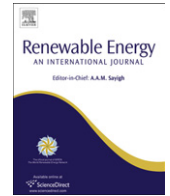




Contents lists available at ScienceDirect

Renewable Energy

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

Two-sided wind catcher performance evaluation using experimental, numerical and analytical modeling

H. Montazeri*, F. Montazeri, R. Azizian, S. Mostafavi

Department of Mechanical Engineering, School of Engineering, Yazd University, Yazd, Iran

ARTICLE INFO

Article history:

Received 19 May 2008
Accepted 4 December 2009
Available online xxx

Keywords:

Two-sided wind catcher
Natural ventilation
Wind tunnel
CFD
Analytical model
Flow visualization

ABSTRACT

Experimental wind tunnel and smoke visualization testing as well as CFD and analytical modeling were conducted to investigate the performance of a two-sided wind catcher. This type of wind catcher is divided internally into two halves for the purposes of air supply and extract. In this study, the two-sided wind catcher model was constructed of two similar one-sided wind catcher models, which were attached together back to back. These one-sided models are 1:40 scale models of Kharmani's School wind catcher in the city of Yazd. Experimental investigations were carried out using an open-circuit wind tunnel and both the induced volumetric airflow into the building and the pressure coefficients around all surfaces of the wind catcher model were measured at various wind angles. Furthermore, the CFD simulation was also used to evaluate the pressure coefficient distribution and airflow pattern around and through the wind catcher. Additional experimental tests and computational fluid dynamics simulation of the wind catcher in the wind tunnel were also conducted in order to assess the accuracy of measurement procedures and the uncertainty of experimental results. This article also represents a semi-empirical approach in which experimental data were used for a detailed analytic model, in order to provide an accurate estimate of the performance of wind catchers. It was found that for an isolated two-sided wind catcher model, the maximum efficiency is achieved at the angle of 90°. At this air incident angle the wind catcher efficiency increases approximately 20% more than the one at zero angle. The experimental investigations demonstrated the potential of two-sided wind catcher for enhancing the natural ventilation inside buildings. It can be seen that CFD simulation and analytical modeling results have a good agreement with the experimental results. Theoretical modeling can also help to assess the accuracy of measurement procedures and the uncertainty of experimental results.

© 2009 Elsevier Ltd. All rights reserved.

1. Introduction

Natural ventilation has become an increasingly attractive method for reducing energy consumption and cost. This environmental friendly technology also helps to provide acceptable indoor environmental quality and maintain a healthy, comfortable, and productive indoor climate rather than the more prevailing approach of using mechanical ventilation.

Wind catchers or Baud-Geers (as they are called in Persian language), have been used over centuries in the hot arid regions of Iran and the countries of the Persian Gulf to provide natural ventilation and passive cooling [1–3]. The wind towers maintain natural ventilation through living spaces due to wind as well as buoyancy effects [4]. The wind catcher system captures wind from external air stream and induces it into the building in order to cool

the inside occupant directly by increasing the convective and evaporative heat transfer from the inner part surfaces. It cools the inner part indirectly by removing the stored heat inside the building structure [5].

Wind catcher is normally a tall structure with the height between 5 and 33 m mounted on the roof of a building. The design of these systems has been traditionally based on the personal experience of architects as well as the dignity, wealth and social position of the house owners and differed in the height of tower, cross-section of the air passages, placement and the number of openings as well as placement of the tower with respect to the structure it cools [6]. Fig. 1 shows several ancient wind catchers with different configurations in the city of Yazd in Iran.

Karakatsanis et al. [2] determined wind pressure coefficients at various openings of a square wind catcher by testing a scale model of the building in a boundary layer wind tunnel. The tests were conducted on an isolated tower, the tower and the adjoining house, and the tower and the house surrounded by a courtyard. Using measured pressure coefficients natural ventilation through the

* Corresponding author.

E-mail address: Montazeri_hamid@yahoo.com (H. Montazeri).