Available online at www.sciencedirect.com

ScienceDirect

Energy Procedia 133 (2017) 268–280

Energy Procedia

www.elsevier.com/locate/procedia

Climamed 2017 – Mediterranean Conference of HVAC; Historical buildings retrofit in the Mediterranean area, 12-13 May 2017, Matera, Italy

Analysis and exploitation of the stack ventilation in the historic context of high architectural, environmental and landscape value

Eleonora Laurini[a*], Annalisa Taballione[a], Marianna Rotilio[a], Pierluigi De Berardinis[a]

University of L'Aquila. Via G. Gronchi n. 18, L'Aquila 67100, Italy

Abstract

The study of passive ventilation aims at studying the processes of heat dissipation that occur naturally with or without the minimal use of mechanical instruments. The recovery of natural cooling techniques can be, in most cases, sufficient to restore the conditions of comfort inside buildings in our latitudes. For this reason we have pursued the goal of optimizing natural ventilation by installing a duct, which exploits the principle of the stack effect, inside a historic building in Poggio Picenze (Aq) dating from the fifteenth century. The goal is to obtain the best performance balancing environmental comfort and minimal energy consumption through the acquisition of an in-depth knowledge of the system operation.

Peer-review under responsibility of the scientific committee of the Climamed 2017 – Mediterranean Conference of HVAC; Historical buildings retrofit in the Mediterranean area

Keywords: stack ventilation, ventilation chimney, monitoring, historic context, energy saving.

1. Introduction

Approximately one-fifth of the emerged surface of our planet and one third of the world population experience hot-dry or humid warm climates. Additionally, most of the inner continental areas are characterized by temperatures above the confront zone during the summer months.

This means that the use of air conditioning systems in the world and their energy costs are continuously increasing.

* Corresponding author. Tel.: +39-340-1746053.
E-mail address: elelaurini@yahoo.it

1876-6102
Peer-review under responsibility of the scientific committee of the Climamed 2017 – Mediterranean Conference of HVAC; Historical buildings retrofit in the Mediterranean area
10.1016/j.egypro.2017.09.386

This trend threatens to erase the benefits produced by the incentive policies of energy conservation, implemented by European countries and other industrialized countries.

If the problem of air conditioning use in the summer months is not seriously addressed, the result is likely a continued and growing electricity consumption.

The need to cool indoor environments is specifically important in the current building sector that focuses on the control of winter energy consumption, neglecting sometimes the building performance during the summer season. As a result, there has been an increase in energy costs caused by the need to control the indoor temperature and humidity of buildings in the summer months [1,2,3].

A good alternative to this trend is the use of design criteria and technologies based on "passive cooling" of buildings, or the use of physical and technical devices, to achieve indoor comfort conditions within a building with low or minimal energy consumption [6].

2. The physical phenomenon of stack effect or chimney effect

The stack effect refers to the draught effect linked only to the natural thermal gradient within the flow duct. The systems that exploit this principle increase the natural effect created by the difference in height between the inlet opening and outlet opening. In the chimney effect the air extractors generate a mass air flow (and associated heat): an amount of fluid immersed in another fluid of higher density tends to flow in the opposite direction to gravitational acceleration vector (in this case the difference in density relates to the difference between the internal and external air temperature).

This effect is not influenced by the surrounding conditions since it is linked to a thermal gradient that can be established regardless of the surrounding environment. In fact there are geomorphological conditions that can amplify the natural phenomenon of ventilation. That's why in some pre-modern cultures the wind was used to alleviate heat discomfort as shown by some archetypal examples, like the Renaissance villas in Costozza, Zisa Palace in Palermo, Iran's wind towers.

The geo-morphological characteristics of Italy and the alternation of the coastline with hilly and mountainous areas determines the prevalence of widespread wind breezes, with low average wind speed (1-2 m / s), with rather variable speed and frequency and directions that change throughout the day.

For this reason in Italy the wind is a resource particularly suitable to be used as a natural form of building ventilation, both in relation to air renewal in confined environments and to the passive cooling of the buildings [4].

The desire to exploit the physical principle of chimney effect has led to the development of a specific typology of buildings that uses well recognizable systems to create flows of air masses in order to obtain the thermal comfort by natural ventilation. Among these systems there is the internal atrium, the solar chimney and fan-assisted draught systems.

The guiding concept of these systems is the exploitation of solar radiation to increase the draught, through the heating of the flow pipe and the air inside it. The advantages consist of the possibility to increase the flow rate in case there is a little difference between the indoor / outdoor temperature, even in the extreme case when the two temperatures are almost the same.

The disadvantage is that they depend directly upon solar irradiation. The system that is most relevant to our case study is the solar chimney. It can have different construction characteristics. Generally it is tall because its function is to increase the natural exchange of air following the physical effect explained above.

It must be emphasized that this system has no operating costs, except for any additional draught fan, while the disadvantage is that the draught flow is good only if the difference between outdoor and indoor temperature is significant (at least 2 - 3 ° C). In the summer months, if the building is not equipped with an air conditioning system, the internal microclimate is at the limit of acceptability, but can be improved by introducing a system to control the humidity of incoming air [5].