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Green wall impacts inside and outside buildings: experimental study

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Abstract

The experimental study of vegetated façades and their hygrothermal effects on heat loads is essential. Indeed, the complexity of thermal fluxes and airflows taking place within green walls modules under extreme climatic conditions is to date not mastered. In addition, phenomena related to buoyancy, street confinement, condensation, frost and sorption-desorption are not considered in most reliable models. This paper presents an experiment on green walls performed to apprehend their thermal and hydrological behavior and their impact inside and outside buildings. The experiment is based on a living wall set up on a reduced scale mockup of buildings and streets. Diurnal monitoring of temperature, humidity and heat fluxes variations near and within the living wall and a reference case enable us to analyze thermal effects of green façades. Measurements were performed in La Rochelle city in France.

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1. Introduction

Green roofs, living walls and green facades can be valuable for building energy performance and for urban microclimate mitigation [1–4]. They reduce the temperature peaks of external surfaces of buildings in summer [5,6]. Green facades affect the heat transfer through the building wall layers. Several experimental studies seek out quantifying the heat gains and losses from green walls [7–9].Several studies estimate that green walls reduce significantly the building's cooling load during summer [2,10].

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Thermo-hydric behavior of green facades is quite complex since they are influenced by their orientation and by surrounding urban environment. Compared to green roofs, experimental studies of green facades are uncommon. In Greece, temperature measurements were performed on a wall facing West and partially covered with creepers [11]. Measurements showed that vegetation cover reduces temperature peaks. Similarly, reference [12] reports a study carried out on a real building with green facade on East. In this study, greening was found to reduce external surface temperature by about 5 ° C. Living walls with substrate imply additional issues related to water and heat transfer within the substrate. Thus, an experimental study [13] conducted in Hong Kong on a vegetated panel composed of a hydroponic medium of Rockwool and grass shows that gravity plays an important role on the vertical distribution of water in the substrate.

In urban environment, green walls thermal impacts are as important as for green roofs, especially in dense cities. When the urban structure is characterized by narrow street canyons, the radiation trapping increases the surface temperature and the reduced airflow recirculation leads to higher air temperatures. Alexandri & Jones [14] performed simulations for different canyon aspect ratios and climates. They studied a canyon with two green roofs and two green walls and found that the air temperature diminution within the canyon could reach about 10°C for a hot and arid climate. More recently, we have developed a new modeling approach to assess thermal impacts of green walls on buildings in urban environment. A case study is presented in Djedjig et al.[15]. The simulated urban scene consists of a series of identical buildings and street canyons. Each building is a three story full scale building. The cooling load was compared for buildings with different aspect ratios (H/W= 0, 0.5 and 1.0) depending on the width of the streets. The results quantify the progressive effects of streets confinement according to the aspect ratio variation and the potential of green walls to mitigate increased cooling loads. The numerical results show that green walls installed on east and west façades of the studied building reduces by 37% the cooling load of nearby buildings with an aspect ratio equal to one and reduce it by 33% for a secluded building, for Athens summer climate.

There is still a lack of experimental data on these effects, so our study focuses on the experimental verification of such results and gives verification data for developed models. In this paper, we present an experimental approach to determining thermal impacts of green walls on buildings. The study was conducted on a reduced-scale model similar to a typical urban scene characterized by five rows of street canyons. The main objective was to assess the impact of vegetated building facades through relative comparisons with a reference building without vegetation and in real climatic conditions. The study also aimed to provide a database of experimental measurements.

2. Mockup design

The experimental platform consists of five rows of concrete empty tanks which stand for reduced scale buildings (Figure 1). Each row is made up of three tanks which form a block of 5 m long, 1.24 m high and 1.12 m wide. The aspect ratio of the street canyons is 1.2 and the scale reduction is approximately 1:10. The experimental bench is built on a 10 m × 20 m terrace of concrete tiles. The canyon facades, oriented to East and West, and roofs are painted in white.

A green wall system was set up on the West façade (GWallF) of one row of buildings. The green wall growing medium consists in Chile sphagnum of 15 cm thick and is fixed on a metal grid which forms an air layer weakly ventilated of 5 cm. There are six different species of vegetation planted on the green wall. This later is watered twice a day by an automatic drip watering system. One row of concrete tanks and one street canyon (RefC) was kept as a reference for further comparisons.