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Numerical evaluation of louver configuration and ventilation strategies for the windcatcher system

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ABSTRACT

The windcatcher system is a green architectural feature that uses natural ventilation to induce external airflow into residential buildings. This paper presents different configuration and ventilation strategies for the windcatcher to evaluate the performance of the system in relation to ventilation and indoor particle dispersion. A commercial computational fluid dynamic (CFD) code is used to evaluate the windcatcher's performance using different numbers of louvers and louver lengths. The effects of buoyancy and window positions on the system's performance are considered. The flow rate of air induced into the windcatcher is found to increase with the number of louver layers and the highest ventilation rate is reached when the louver length equates with the reference length. With respect to the buoyancy effect, the results show that the system performs well in stimulating airflow and removing contaminants when a window is positioned on the leeward side. A uniform and low particle concentration is created when a window is positioned on the leeward side. However, due to the high air velocity below the windcatcher, the general airflow distribution of the system is not uniform. A damper or egg crated grill should be installed at the terminal of the system, especially when the external wind is strong.

1. Introduction

In accordance with increasing environmental awareness and the ongoing depletion of natural resources, more and more attention is being paid to sustainable and green architectural building features. Unlike conventional building methods, green architectural features, such as the windcatcher, solar chimneys, light wells and atria, increase the height of the column of warm air inside buildings which consequently increases the driving force of the stack effect [1]. In recent years, natural ventilation has also been attracting considerable interest in the field of green building design [2]. As a result of the stack effect and of the fact it is wind driven, natural ventilation acts as an effective way of reducing energy consumption in buildings [3]. One ancient form of natural ventilation, known as the windcatcher system (see Fig. 1), has been employed in arid regions like the Middle East for more than three thousands years [4]. However, the system has been largely ignored in modern building ventilation design (Fig. 2).

The shape and internal structure of the traditional windcatcher not only affected the airflow rate entering the system and the cooling capacity of the building, they were an indication of the dignity, wealth and social position of the house owner [5]. Nowadays, windcatchers are designed with different heights, numbers of openings and installment positions, as changes in wind direction and velocity can have an impact on the performance of the system [4]. Furthermore, as external wind is induced directly at a high level, the system is capable of avoiding the higher concentrations of contaminants found at ground level.

2. Literature review

A number of studies have assessed the performance of the windcatcher system. Elmualim [6] analyzed the performance of a windcatcher installed in a building in relation to ventilation tracer-gas measurements. The results showed that the chosen windcatcher provided a significantly higher airflow rate than in an equivalent area ventilated by an openable window. Kirk and Kolokotroni [7] carried out air exchange rate tests by applying the tracer-gas decay method in three operational buildings installed with windcatcher systems. The results showed that air exchange rates are related to wind speed. However, for low wind speeds a correlation was found between the airflow exchange rate and the internal external temperature difference, which indicates the effect of buoyancy forces. Moreover, in this condition, the wind and buoyancy pressures are of a similar magnitude.

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