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Natural light from a wall in buildings: Experimental analysis of the ventilated illuminating wall performances

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Abstract

The Ventilated Illuminating Wall (VIW) is a technological device set up by the authors. It is a passive solar system. In buildings without direct interface to outdoor, it is able of providing natural light and air for indoor ventilation. The authors built a 1:1 scale prototype of the VIW in the laboratory of Technical Physics of the INGEO Department of Pescara. It consists of a multilayer structure applied on a window of the perimeter wall of the building. Daylight is captured by a horizontal glass surface and redirected into the system thanks to the reflections by a highly reflective film applied on the internal walls of the VIW. The reflective film is the same used in the light pipe technology.

In this paper, the authors show a technological description and the building steps of the device and the results of an experimental analysis on daylight performances. The data reported in this work regard both winter and summer conditions, and they can be considered satisfactory in every situation. Under overcast sky, the internal illuminance trend is similar to the external one, particularly in positions close to the system, and the influence of the VIW on internal illuminance is on average of about 2 m. Under Clear sky with sun, the system has a higher efficiency, thanks to the intense reflections, which cause some peak values of illuminance.

In general, the VIW is able to furnish a significant high-quality natural light contribution to the room. It is particularly suitable in museums and exhibition rooms with large plant area, because it provides a soft distribution of light.

Keywords: Daylight; Natural light; Passive solar system

1. Introduction

Daylight availability in buildings is one of the most important factors that influence the indoor comfort. Every human activity is carried out more comfortably in rooms with natural light rather than artificial light. In fact, natural light allows to feeling the passing of time and it assures a comfortably condition with lower illuminances than artificial light. Besides, natural light makes a significant contribution to energy saving in buildings (Momani et al., 2009), but in many situations, it is not available or adequate: for example, in underground rooms, that are not facing with outdoor, or in large plant area rooms, such as industrial or commercial buildings equipped by windows only on the perimeter walls. In these cases, artificial light is used all the time with very high-energy consumption.

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Many technological devices have been developed to capture daylight from the top of the building or a free sky exposed vertical wall and distribute it to underground areas, such as light pipes (Canziani et al., 2004; Jenkins et al., 2005; Jenkins and Muneer, 2003).

In a previous work, the authors proposed an innovative version of light pipe, called "Double light pipe", by which daylight can be furnished to both the final room and the passage environment (Baroncini et al., 2008,2010). Recently, they proposed a particular version of the double light pipe, which is able to assure natural ventilation in underground buildings in addition to daylight (Boccia et al., 2012). Furthermore, some other authors proposed combined light-vent pipes for both daylighting and indoor ventilation (Varga and Oliveira, 2000).

Daylight can sometimes generate the risk of glare or other discomfort phenomena, chiefly when very intense direct components of light or very important reflections from shiny surfaces are present in the environment. (Wienold and Christoffersen, 2006; Piccolo and Simone, 2009). This is a particular issue in museums, exhibition rooms or similar, where very soft lighting distribution is requested.

In museums or exhibition rooms, low illuminances are usually preferred on the illuminated surfaces, in order to obtain a good balance of luminances between the visual task and the background, avoiding the risk of glare and uncomfortable reflections from the surfaces. In this perspective, artificial light is often preferred to daylight, because it can be modulated and modified as required, and windows or skylights are usually obscured. On the other hand, it is known that the enjoyment of works of art is better in the presence of natural light than in the absence of it, and a significant energy saving can be achieved by using natural light instead of artificial light. (Navvab, 1998; Cannon-Brookes, 2000; Chang-Sung and Seung-Jin, 2011)

The VIW is an innovative device, which can be applied only to the external walls of a building. It can be installed both in buildings above ground or in hypogeal ones. In these two cases, it has a different behavior from the point of view of ventilation, while the illuminating performance is the same. In this paper, the case of a 1:1 scale prototype of the VIW is presented, which has been recently patented by the authors.

In the case of underground buildings, it is applied on a perimeter wall leaning against the ground. It cannot either be installed on an internal partition.

The VIW is able to assure a good quality light distribution because it allows the entry of daylight preventing the direct solar radiations to enter the room and it is particularly suitable in museums and similar rooms. Besides, it avoid thermal radiation to enter the room in summer condition and enables a significant energy saving.

The VIW captures natural light from the top of the building by a horizontal glass surface placed on the coverage and transports it through the interspace leaning against the window thanks to a very high reflecting material

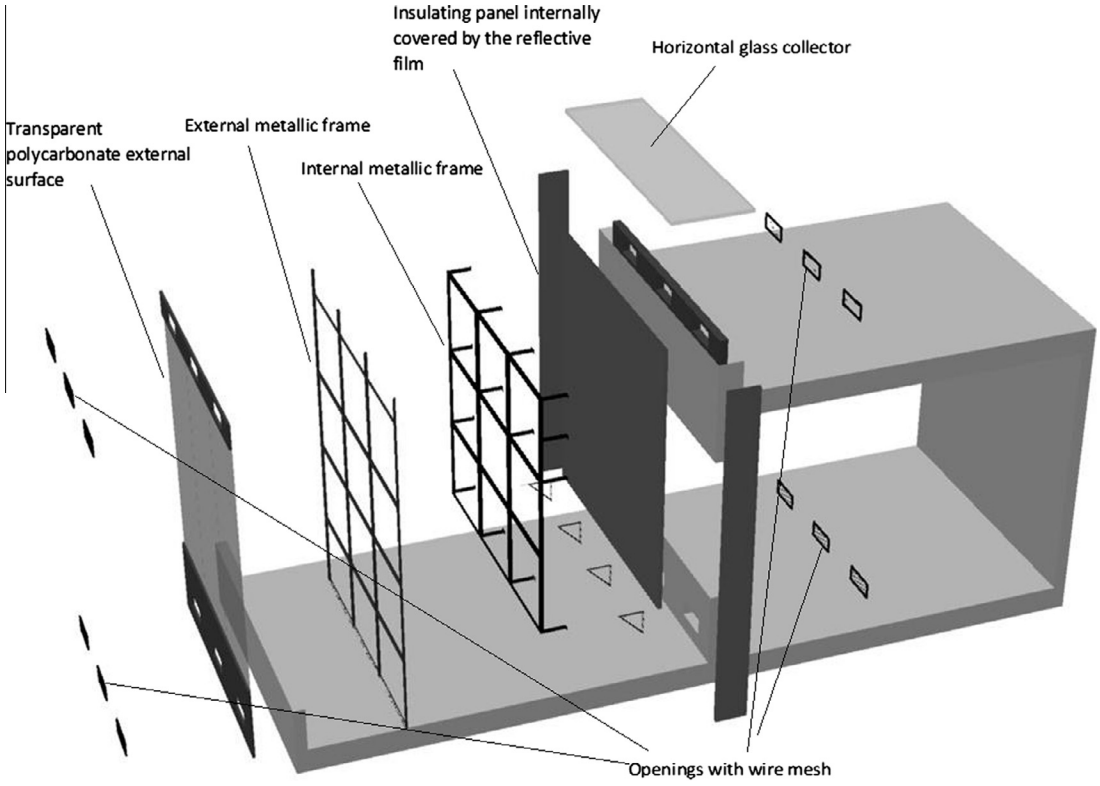

Fig. 1. Exploded view of the system with all the components.