Building and Environment 97 (2016) 166–176

Contents lists available at ScienceDirect

Building and Environment

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

An experimental study of all-season operation strategy for a respiration-type double-layer glass curtain wall system in cold zone of China

Xiangfei Kong, Shaoning Liu, Hua Yang*, Yuliang Zhong, Chengying Qi

School of Energy and Environmental Engineering, Hebei University of Technology, Tianjin 300401, PR China

ARTICLE INFO

Article history:
Received 11 September 2015
Received in revised form
7 November 2015
Accepted 26 November 2015
Available online 2 December 2015

Keywords:
Double-skin façade
Curtain wall
Cold zone
Operation strategy
All-season

ABSTRACT

Double-skin facade (DSF), as one of modern architecture envelopes, is beautiful and transparent. However, as transparent building envelope, double-skin facade has shortcomings in thermal performance, such as direct sunlight in summer. In order to overcome these drawbacks, a year-round optimum operation strategy of respiration-type double-layer glass curtain wall, which is one kind of double-skin facade with natural air circulation and blind system, has been researched by an experimental way in an office building. The optimum operation strategies that included changing air circulation and adjusting blind sun shading angle and installation position has been studied through comparative experiments in two identical rooms of the office building. For a year-round using in the cold zone of China, the related experiments were conducted in three stages: summer, winter and transition season. It was found that the optimum operation strategies in three seasons were different, but all of them have obtained well results. First of all, with the sun shading of blinds and the air external circulation, temperatures of air flow duct and room were decreased in summer. And then, with blinds removing, the indoor room can be warmed up by "greenhouse effect" created by respiration-type double-layer glass curtain wall for winter using. At last, in transition season, respiration-type double-layer glass curtain wall has increased the indoor thermal comfort and supplied fresh air.

1. Introduction

Building energy consumption has been continuously increased, which has been doubled during the last decades in China [1]. According to the growing trend of developed countries, the building energy consumption will account for at least 40% of all social total energy consumption in China [2]. Even worsely, as people increasingly craved for more building comfort and spent more time inside buildings, energy consumption for space mechanical cooling and heating were sharply increased. Consequently, finding a sustainable way in building energy consumption reduction has far-reaching effects [3,4].

The artistic exterior appearance is one of the most important aspects in modern buildings design. To have a light weight structure and attractive visual appearance, the glass curtain wall is always a popular choice for the building envelope [5], especially in high-rise buildings. However, because of the relatively lower thermal resistance than traditional building wall, glass curtain wall has 5–6 times larger of heat loss than that of traditional building wall [6]. It is particularly of the case for the single-layer type of glass curtain wall. Reasonably, the glass curtain wall is considered as the most active and sensitive part of heat conduction in building envelop. As a result, improving the thermal performance of glazing material and then achieving energy efficiency of building envelop are the top concerns within professionals.

As one kind of passive solar heat storage system, double-skin façade (DSF), including two-layer glazing (internal facade and external facade) and ventilated air channel (to separate the two layers) can offset the disadvantage of high heat conduction for the system single-layer curtain wall [7,8]. In summer condition, the heat from solar radiation in air channel is accumulated due to the "greenhouse effect". To counteract it, most of researchers focused on stack effect theory, solar chimney concept and sunshade method to discharge the accumulated heat, and then enhance the performance of the DSF [9–12]. Based on the hot and humid climate condition, Wong et al [13]. has used CFD to study a series of thermal

* Corresponding author.
E-mail address: yanghua@hebut.edu.cn (H. Yang).

