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Heating, ventilating and cooling impacts of double windows on historic buildings in Mediterranean area

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Abstract

Based on multi physical experiences and lessons learned, this paper presents different impacts of double windows in buildings. A general review of double window uses was produced. The specific constraints of historical buildings were also analyzed. Then a multi physical investigation about heating, cooling and ventilating aspects was developed. That led to the assessing of energetic impacts of double windows in retrofitted historical buildings in Mediterranean area. It highlighted some well-known fields like the winter functioning or the heat recovery potential but also some fields of investigation like the questions of the warm summer behaviour or the historic building integration.

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1. Introduction

The European Commission [1] aims to reduce greenhouse gas emission of 40% in 2030 relatively to emissions in 1990. In order to reach this target, 25% of energy savings is required. The Commission also indicates that in some sectors such as buildings, significant efforts have to be furnished.

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In many Mediterranean countries, there is a great number of old buildings with a major architectural and historical interest. In South Europe (Greece, Malta, Spain, Italy), 37 % of buildings were built before 1960 (Economidou et al. [2]). In France, more than 10 million of dwellings, which represent a third of the existing building stock, were built before the middle of the 20th century with traditional constructive techniques and aesthetic interest (Caisse des dépôts [3]). This stock constitutes both a strong energy savings potential and a significant cultural heritage.

It is then primordial to conserve this heritage. A review of the different regulations concerning architectural heritage conservation is drawn up by Mazzarella [4]. At the world wide scale, the UNESCO's Convention concerning Protection of the World Cultural and Natural Heritage make the signatories aware of their responsibilities of protection of their historic heritage for the future generations. Several conferences took place in Europe since 1960's about the preservation and the management of the heritage. The Convention for the Protection of the Architectural Heritage of Europe signed in 1985 proclaims the principles of conservation (Conseil de l'Europe [5]). However, the issue of the historic buildings retrofitting has not been clarified yet. Litti et al. [6] show the lack of a systematic methodology for retrofitting when dealing with historic buildings. It is to national governments to state about this. In France, legislation and regulation can be found in the 'Code du patrimoine' (Legifrance [7]). It states among others things the different cases and procedures in terms of heritage definition and subscribing. The role of all the actor involved during a work procedure is also stated. In Italy, similar guidelines have been produced like the legislative decree 42/2004 "Code of cultural heritage and landscape". They are described by Mazzarella [4].

According to the World Map of Köppen-Geiger Climate Classification, Mediterranean climate is presented as warm temperate with dry summers for the North area and the Maghreb littoral and as arid and hot for Egypt and Libya coasts (Kottek et al. [8]). Others climates like continental or mountainous ones occur elsewhere. Spain climate, for example, presents more important humidity (Canas and Martín [9]).

A significant part of heat transfers occurs through windows. Up to 60 % of the total energy losses through the building envelope is lost through windows for a two-stories building with 30 % of the walls covered by windows (Gustavsén and Jelle [10]). The losses decrease to 45 % if the window area is reduced to 20 %. These architectural choices coupled with climatic context lead to a high energy consumption. For Southern countries of Europe such as Portugal and Italy, the energy use is relatively high considering mild winters. This can indicate a lack of thermal insulation of their buildings. Moreover, air-conditioning systems often equip homes in those countries which tends to increase the part of cooling in the overall consumption (Economidou et al. [2]).

The need of retrofitting historic buildings is then crucial. But their status raises complex questions and limits possibilities. Then adaptable solutions need to be investigated and applied. The main goal of this research paper is to present multiphysical impacts of double windows, as solution for historic buildings. Firstly, a detailed presentation of a double window will be made. Then, the Mediterranean historic buildings context will be drawn up by showing the importance of the interaction between windows and the rest of the building. Finally, a listed review of the double windows characteristics will be presented. That will allow to highlight the state-of-the-art knowledge about an application in a Mediterranean historic building.

2. Different configurations of double windows

Double windows are well-known devices but their number of application and configuration is high. Added to their ability to be integrated in different climate, it has conducted to many studies and a worldwide spreading. These points are tackled in the following parts.

2.1. Historical diffusion and scientific studies

Double windows have been studied since the 1960's and 1970's in Northern climate context like Scandinavia or Canada (Christensen et al. [11]). This system provided better thermal performance than usual simple glazed windows. Christensen and al. showed testing plans, procedures and results of experimental measurements concerning the thermal

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