Frontiers of Architectural Research (2014) 3, 271–282

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Frontiers of Architectural Research

RESEARCH ARTICLE

Comparison of thermal performance between test cells with different coverage systems for experimental typical day of heat in Brazilian Southeastern

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Received 6 December 2013; received in revised form 17 April 2014; accepted 20 April 2014

KEYWORDS
Light Green Roof (LGR);
Thermal performance;
Dynamic Climatology;
Internal temperatures;
Spatial distribution;
Experimental typical day

Abstract
This article shows experimentally the thermal performance of two test cells with different coverage systems, Light Green Roof (LGR) and ceramic roof by analyzing internal surface temperatures (IST) in the ceiling and dry bulb temperatures (DBT). The objective was to evaluate the spatial distribution of temperatures in buildings according to spatial and temporal Dynamic Climatology approaches. An experimental, typical day for heat conditions was determined. The data of the main climatic variables provided by an automatic weather station and temperatures inside the test cells were collected using thermocouples installed such that the entire space is included. The results led to the conclusion that the LGR has a balanced IST and DBT spatial distribution compared with ceramic roofs. Nevertheless, the analysis of the thermal performance is only one of the variables that must be considered when developing a construction proposal that is adapted to the context. The manner in which the thermocouples were placed inside the test cells also showed the importance of specifying the location of the sensors in experimental studies on the behavior and thermal performance of buildings.

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Peer review under responsibility of Southeast University.

http://dx.doi.org/10.1016/j.foar.2014.04.007
2095-2635/

1. Introduction

Architecture has a fundamental role in creating internal and external spaces. It follows housing standards determined by individual needs, particularly with respect to human comfort based on the principles of natural thermal conditioning.

The environment consists of many elements that relate to each other and directly affect the human body, which tries to adapt without great loss of energy. The conditions in which man can achieve a comfortable level of perception are part of the "comfort zone." The comfort zone is determined by the needs of man in maintaining hygrothermal balance; in the case of buildings that depend on human physical conditions, the time of occupation, length of stay, and activities, among other factors determine the comfort zone (Freitas, 2005; Budyco, 1974).

Human thermal comfort depends on, among other things, four climate variables: solar radiation (the genesis factor of climate), air temperature, humidity, and ventilation. Body metabolic heat dissipation basically occurs in three ways: radiation (45%), convection (30%), and evapotranspiration (25%). Dissipation possibly occurs through conduction if the body is in contact with cold surfaces. The mechanism of heat convection is a function of air velocity because body radiation depends on the surrounding temperature. Evapotranspiration partially depends on the pressure of water vapor. Insufficient or excessive heat dissipation in the environment can cause discomfort. Therefore, natural thermal conditioning depends mainly on solar radiation and outside air temperature (Docherty and Szokolay, 1999). Comfort can be evaluated by the skin, since its surface temperature is around 33–34 °C. Thus, if the surrounding temperature is higher or lower than the specified range, thermal discomfort will likely result.

Buildings protect individuals from the weather. When buildings do not follow comfort principles, individuals are exposed to the emergence of physical or mental disorders. The inside of buildings presents particular environmental conditions that differ from the external environment and, theoretically, are more suitable for human occupation (Silva and Vecchia, 2003).

According to Olgyay (1998), the process for creating suitable spaces for human life can be divided into four steps: (1) analysis of local climatic conditions; (2) evaluation of the influence of climate based on human sensory perception; (3) search for appropriate technological solutions for construction that are consistent with local climate;

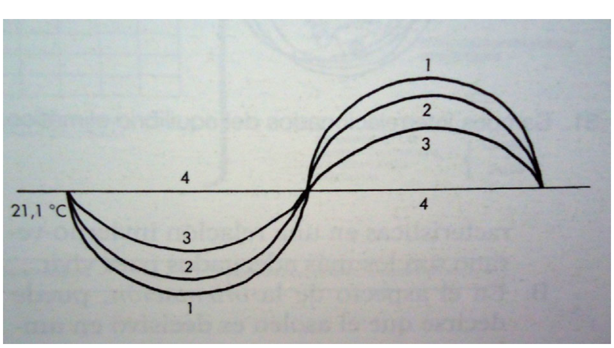

Fig. 1 Sequence for interrelation of variables (Olgyay, 1998).

and (4) architectural application from the previous three phases (Fig. 1).

The temperature variations, solar radiation, air speed, and air humidity are conditioned by the dominant air mass that acts at the project site in the mesoclimatic scale. However, other conditions must be taken into account, such as factors that modify initial climate conditions, such as topography, relief, altitude, latitude, longitude, continentality, and vegetation as well as the scale of time approach (years, months, and days) and space (macroclimate, mesoclimatic, and microclimate) (Egan, 1975). Therefore, the application of dynamic climatology is more appropriate because it recognizes zonal and regional climates. These are then correlated to general atmosphere circulation, based on meteorological data taken at the surface and obtained automatically in real time, enabling the validation of energy efficiency simulation software.

In this work, the study of the spatial distribution of temperatures in two test cells was based on the concept of the experimental typical day, which represents a specific climate condition according to the Dynamic Climate approach. The possibility of adopting this approach in a short time contributes to the understanding of climate conditions and its possible effects on the built environment, with respect to energy conservation as well as the behavior and thermal performance of buildings (Cardoso et al., 2012; Cardoso and Vecchia, 2013).

2. Methodology

This paper is investigative in character. It analyzes the vertical variation of internal air temperature or dry bulb (DBT) as well as the spatial distribution of the inner surface temperature in the ceiling using two test cells with different coverage systems. Then, their thermal performances are compared in a heat situation. No standard establishes how internal temperatures data should be collected in a building. This work seeks to standardize methodological procedures for gathering such data in built environment. This research was based on Dynamic Climatology, which prescribes the experimental typical summer day for obtaining analysis results.

In this work, temperature data were collected using thermocouples installed at predetermined locations in two test cells, on a LGR and on a ceramic roof with a wooden structure and concrete slab. These locations were constructed in conventional manner. The data regarding the main climatic variables for the experimental typical day were collected by an automatic weather station at the Science Center of Engineering Applied to Environment (CCEAMA), University of Sao Paulo (USP).

2.1. Location and characterization of the test cells and automatic station

The study was conducted at the experimental plot of the Climatological Station at the CCEAMA (Fig. 2), located at Lobo's dam margin in Itirapina, Sao Paulo State, Brazil, between the geographical coordinates 22°01'22" / 22°10'13" South and 43°57'38"/ 47°53'57" West, at an altitude of 733 m above sea level.