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Thermal conditioning for urban outdoor spaces through the use of evaporative wind towers

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ABSTRACT

The aim of this paper is to study the thermal comfort levels achieved in open spaces by means of evaporative wind towers. These systems have been installed in an urban area characterized by its hot and dry summer climate. Conventional wind tower designs for enclosed and semi-enclosed spaces have been adapted for this new installation. These systems are usually composed of a few number of wind towers, this one however is composed by a group of sixteen, increasing the total dimensions of the installation. To integrate this construction into the urban public area, it was built in a circular arrangement, creating an activity and meeting point for pedestrians. This passive system was monitored during the summer of 2008. Measurements of temperature, solar radiation, humidity and wind speed were analyzed. During the analyzed period, the average cooling efficiency of the system varied from 38% at the exit of the tower, to 32% at 1 m high. At this last position, the average exceeds the wet bulb temperature up to 8 °C with an increase of moisture around 27%. The shading effect produced by the global installation itself has been modeled theoretically to evaluate the incident solar radiation at the pedestrian area. Two indices have been applied to predict the perception of heat and cold in the south pedestrian zone: Heat index and TS index. In this position, both variables approached the thermal sensation to the comfort levels by the use of these passive strategies when ambient conditions are hot and dry.

1. Introduction

The use of bioclimatic techniques in the design and construction of buildings is an effective way to reduce their energy demands. These passives strategies make use of the renewable sources available in each location to condition the building. A traditional technique, known as wind tower, is employed to produce passive natural ventilation to increase the thermal comfort conditions. Its operation is based on air movements due to the pressure differences. This difference is caused either by the movement of wind or by the effects of negative buoyancy created by the stratification of the air. To increase and guarantee the wind speed inside the tower a fan is included, providing enough airflow to ensure the correct performance of the system. In hot and dry climates, where temperatures are high and the relative humidity is low during the summer period, the potential of wind towers could be increased by the use of evaporative systems. These towers reduce the temperature by water injection, increasing the moisture content of the air.

Initial studies were focused on the reduction of energy consumption by using these passive techniques to guarantee summer thermal comfort in buildings. Bahadori [1] published one of the first studies on this subject introducing two new designs of wind tower that avoid most of the disadvantages of conventional Baud-Geers. Moody et al. [2] analyzed the possibility of replacing conventional evaporative coolers with evaporative wind towers, in areas without an electricity grid. A few years later, Givoni [3] completed a mathematical-experimental study on the same building designed by Cunningham and Thompson [4]. The main results show a strong dependency between wet-bulb depression, wind speed and temperature of the solar chimney. Later on, Givoni [5] estimated the temperatures inside lightweight residential buildings and the equation that characterizes the efficiency of the system. Recently, a new mathematical model of thermal performance considering the heat and mass transfer balance was developed by Bouchahm et al. [6]. The height of wetted column and the size of conduits partition inside the tower were determined as two important factors of the wind tower configuration.

In the recent years, the use of evaporative wind towers to cool open or semi-open public spaces are growing. This is highlight by the studies performed at the Universal Exposition of Seville in 1992 by

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