Cross Ventilation Using Wind Towers: How the position of a roof-top wind tower affects its ventilation effectiveness

Abstract

During the 21st century, with the growing environmental concerns, the research on different innovative building systems has become of major significance as it can accelerate the transition toward sustainable building design. For this reason, natural ventilation solutions including the wind tower technology have been more and more contemplated as potential alternatives to the more energy-intensive air-conditioning systems.

In spite of the effectiveness of wind towers in providing an acceptable indoor air quality and cooling previously verified by several scholars and despite its satisfactory performance in providing natural ventilation in the handful of buildings utilizing this technology, its uptake in the sustainable building industry is rather slow. This hesitance on the one hand could be due to design issues related to the integration of this component in the architecture of mainly high-rise buildings and on the other hand highlights the necessity of proposing a clear architect-friendly guideline addressing seemingly basic questions regarding the wind towers such as: where to place it, what type of wind tower to choose, what advantage it has compared to a window, whether it is applicable in multi-zone spaces, etc.

This thesis aims to address some of these questions. For that, Computational Fluid Dynamics code ANSYS Fluent 18.0 has been employed. Verified and validated using pre-existing wind tunnel data, several steady-state RANS simulations have been done to predict cross-ventilation using a wind tower. The three-dimensional coupled simulations have been performed using realizable k-ε turbulence model in an isothermal condition and with an atmospheric boundary layer wind profile. In order to evaluate the cross-ventilation performance of wind towers, a one-sided and a four-sided rooftop wind tower have been joint each with a room window. Cross-ventilation using two windows, has been compared with cross-ventilation using a wind tower-window combination. The performance of four-sided wind towers in presence and absence of a window has been assessed. The effect of different rooftop positions of the wind towers on cross-ventilation at various wind incident angles has been determined. And, finally, the effect of

different placements of a room partition in cross-ventilation by a one-sided wind tower has been assessed.

The results of this thesis not only provide a knowledge about the airflow through wind towers and link some of the previous wind tower studies, but also point out to an important issue related to the ventilation assessment: the unpredictability of the variations of different ventilation indicators and thus the necessity to analyse them simultaneously.