Experimental Monitoring of an EAHX for Building Air Refreshment in Marrakech

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Abstract

An experimental study of an Earth-to-Air Heat Exchanger (EAHX) for air refreshment connected to a residential building in Marrakech has been performed. The EAHX is constituted of 3 PVC pipes of 72 m length each buried at 2-3m in the building's garden. Each pipe is equipped with a fan which forces ambient air into the pipe to get fresh air and then blow it into the building. The EAHX was monitored during 38 days of summer 2013. Dataloggers for temperature and humidity measurements were installed inside one of the EAHX pipes. Results of this monitoring are presented in terms of temperature and humidity profiles and analyzed to assess the energy performances of the EAHX for air refreshment in Marrakech climate. It is shown that the EAHX is a good semipassive system for air refreshment as its outlet temperature is quasi-constant during summer and equal to 25°C, while the outside temperature reaches up to 40.8°C.

Reference

Experimental Monitoring of an EAHX for Building Air Refreshment in Marrakech

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Abstract An experimental study of an Earth-to-Air Heat Exchanger (EAHX) for air refreshment connected to a residential building in Marrakech has been performed. The EAHX is constituted of 3 PVC pipes of 72 m length each buried at 2-3m in the building’s garden. Each pipe is equipped with a fan which forces ambient air into the pipe to get fresh air and then blow it into the building. The EAHX was monitored during 38 days of summer 2013. Dataloggers for temperature and humidity measurements were installed inside one of the EAHX pipes. Results of this monitoring are presented in terms of temperature and humidity profiles and analyzed to assess the energy performances of the EAHX for air refreshment in Marrakech climate. It is shown that the EAHX is a good semi-passive system for air refreshment as its outlet temperature is quasi-constant during summer and equal to 25°C, while the outside temperature reaches up to 40.8°C.

Keywords: Earth-to-Air Heat Exchanger, Monitoring, Building, Air Refreshment, Energy Performances.

I. INTRODUCTION

During last decades, the use of air conditioning systems in Marrakech became very popular. This leads to a huge increase of electricity consumption and the Electric Peak load. Comfort cooling is one of the significant responsible of such situation. Indeed, buildings represent about 51% of electricity consumption in Morocco with 33% for residential buildings [1, 2]. The national agency for energy efficiency (ADEREE) [1] has developed a strategy for energy efficiency in the most energy consumer sectors, including residential buildings. One of the main objectives of this strategy is to integrate passive systems, such as thermal insulation and solar protection, to the new buildings starting from 2015. It is believed that in some climate zones of the country, such zone ZS (Marrakech) [3], passive cooling techniques have to be considered. Passive cooling relies on the use of techniques for solar and heat protection, heat modulation and heat dissipation. Modulation of heat gain deals with the thermal inertia of the building (storage capacity of the building structure), while heat dissipation techniques deal with the potential for disposal of excess heat of the building to an environmental sink of lower temperature, like the ground, water, ambient air or the sky [4]. One of the interesting heat dissipation techniques consists in forcing air from outdoor through an Earth-to-Air Heat Exchanger (EAHX), also called air-soil heat exchanger, earth-air tunnel, buried pipe system, for dampening of the temperature amplitude carried by the airflow, the building underground serving as an energy buffer [5].

Important research, both experimental and theoretical, has been carried on the use of EAHX for air refreshment in buildings. Santamouris and Kolokotsa [6] recently reported data and results of 30 buildings experimental projects performed in cold, mild and hot climates around the world. Through the reported results, the benefit of the EAHX system is well established for both heating and cooling in many regions in the word. Nevertheless, it is also established that energy performances of this system greatly depend on climate and soil conditions [4-13].

The objective of this paper is to report and analyze the results of an experimental study of an EAHX system connected to a villa type house located in Marrakech suburb.

II. DESCRIPTION OF THE EAHX

The EAHX is constituted of 3 parallel and identical PVC pipes of 72 m length each and 15/16 cm inside/outside diameter, buried at 2.2-3.5 m and equidistant with an inter-space of about 14 cm. Each pipe is equipped by a 50-125 W fan at its entrance located inside a technical shed with openings protected by mosquito netting. The EAHX is installed in a villa type house located in the suburb of Marrakech (31°37’ N latitude and 8°2’ W longitude). Two of the pipes are connected to the first floor and the third is connected to the second floor of the house. Fig. 1 presents a scheme of the EAHX and its connection to the house. The details of the implementation of the EAHX are presented in Fig. 2.

