Renewable and Sustainable Energy Reviews 53 (2016) 23–49

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser

Review of simulation modeling for shading devices in buildings

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ARTICLE INFO

Article history:
Received 20 May 2015
Received in revised form
3 August 2015
Accepted 8 August 2015

Keywords:
Solar shading device
Simulation modeling
Simulation tools
Buildings

ABSTRACT

Many countries around the world are confronted with the challenge of decreasing energy consumption, while the use of electrical appliances is continuously increasing in buildings. The requirement to minimize the energy consumption can be fulfilled by revaluating architectural aspects. One of these aspects is related to overheating problems, caused by facades with large, glazed portions. In such designs, shading elements must carefully be integrated and considered at an early-design stage in the design process. Shading of buildings is crucial especially in climates with hot summer. It is significant to protect the window from solar radiation in summer while allowing maximum solar radiation in winter. For this reason, precise figures of their performance are needed. As such, simulation tools are often used for identifying the most suitable shading element that suits the building.

In literature, there are many studies that have been done to designate the energy performance of shading devices in buildings by using simulation tools. This study focuses both on the shading device types used in the building sector and the previous studies done for designating the performance aspects of different shading devices types. Numerous studies for different building types located in different climatic regions have been reviewed in order to underline the importance of simulation modeling for shading devices in buildings.

Contents

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http://dx.doi.org/10.1016/j.rser.2015.08.020
1364-0321/

1. Introduction

1.1. Importance of shading devices

Energy efficiency becomes one of the main goals of the European policies to put emphasis on the significance of energy guarantee and climate change [1]. Buildings in the European Union consume at around 40% of the total final energy use and 36% of the total CO_2 emissions of the EU Member States [2]. The use of shading devices is vital for facades with large, glazed portions in the sense of energy conservation in buildings. Highly glazed facades are widely used in new buildings to provide natural light and external view. However, it should be considered that there is a risk of creating high heating and cooling loads in these buildings [3,4]. There are different shading device types used to improve building energy performance, like overhangs [5], external roller shades [6], venetian blinds [7] and internal shading [8]. These shading devices have been used in different case studies by various researchers as mentioned above. The numerous studies done on shading devices also shows the importance of their usage in buildings. Therefore, the application of exterior shading devices is an essential issue for decreasing the cooling loads of buildings in hot climatic regions.

The most significant reason of using a shading device is to prevent the penetration of direct sunlight and solar radiation into the building in cooling period and to permit the wanted solar gains in heating period [9]. The homogenous distribution of daylight in the interior is desired both in heating and cooling periods. In fact, while designing the glazed facades with shading devices in any building, there are various aspects that have to be considered such as the building type, the natural light prospects, and the latitude. Especially, building form and orientation play influential roles on the shading device types. The type of shading device used has an effect on providing desirable daylight, thermal comfort and visual comfort levels [10]. While providing these design issues, the cost-effectiveness should also be considered [9].

Littlefair et al. [11] stated that providing shade has energy benefits. Building Research Establishment case study forecasted that the integration of air conditioning in a 1960s open plan office would cause an increase of 55 kW h/m^2/year and £15/m^2/year. It is designated in the same study that comfort could be managed via the use of solar shading and night ventilation with zero cooling energy consumption. Such precautions bring an extra cost that is much less than cooling equipment installation. Even though cooling equipment is installed in a building, the gain from shading may have a payback less than 5 years [11]. Dubois (2001) demonstrated the effects of an awning on an office window on the south facade. It is indicated in this study that large energy savings (around 12 kW h/m^2/year) might be achieved by mounting seasonal awning. However, if fixed awning were used, the energy saving would be 11 kW h/m^2/year. Therefore, this result designated that the shading devices should be removed in heating season [12].

If shading devices are mounted on the exterior, they can block solar radiation efficiently before it penetrates through the window glazing. However, when they are mounted to the interior, far-IR radiation reradiated from the interior surfaces cannot pass through the glass. Therefore, the heat is trapped inside the building. This results in the increase in cooling loads during overheating period [13].

Green facades improve thermal comfort for indoor environment by protecting buildings from solar radiation. It reflects or transmits only a required amount of solar radiation into buildings. Leaves absorb most of the solar radiation for photosynthesis and evapo-transpiration [14]. Thus, it decreases overheating in a building. In hot climatic regions, the more leaves cover the facade, the better the thermal performance is and the more energy-efficient the building is [15].

1.2. Aim of the study

This study makes a review about the developments on the use of shading devices in buildings so far. Between the years 1996 and 2015, there were different studies have been done in order to show the importance of simulation modeling for different types of shading devices in buildings. According to our research, several simulation softwares have been developed since 1990s. Moreover, these simulation tools have been used in various studies as mentioned above. The focus of the study is to find or to design accurate shading device for the energy efficiency of a building. For this reason, simulation modeling is the easiest and fastest way to achieve this aim.

1.3. Previous reviews about simulation modeling on shading devices

When primitive studies about simulation modeling on different shading devices are brought together with detailing, it is seen that most of them in this field have been gaining a value year by year as various simulation tools are being developed. Interesting studies were done in the early 2000s as it was in Datta's study by using TRNYS simulation tool [16]. He studied the thermal performance of a building and developed a shading model for windows. The selected shading device type is external fixed horizontal louvers with various slat lengths and tilts. The study was carried out in four different Italian cities: Milano, Roma, Napoli, and Palermo. The aim of this study was to find the proper shading device for each city in terms of thermal performance of the building. Another study according to Tzempelikos and Athienitis [6] was done by using the same simulation tool. The solar radiation engine in TRNSYS was used to attain accurate hourly horizontal irradiance values for 1 year. Outcomes of thermal and daylighting analysis