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Assessment of the inner skin composition impact on the double-skin façade energy performance in the Mediterranean climate

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Abstract

The objective of this paper is to assess the impact of the inner layer composition in a double-skin façade system on the energy requirements of conditioned office buildings. Considering a typical office building in Tunis covered with a naturally ventilated box-façade, simulations are conducted for the hot and the cold seasons. The results show that the implications of the internal glazing type, the glazing surface and the thermal mass are different according to the season.

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Keywords: Double-skin façade; Inner skin composition; Building Simulation; Heating and cooling loads; Mediterranean Climate.

1. Introduction

In the last few years, we assist in Tunisia, as in several other countries of the southern side of the Mediterranean,

Nomenclature

ε	emissivity
ρ	refectivity
τ	transmissivity

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to the emergence of modern business districts, with largely glazed façades that match with the transparency symbolism in offices building. Obviously, the architectural trend of large glazed surfaces influences the energy performance of buildings. Compared to a classical façade with fenestration, an all-glazed surface allows capturing more solar radiation, which is interesting in winter, especially in cold countries. But, on the other hand, with large glazed surfaces, the heat losses through the envelope of the building are more important, which can result in an increase of the heating load. In summer, both the increase of solar radiation and of heat losses is disadvantageous. This systematically causes increase of the cooling load. These energy concerns are often ignored to put in front the aesthetic desire of transparency.

To reconcile aesthetic goals and energy efficiency, a thermal buffer zone can supplement the glazed façades, in order to reduce heat losses, enable passive thermal gain from solar radiation and allow an air circulation coupled with shading to avoid summer overheating ; it's the concept of double-skin façade (DSF). By creating an air gap within a double-skin façade, various operation strategies of the cavity are offered with different possible ventilation schemes (interior/exterior air curtain, air exhaust/supply…). The air flow through the glazing cavity can be driven by either natural stack and wind pressures (aided sometimes by the use of fans) or mechanical supply and exhaust systems. Naturally ventilated façades are either applied as supply windows in naturally ventilated offices, or as air curtain envelopes in fully conditioned offices. Investigating the natural ventilated designs is particularly interesting since it allows to take advantage from the thermal stack effect and to achieve energy efficiency goals in a less expensive way than with mechanical designs.

In cold climates, it's often assumed that buildings having these façades can save large amounts of energy. Meanwhile, their performance in the Mediterranean climate, which is characterized by a mild winter and a hot summer, is to date, a subject of debate. As overheating in a largely-glazed building is set to become an increasingly critical issue, adding a second glazed skin is intuitively not recommended, because it's suspecting to lead to greater air conditioning load.

Some studies revealed that in the context of a moderate climate, adding a second glazing creates an additional cooling demand [1,2], however, in other cases, the double-skin façade is presented as a technique which can reduce cooling load in the building in the Mediterranean climate [3,4]. These latter studies refer to the potential of improvement of the building energy performance with a double-skin façade, if these aspects are addressed carefully during the early design phase. The little work that has been done on the energy performance assessment of the double-skin façade in the Mediterranean climate doesn't settle this issue. Furthermore, the DSF concept covers a wide range of design typology depending on the several design parameters. Some typologies are more suitable than others in a given climate.

Clearly, the energy performance of the double-skin façade depends on the composition of the two skins delimiting the façade that are responsible for heat gains on one hand and for hat losses on the other hand. The summary of research on the design parameters of naturally ventilated double-skin façades presented by Barbosa and Ip [5] reveal that the majority of literature references treated the outer skin glazing proprieties on the DSF energy performance. Only few studies have been conducted on the inner skin composition. Radhi et al. [6] discussed the application of combined concrete and glazed windows on the inner skin of the façade. They studied the variation of temperature and solar gain due to glazing type. They indicated that the concrete walls, that store a large amount of radiation heat, are at higher temperatures than glass, in where only a small amount of heat is absorbed while the largest amount is transferred into the adjacent zones or reflected back. The study conducted by Fallahi et al. [7] showed that the application of thermal mass on the inner skin presented more cooling requirements than the case when the thermal mass is used in the shading device and in the external skin. The effect of the Window-to-Wall Ratio (WWR) on the solar radiation gain through the DSF was evaluated by Chou et al. [8] and Manz et al. [9]. They observed that a balanced WWR is essential to reduce the solar heat transfer into the building.

In this paper we are interested in the assessment of the contribution of double-skin facades in the Mediterranean climate, considering the inner skin composition. We use the validated numerical model presented in [10] and coupling TRNSYS 17 and CONTAM, to analyze the dynamic thermal behavior of double-skin facades in the Mediterranean climate. These simulation tools are presented in section (2) of this paper. The present work follows up the validation process and intends to avail the validated model in a whole building case study, which is described in section (3). The purpose of this paper is the assessment of the role of the inner skin design of a naturally-ventilated double-skin façade in the energy consumption in the context of a Mediterranean climate. The results are