A SOLAR CHIMNEY FOR NATURAL VENTILATION OF A THREE – STORY BUILDING

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ABSTRACT

Energy consumption of buildings can be significantly reduced with appropriate design for natural ventilation, particularly based on solar energy. Solar heat gained on the building envelope can be converted into thermal effects to induce air flow for natural ventilation or cooling of the building interior and the building envelope. For the ventilation application, the solar chimney should provide sufficient air flow rate. In this study, we investigated a solar chimney for ventilation of a three – story building. The chimney was assumed to be integrated into the building envelope and connected to all three stories of the building. To predict the air flow rate induced by the chimney through each story, a computational model was built based on the Computational Fluid Dynamics (CFD) method. By changing the design parameters (location and dimensions) of the chimney, ventilation rate through each story was computed. Temperature distribution in the chimney and the thermal efficiency of the chimney were also obtained for different design scenarios. From the results, the optimal design of the chimney which can provide nearly equal ventilation rate for all three stories was found. This study can serve as a demonstration for applications of the CFD technique in design of sustainable buildings.

Key words: *Solar chimney, flow rate, thermal efficiency, natural ventilation, CFD.*

1. INTRODUCTION

With appropriate designs for natural ventilation, energy consumption of a building can be significantly reduced. Methods for natural ventilation can be based on effects induced by external wind flow or heat [1]. The methods based on heat usually employ structures absorbing solar radiation which can be converted into thermal effects to induce air flow for natural ventilation or cooling of the building interior and the building envelope. The structures creating such effects are classified as Solar Chimneys [2].

Many studies have reported effectiveness of solar chimneys in reducing energy consumption on buildings. In Japan, Miyazaki et al. [3] showed that a solar chimney integrated into an office building in Tokyo could save up to 50% of annual energy consumption. That number for a solar chimney attached to a test room in Qatar was 8.8% [4]. In China, Hong et al. [5] reported that a solar chimney for a two–story building saved up to 77.8% of energy for ventilation.

When integrated into multi–story buildings, different configurations of solar chimneys have been examined [6,7,8]. Punyasompun et al. [6] compared two types of solar chimney for a three – story building: separate solar chimneys for each floor and a combined one connected to all floors. They reported that the combined solar chimney outperformed the separate ones with lower air temperature in each room and higher induced air flow rate. Asadi et al. [7] compared the induced air flow rate obtained with seven different configurations of solar chimneys for a seven–story building. Their results showed that the solar chimney on the southeast corner of the building offered the highest 24h ventilation rate while the one on the middle of the south wall offered the highest flow rate in day time. Similar conclusion was also reported by Mohammed et al. [8] for a two – story building.

One of the factors influencing most the performance of solar chimneys is the location of the air inlet [9,10]. Effects of the inlet location of the air inlet of the solar chimney for a single room were reported by Shi et al. [10]. Those for multi – story buildings have not been reported thoroughly in the literature. Although Mohammed et al. [8] also considered different locations of the solar chimney inlet in their simulation,