Better Natural Ventilation Design for Single Sided Apartments Utilising Computational Fluid Dynamics

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Abstract: Wind-driven natural cross ventilation to many single-aspect apartments can be achieved via building indentations and façade articulation. The ventilation rate of these apartments will rely on pressures differences between openings caused by approaching wind pressure, local wind climate and interaction with the surrounding built environment and external pressure gradients on the building indentations or any other facades articulation and their potential driving force on natural ventilation. Detailed simulation methods are therefore required to consider all above mentioned parameters and provide internal and external airflow information to the design team to allow for design modifications or refinement where required to provide robust natural cross ventilation for such apartments.

This study assesses the above parameters for a proposed development, designed with recesses and slots to enhance natural cross ventilation in single-sided apartments, and presents a reliable procedure to advise on compliance with national and/or international design guidelines utilising an advanced combined outdoor-indoor Computational Fluid Flow (CFD) analysis integrated with localized weather data for the project site.

Keywords: CFD, Natural Cross Ventilation, Single Sided Apartments, Australian Design Guide, Multi-Residential Buildings.

1. INTRODUCTION

Buildings account for 30-40% of total energy consumption, and natural ventilation is an effective strategy to reduce energy consumption, especially in multi-storey residential buildings. Other advantages of natural ventilation include increased space usage (e.g. less ductwork), reduced maintenance, improved user satisfaction, etc.

Natural cross ventilation is achieved by apartments having multiple openings where there exists a pressure difference between those openings, e.g. if the wind pressure at one opening is greater than the pressure at other openings, airflow will be pushed through the apartment in the direction positive to negative.

Several factors should be considered when assessing the wind-driven natural ventilation potential of an apartment, including the following:

- Exposure to the prevailing local wind climate and exposure to higher strength winds on elevated terrain.
- Interaction with the surrounding built environment.
- External pressure gradient variations created by articulated facades and their potential driving force upon natural ventilation.
- Internal geometry, e.g. the presence of room partitioning will affect the pressure drop inside the apartment.

Consideration of the above factors will allow a reliable assessment of the impact of pressures differences caused by wind.

The prediction of wind-driven natural ventilation in single-sided apartments of high-density residential buildings has been the subject of a number of research and commercial studies. Examples are shown in [1-10]. Among the existing methods to predict the wind driven ventilation rate, there is:

- Empirical Method [6,7] for a single fronted unit with one opening. This model calculates the ventilation rate as:

  $$Q = Cv\ A\ U$$

  Where A is the opening area (half of the single opening), U is the reference wind speed and Cv is the value of the opening effectiveness. This approach can provide a rapid estimate, and the accuracy of the calculation will depend upon the approximated Cv values for various wind directions.

- Wind Tunnel Testing [8,9]. There are known limitations in the physical scale modeling of ventilation flow through the openings [8], which restrict the simulation of ventilation in wind tunnel models to cases where the external pressure

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sions, opening size, etc.) if the pressure difference between openings is not enough to provide appropriate ventilation rate and ensure compliance with the adopted design guide.

6. CONCLUSIONS

A reliable procedure is presented to assess natural cross ventilation in single sided apartments, and advise on compliance with national and/or international design guidelines utilising a combined outdoor-indoor flow Computational Fluid Flow (CFD) analysis integrated with a localised weather data.

This study has demonstrated that natural cross ventilation for indentation apartments can be achieved when single sided apartments are designed to have openings (windows and sliding doors) in different pressure regions, rather than relying on purely wind driven.

Effective air circulation for a number of analysed apartments is achieved without having indentations with a width to depth ratio of 2:1. The proposed methodology in the current study is recommended if a project cannot satisfy the building indentations (2:1) width to depth ADG requirement due to the planning and design issues.

The study addressed the orientation of the building, the configuration of apartments, local wind climate and interaction with the surrounding built environment, external pressure gradients on the building indentations and/or any other facades articulation and their potential driving force upon natural ventilation.

The paper also discussed some of the parameters that have influence on the numerical results accuracy.

The presented tool helps to optimise the configurations of single sided apartments during the concept design stage to enhance fresh air movements through an apartment, and create a comfortable indoor environment. The CFD tool can also have multiple “downstream” applications, for example the same model could be used to examine thermal comfort, air quality (pollutant transport) issues, wind-driven rain ingress, wind induced noise, fire simulation, etc.

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