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The traditional house with horizontal opening: a trend towards zero-energy house in the hot, dry climates

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Abstract

The aim of this article is to study by numerical simulation with the TRNSYS-COMIS software, the thermo-aeraulic behavior of a traditional house with a horizontal opening in the central space of the house, and in the city of Kenadsa (southwestern Algeria, hot dry climate). In these regions with hot, dry climates, traditional architecture was developed using empirical knowledge provided by a combination of passive strategies for thermal control, results of a thorough knowledge of weather conditions. The paper presented in the context of this work is related to an attempt to bioclimatic architectural approach, to reduce the energy consumption of heating and cooling of buildings in these areas, while improving thermal comfort. This approach aims to improve the quality of the built environment by developing a new or updated conceptual model, firstly by enhancing local natural resources, and secondly by processing information through scientific tools [1]. Several variants were examined: dimension of the horizontal opening, combination with other openings (of ventilation holes in the parts around the central space, and stairwell) and the effect of building materials used in the building fabric. The proposed model for the simulation of horizontal opening home is validated with an experimental study [2]. The results of this study are presented in the form of hot and cold hours in a year, maximum and minimum indoor comfort temperatures, and frequency of effective ventilation per person as air quality performance indicator in each room.

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Keywords: Horizontal opening, traditional house, ventilation improvement, comfort, hot and dry climate, simplified model

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Introduction

Energy consumption associated with buildings has a significant impact on the environment. Actually, the energy consumption in the building sector is between 40% and 55% of the total demand in the south city in Algeria [1]. Traditional architecture in areas with hot and dry climate has developed an empirical knowledge, particularly oriented towards the realization of comfort in hot weather [3]. The user comfort was provided by a combination of passive strategies for thermal control, results of a thorough knowledge of weather conditions. The traditional architecture provided us excellent techniques which are climate responsive in nature. The principles which were used in traditional buildings can very well be implemented in the modern buildings to improve their energy efficiency and. If these principles are adopted in modern buildings it is possible to build sustainable buildings for the future [2, 4].

In recent years number of studies have been carried out on climate oriented building design to enhance thermal comfort conditions in living space and at the same time to reduce both the embodied and operational energy consumption [5]. Passive design strategies, in particular the application of natural ventilation, are the main techniques to moderate thermal discomfort in buildings [6]. Furthermore, many studies have shown reduced operating costs, better thermal comfort and indoor air quality, to be some of the advantages of the application of natural ventilation in buildings [7, 8]. The patio house with zenithal opening or covered patio house called "ain eddar" in south-west Algeria" is a type of very common traditional houses in the Saharan regions to the Maghreb countries. In those areas, people seek protection from direct sunlight while enjoying the air coming through the zenithal opening.

Horizontal large openings are openings in ceilings and in floors where the open area is in the horizontal plane. A staircase forms a horizontal opening between levels. The special case considered here is the ceiling opening in the patio to the roof. Several studies have examined heat and mass exchange through horizontal openings in buildings, by natural convection [9,10, 11] or by mixed convection [12]. Most of these studies have been performed using small-scale experiments.

Few authors have used the CFD technique to study the airflow through horizontal openings [9, 13] and [12]. In contrast, there is extensive literature showing the evaluation of turbulence models to predict indoor air conditions in single cavities or rooms with different convection regimes [14, 15,16]. The objective of this paper is to study the effect of opening on the zenithal thermoaeraulic behavior of a house situated in a warm, dry climate with the TRNSYS software coupled with COMIS. The zenithal opening is modeled based on the simplified formula [17].

Nomenclature

HC	hot hours according to EN 15251
HTF	cold hours according to EN 15251
% DHC	percentage of reduction of hot hours
% DHTF	percentage of reduction of cold hours
Tmax	maximal temperature
Tmin	minimal temperature

1. Modeling

1.1 Modeling the large opening and general simulation model.

We have used the software TRNSYS coupled with COMIS [19] to conduct our simulations. It uses the following equation (1) to model air flow through horizontal openings. This equation is valid in absence of wind. The actual airflow rate with wind is generally larger.

[17, 18,] and [13] are recent additions to the investigation of air flow through large horizontal openings.

Blomqvist derives a simplified formula for the large opening flowrate as:

$$q_e = C_e.(g'.\sqrt{A})^{0.5} \ (m^3/s) \qquad (1)$$