of the region in the months of November, December and January that can give a period of up to 55 days in the absence of sunlight. This is a very similar climate to that of the area of Madrid, while taking this more annual rainfall and fewer days of fog per year.

According to these considerations, a long-term experiment was carried out in order to obtain data on the behaviour of green facades in buildings as a passive system for energy savings in dry Mediterranean Continental climate. The experimentation started refers specifically to double-skin green facade or green curtain. This typology has been chosen because of its easiness to assemble and disassemble, its easiness to integrate it into the building, and because it requires minimum posterior maintenance.

On one hand, in the town of *Puigverd de Lleida* (Lleida, Spain) an experiment was implemented to compare the growth of four different climbing plants under dry Continental Mediterranean

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Table 1
Classification of green vertical systems of buildings.

	Extensive systems		Intensive systems
Green facades	Traditional green facades		
	Double-skin green facade or green curtain	Modular trellis Wired Mesh	
			Perimeter flowerpots
Living walls			Panels Geotextile felt

climate conditions, as well as their ability to provide shadow. On the other hand, a double-skin facade green or green curtain built in May 2007, in the village of *Golmés* (Lleida, Spain) was monitored during one full year. In this building, the species planted on all three fronts is *Wisteria sinensis*, a deciduous climbing plant which is characterized by its rapid growth and great development, well adapted to the conditions of the dry Mediterranean Continental climate.

2. Puigverd de Lleida experiment

2.1. Objective

The main objective of this experiment is to study the growth in a trellis modular structure and compare the ability to provide shade of four climbing species in dry Mediterranean Continental climate.

2.2. Methodology

To perform this experiment four modular trellises prepared to accommodate a container garden at the bottom were designed and built (Fig. 1). The facade was mounted in south orientation.

Table 3
Daily average light transmission measured at *Puigverd de Lleida* green facade.

Species	Light transmission factor
Virginia creeper	0.15
Honeysuckle	0.18
Clematis	0.41
Ivy	0.20

The substrate used was a mixture of universal substrate for kindergarten and topsoil. The choice of plant species was made from a previous list of climbers made for the Mediterranean Continental climate. In the selection, the resistance of the species, the height they can reach, their adaptation to growth in modular trellis, and availability in nurseries, were considered. The species chosen were ivy (*Hereda helix*) and honeysuckle (*Lonicera japonica*), as perennial plants, and virginia creeper (*Parthenocissus quinquefolia*) and clematis (*Clematis* sp.), as deciduous plants.

The plants were planted in July 2008 and were maintained and monitored for plant growth for 1 year. The illuminance data collection was made on 28 July 2009 (the month with the maximum solar radiation in *Lleida*) using a TESTO 545 light meter. The illuminances, in front and behind the curtain, for each species were measured. This operation was repeated every hour from 9 am to 17 pm.

2.3. Results and discussion

Plants that were best developed in height were the two perennials, ivy and honeysuckle, but they left some areas with lower density of foliage. The virginia creeper, provided greater density of foliage, but during the first year it had difficulty growing in height in the trellis structure. Finally, clematis did show the worst growth, something predictable, because they are the most sensitive to Continental Mediterranean climate. In the spring showed good growth, but when the first heat of summer came, it hit hard and lost many leaves. At this time growth stopped.

Table 2
Parameters that influence in the behaviour of the green vertical systems as passive energy saving systems.

Interception of solar radiation. Shadow	Thermal insulation and storage	Evaporative cooling	Variation of the effect of the wind
Density of the foliage (number of layers)	Density of the foliage (number of layers) Changes in the air in the intermediate space Barrier effect of wind Substrate: thickness, bulk density and moisture content[a]	Type of plant Exhibition Climate (dry/wet) Wind speed Substrate moisture[a]	Density of the foliage (number of layers) Orientation of the facade Direction and wind speed

[a] Only in certain types of green verticals systems, such as living walls.

Fig. 1. *Puigverd de Lleida* experiment.