Energy and Buildings 150 (2017) 498–506

Contents lists available at ScienceDirect

Energy and Buildings

journal homepage: www.elsevier.com/locate/enbuild

Evaluating the effective distance between living walls and wall surfaces

Tabassom Safikhani [a], Mohammad Baharvand [b,*]

[a] Daneshpajoohan Pishro Higher Education Institute, Architectural Department, Isfahan, Iran
[b] Department of Architecture, Isfahan (Khorasgan) Branch, Islamic Azad University, Isfahan, Iran

ARTICLE INFO

Article history:
Received 18 February 2017
Received in revised form 7 June 2017
Accepted 12 June 2017
Available online 13 June 2017

Keywords:
Living walls
Temperature reduction
Cavity distance
Simulation
Experimental test

ABSTRACT

Living walls are described as pre-vegetated panels attached to vertical surfaces, or stand independently on vertical structures. They have numerous economic, environmental and social benefits for cities and environment as well as benefits for the indoor of buildings. It is claimed that providing a cavity between greenery and wall surfaces by applying a distance between living walls and the wall surfaces of the buildings can improve the performance of living walls. The cavity protects the wall against foliage and preserves it from decay, moreover acts as insolation and reduces heat transfer. The aim of this study is to examine the thermal performance of different distances between a living wall and the wall surface of the building in hot and humid climate of Malaysia. The study is divided into two parts, a computer simulation and an experimental test. In the first part, DesignBuilder was used as software for simulation to find optimum distances, and a validation was done to show the qualification of the software. An experimental procedure was formed to measure cavity and indoor temperature by applying real plants. For experimental test two identical boxes were used as small-scale rooms. One of them has the coverage of living wall and another has no greenery and is used as base sample. Blue trumpet vines (Thunbergia grandiflora) were plants for living wall. The data were recorded over the course of two months from April to June, 2013. The results and analysis of the results shows that 30 cm distance between the living wall and wall surface has higher effectiveness on the cavity and indoor thermal condition.

1. Introduction

Modern life style and acceleration of urbanization lead to expansion of urban areas. Population in cities require buildings for accommodation and vehicles for transportation as well as basic needs such as food, electricity, and so on. Incompatible population expansion in urban areas and facilities creates problems such as air, water and noise pollution as well as increase temperature and uncomfortable weather condition.

Previous studies have shown that applying greenery in urban areas has numerous environmental, economic and social benefits [1–3]. Plants clean the air by absorbing flow and dust, and freshen the air by consuming carbon dioxide and restoring oxygen [4,5]. Plants shading effects and evaporation of leaves helps to reduce temperature [6,7]. Moreover, plants reduce noise annoyance [8] and control storm water. Apart from these benefits, they are visually pleasant [9].

There are two categories of greenery in cities, namely, natural and artificial [10]. Native plants in environment are natural, and plants potted and grown by human in the process of urbanization are artificial. Although native plants are more beneficial than the artificial [10], it is not economic, and retaining native plants is not easy because of huge population and land cost. Vertical greenery systems are innovative methods to grow artificial plants. Meanwhile, they have important effects on temperature reduction [11].

1.1. Aim of the study

Vertical greenery systems are usually used as landmarks or for aesthetic purposes. They can be a part of the buildings or structures by installing on the facades or balconies. Although these cases make attractive facades and pleasant views for cities, their thermal effects are very important. Vertical greenery systems protect the facade against direct solar radiation and work as passive cooling systems [12] and reduce the temperature of the buildings.

* Corresponding author.
E-mail addresses: tabassomsafikhani@yahoo.com (T. Safikhani), Baharvand12@gmail.com (M. Baharvand).