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III. EXPERIMENTAL PROTOCOL

The monitoring of the EAHX was conducted through seven dataloggers TESTO174T installed inside the horizontal part of one of the pipes. These dataloggers, that measure air temperature every 10min, are fixed to a metallic support well attached to a rope (Fig. 3). This system ensures that the dataloggers are not in contact with the pipe. Two other dataloggers TESTO174H are suspended in the vertical part of the pipe at its outlet. The latter measure both air temperature and humidity at two vertical positions. The positions of the dataloggers are given in Table 1. The numbers in the brackets indicates the vertical position of the TESTO174H dataloggers. It is important to mention that the probe of the dataloggers is protected from radiation, so that it measures air temperature.

![Datalogger TESTO174T in its metallic support.](image)

**Figure 3:** Datalogger TESTO174T in its metallic support.

<table>
<thead>
<tr>
<th>datalogger</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Position (m)</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>7</td>
<td>15</td>
<td>31</td>
<td>63</td>
<td>72 (-3.2)</td>
</tr>
</tbody>
</table>

**Table 1:** DATALOGGERS AXIAL (AND VERTICAL) POSITIONS INSIDE THE EAHX PIPE.

Two other TESTO174H dataloggers were placed in the technical shed and the blowing vent inside the house. The former was suspended at 50cm from the pipe entrance.

The monitoring was conducted during 38 days of summer 2013, from June 29th to August 5th. During this monitoring the fans of the two non monitored pipes were off, except for some hot days. Two fan’s powers were tested: 44W and 90W. The results presented here concern the fan power 90W that procures a mass flow rate of 312 m$^3$/h, which corresponds to an air velocity of 5 m.s$^{-1}$ inside the pipe.

A weather station was installed on the roof of the technical shed. It measure ambient air temperature and humidity, global solar radiation, wind velocity and direction. Figure 2, shows the daily averaged ambient air temperature and global solar radiation during the monitoring period.

![Daily averaged ambient air temperature and global solar irradiation during the monitoring period](image)

**Figure 4:** Daily averaged ambient air temperature and global solar irradiation during the monitoring period.

IV. RESULTS AND DISCUSSION

Figure 5 shows time variations of the hourly averaged supply air temperature (measured at the pipe outlet, inside the blowing vent) during 15 days of July (8-22 July 2013). Ambient air temperature (measured inside the technical shed at 50cm above the pipe inlet) is also reported. It can be seen that air is supplied at a quasi-constant temperature of 24.5°C with 23-62% of humidity. Indeed, blown air temperature varies between 25.4°C and 23.5°C with day amplitude around 0.6°C. On the other hand, hourly averaged ambient air temperature varies between 40.8°C and 22.2°C with day amplitude that may reach 16°C.

![Time variation of the hourly averaged temperature](image)

**Figure 5:** Time variation of the hourly averaged air temperature.
Figure 6 illustrates air temperature profiles inside the monitored pipe during the day of July 15th, 2013. Axial position x = 0 corresponds to the entrance of the horizontal part of the pipe buried at 2.20m. During the whole day, air temperature tends to a constant value around 24°C at the outlet of the horizontal part of the pipe buried at 3.2m. Air temperature inside the pipe falls below 25°C. Air temperature elevation is attributed to the EAHX manhole showing time evolution of the blown air to the whole temperature elevation is attributed to the EAHX manhole showing time evolution of the blown air to the entrance of the horizontal part of the monitored pipe. This temperature elevation is attributed to the EAHX manhole where the pipes are not insulated and exposed to solar irradiation, essentially by the end of the day (Fig. 2). Despite this point, the EAHX is able to provide comfortable cool air at 25°C to the house along the day while the outdoor air temperature reaches more than 37°C.

Figure 7: Hourly averaged ambient and blown air temperature profiles during the day of July 15th 2013.

V. CONCLUSION

In this paper, the results of an experimental monitoring of an Earth-to-Air Heat Exchanger (EAHX) are presented and analyzed. The EAHX is dedicated to air refreshment of a house in Marrakech. Air temperature and humidity measurements, conducted during 38days of summer 2013 inside one of the three EAHX tubes, show that this system procures comfortable air to the house. Indeed, while the outside air temperature reaches more than 40°C, air is blown to the house at quasi-constant temperature of 25°C with humidity ranging from 21% to 62%. The EAHX provides air temperature reduction up to 16.3°C with mass flow rate of 312 m³/h, which corresponds to 5 m.s⁻¹ air velocity inside the pipe. Blown air temperature day amplitude is up to 0.6°C while the outside air temperature amplitude may reach 16°C.

ACKNOWLEDGMENT

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