http://dx.doi.org/10.1016/j.buildenv.2015.11.030
0360-1323/

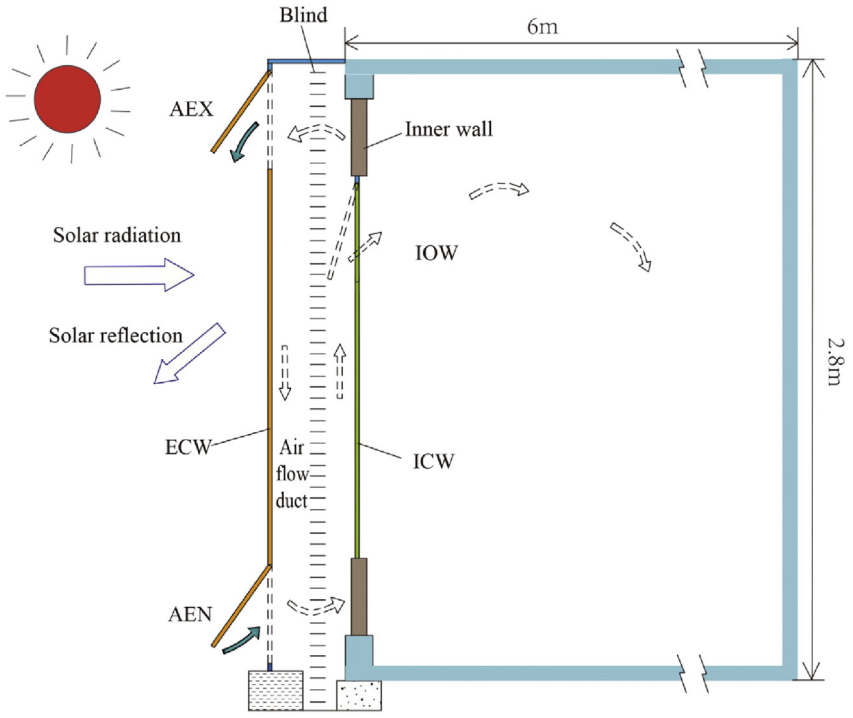

Fig. 1. Structure of RDGCW system.

Table 1
The physical parameters of RDGCW [29].

Material	Absorption coefficient	Thermal conductivity W/(m K)	U-value W/(m^2 K)	g-value	Transmission coefficient	Reflection coefficient	Area (m^2)	Thickness (mm)
Single-type coated glass (outer curtain wall)	0.22	0.75	6.15	0.89	0.71	0.07	11.20	6
Double-layer glass (inner curtain wall)	0.23	0.375	2.70	0.74	0.66	0.11	9.25	12
The inner opaque wall	–	0.59	1.47	–	–	–	1.95	370

comfort parameters with different double facade configurations and provided evidence for a new type of double-skin facade configurations. Also, a new DSF system equipped with integrated movable shading devices was proposed by Baldinelli [14], and its model were presented and simulated, showing that the proposed DSF system significantly improved the building energy

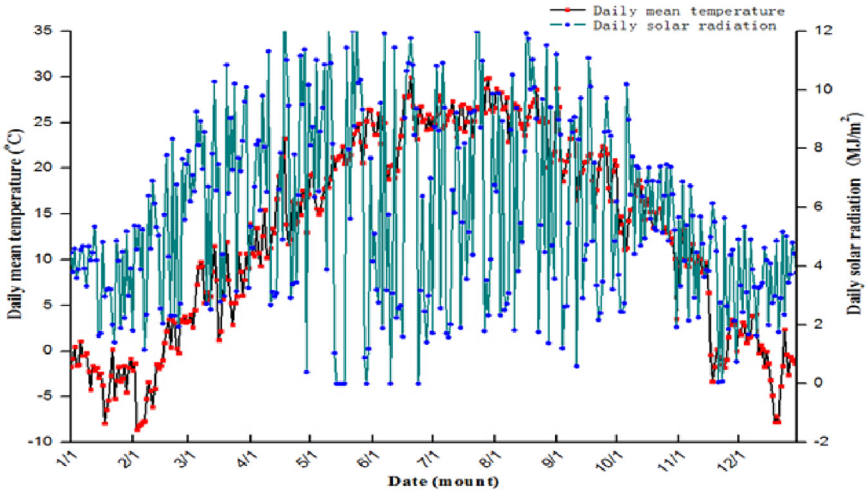

Fig. 2. Typical climate variation trend of cold zone in China [30].