http://dx.doi.org/10.1016/j.enbuild.2017.06.029
0378-7788/

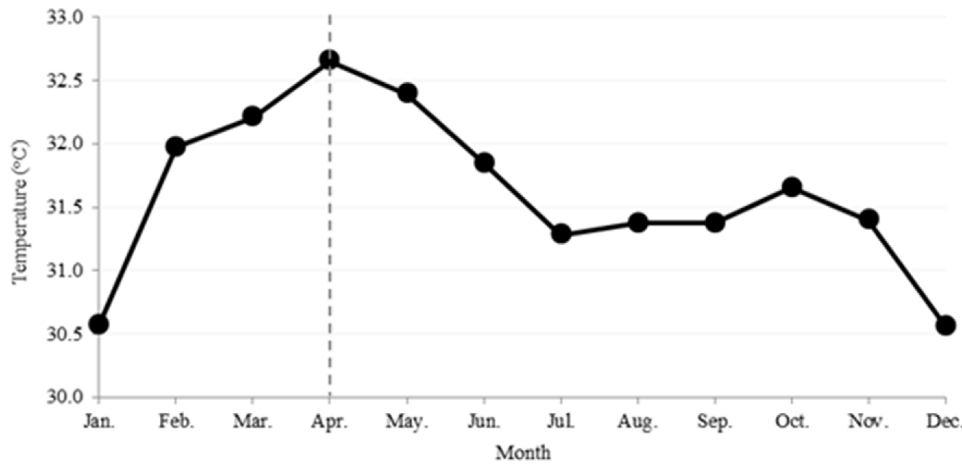

Fig. 1. Average monthly mean maximum temperature from 2002 to 2012.

Green facades and living walls are two main categorises of vertical greenery systems [3,13]. In green facades, plants grow vertically and cover the facades while the roots are on the ground. Self-clinging plants attached to the walls create direct green facades, while double-skin green facades are used a support structure in front of the wall to support vertical growth of plants [14]. Living walls include pre-vegetated modules attached to a structural wall. Living walls can be panel systems, felt systems and container systems [15]. By applying living wall, the facade of tall buildings and huge screens can be covered in a short time. Moreover, replacing each module by new and fresh plants is possible [16]. A study formed in hot and humid climate of Malaysia shows that in terms of temperature control, living walls have better thermal performance than the green facades [17]. Another comparative study showed that during cold seasons green walls have better energy saving potential than the green facade, and it does not consume extra energy during heating periods [18].

Although thermal efficiency of vertical greenery systems is related to the type of system, the distance of installation from the wall surface is an important issue and directly affects the system efficiency. Creating a cavity between greenery systems and wall surfaces by applying the distance reduces the connection of foliage with the buildings. The aim of this study is finding appropriate distance between a living wall and wall surface in hot and humid climate of Malaysia to improve thermal performance of vertical greenery systems.

2. Scopes, methods and process of study

The scope of the study is living wall clung to west wall by limited distances ranging from 5 cm to a maximum 50 cm. The plants species are Blue trumpet vine (Thunbergia grandiflora) that are adapted to the hot and humid climate of Malaysia and grow very fast and create a consistent and adequate density [19]. The plants grow during the experiment. Therefore, the qualities of plants differ on the first day of experiment by 5 cm distance between wall surface and living wall system and the last day by 50 cm distance. To avoid this difficulty and to have plants of same quality, a computer simulation was performed before starting the experimental test and some distances selected as optimum distances. Therefore, this study is divided into two parts; a computer simulation and an experimental test. The process of study is:

- Applying a computer simulation
  - ○ Decision making for the date of simulation and experimental test
- Validation of the software
- Applying simulation

- Experimental test
- Preparation of materials, components and equipment
- Data collection
- Discussion

2.1. Simulation

Computer simulation is a suitable method for optimizing internal and external building performance. The results of computer simulation are applicable before, after and during the building construction process [20]. The objective of this part of study is to find the optimum distances between simulated vertical shading and the wall of the building in terms of temperature reduction.

2.2. Methodology

Based on the researches [21], there is limited confirmation about computer simulation results of vertical greenery systems. Moreover, shading is much more effective parameter than the other parameters in temperature control [11,22]. Therefore, a partition (without greenery) was simulated and located in front of a simulated test box. The simulated test box was 60 cm × 60 cm × 160 cm with flat roof and 10 cm side tent. The activity assumed unoccupied and there were no heating, ventilation and air-condition (HVAC) system. The simulated partition was 160 cm × 100 cm and located in front of the west surface of the test box. The material was one layer wood and U.value was 1.2 w/m^{2}k. For different distances between simulated test box and the partition ranging from 5 cm to 50 cm by 5 cm intervals, the temperature inside the test box, cavity area, external surface temperature and average cavity ventilation are studied.

The location of study was in Skudai, Johor, Malaysia, with 1.56°N latitude, and 103.62°E longitude. The weather data was provided from Universiti Teknologi Malaysia (UTM) weather station installed on the rooftop of Built Environment faculty. It was facilitated by mini outdoor environmental dust monitor (model EDM 164 from Grim). To provide complete weather data, the meteorological data from Senai station (official meteorological station of Johor Bahru, Malaysia) was added. Monthly average of the maximum temperatures for a 10 year period was related to April (32.7 °C) (Fig. 1). Therefore, April is selected for validation, simulation and start of experimental test.