Application of Natural Ventilation for Commercial Developments

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1 INTRODUCTION

The recent tend towards improved energy efficiency for existing and future buildings has placed an emphasis on sustainable design, including a reduced reliance on energy demanding components of a building. This paper looks at the implementation of natural ventilation in commercial developments with the aim of reducing or optimising the design and use of HVAC systems. This paper discusses two developments currently under construction. A detailed analysis by Windtech Consultants of the natural ventilation performance characteristics for the two developments was undertaken using wind tunnel testing. The results show that natural ventilation can either negate the need for HVAC systems or optimise their configuration, depending on the local wind conditions and potential for natural ventilation. Important factors to be considered include the development's exposure to prevailing breezes, the effect of surrounding buildings, building massing, locations of openings, orientation and sizes of openings, façade design and local conditions, including wind speeds, directionality, humidity and temperature.

The harnessing of the elements of nature in the design of buildings has been an important part of building design. Some elements in nature such as the sun path are relatively consistent making it easy to reliably establish appropriate design parameters. However wind conditions vary for site to site and are influenced by a range of factors. The effectiveness of natural ventilation is also influenced by the local temperature and humidity as well as seasonal variations.

Design principles for residential buildings are widely discussed and ideal configurations for residential units are generally detailed in local planning requirements, such as SEPP 65 in NSW[2], to obtain acceptable levels of natural ventilation, in-principle. However the design of commercial developments is generally not addressed as these buildings are normally effectively sealed with internal ventilation provided through the use of mechanical systems. In the past, developers and designers have opted without hesitation for mechanical ventilation systems, which enable control of the internal conditions of a building without further consideration. However, recently there has been increasing concern at the increased level of carbon emissions especially from commercial buildings. This has seen some areas require new and older buildings to provide an energy efficiency rating, with in an increasing number of cases this having a reported effect on the lease or sale price of a building. It can be seen in Table 1, based in a US study in 2008, buildings with a LEED or Energy Star rating proved to have higher occupancy rates and also higher rental rates per square foot.

Table 1: Comparison Between Green Versus Conventional Buildings [1]

Building Type	Occupancy Rating	Rental Rate per ft^2	Sale price per ft^2
Energy Star Certified Building	91.5%	$30.55	$288
Non-Energy Star Building	87.9%	$28.15	$227
LEED Certified Building	92.0%	$42.38	$438
Non-LEED Building	87.9%	$31.05	$257

The best way to benefit from natural ventilation in commercial buildings is to incorporate natural ventilation principles in the concept design phase of the project. This enables proper optimisation of the layout of opening locations which works for natural ventilation without compromising function. The next section of this paper considers two case studies: one is the Chatswood Civic Place, located in Chatswood in NSW while the other is Macquarie University Library located in North Ryde in NSW.

2 CASE STUDIES

2.1 Chatswood Civic Place

Chatswood Civic Place is a new development currently under construction in the CBD area of Chatswood. The development consists of a 4 level L-shaped development on top of a single storey common podium across the site. The development is to house two theatres with a civic hall and retail tenancy on the ground levels. Windtech Consultants undertook the natural ventilation study for the large internal foyer areas of the development.

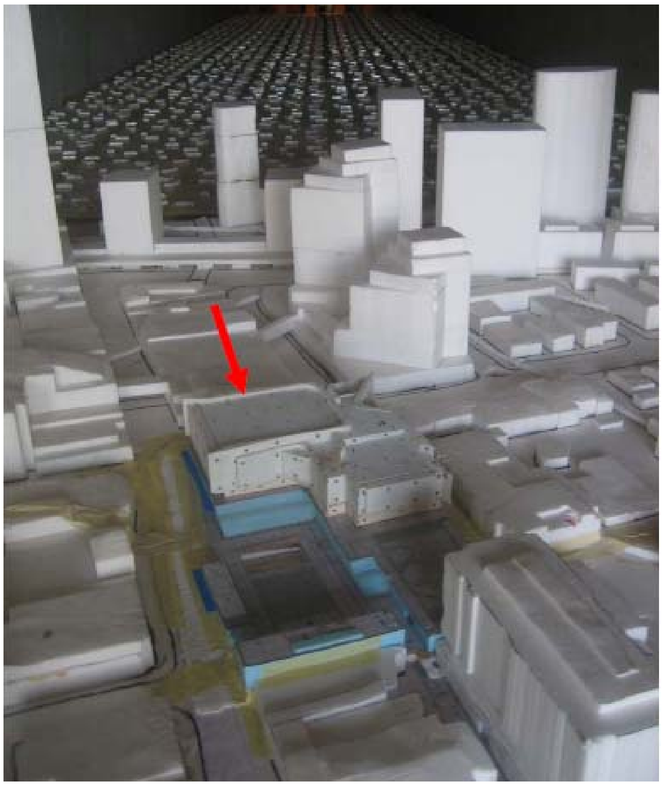

Fig. 1: Wind tunnel model for Chatswood Civic Place, Chatswood

2.1.1 Natural Ventilation Requirement

Chatswood Civic Place houses two large theatres which are joined on two levels to a large internal foyer area on the eastern and southern aspects of the development. The requirements from the client for the development were to determine the natural ventilation performance of the internal foyer areas and provide any recommendations for opening sizes and locations to optimise the natural ventilation performance for these areas. The idea for designing the development to capture the natural ventilation was to minimise the reliance of the mechanical system for the development while also aiding in smoke egress in the event of a fire prior to the over-riding fire control system taking over. The openings to the foyer area of the development would be predominately left open during times where the presence of crowds would greatly increase the load on the mechanical system.

2.1.2 Testing Setup

Testing for the natural ventilation performance of the development consisted of instrumenting a 1:300 scale model of the development placed in a surrounds model which incorporated the surrounding buildings and topographical effects for 400m in all directions. This was then placed in Windtech's boundary layer wind tunnel and tested for 36 wind directions.

Pressure sensors were placed at all proposed openings to the internal foyer area which were located on the Level 1 and Level 2, as well as potential roof mounted ventilation openings at locations detailed with the client. The roof mounted openings had to be placed in locations that would not interfere with building services and also not reduce efficiency of the internal flow path of the development.

2.1.3 Discussion

The results from analysis of the wind tunnel testing indicated that with the inclusion of roof mounted vents designed to specific requirements, the internal foyer area of the development would achieve natural ventilation of 1m/s on average, as stated in the SEPP65 Residential Design Code for air quality and cooling. This in turn also meets the requirements for ASHRAE Standard 55 and 62 for thermal comfort and ventilation for acceptable indoor air quality based on the size and use of the internal foyer space.

In addition to this the direction of the flow through the development and internal structure was also undertaken and found that based on the location of the openings, the flow direction would also be thermally efficient. With the development having larger glass facades as well as having roof mounted vents, the natural thermally driven component of flow through the void space would be further enhanced due the stack effect as the flow was shown to typically enter the development through the lower level entries and exit through the roof mounted vents. This effect would complement the wind driven ventilation, which was generated by the negative pressure region generated at the location of the vents on the roof in conjunction with positive pressures at the lower level openings.

Based on the testing for the development, the client was able to reduce the requirement for mechanical ventilation for the larger internal foyer. This benefit would in turn significantly reduce the energy requirements of the development in the long term. Additionally, the roof mounted openings were also detailed by the mechanical engineer to allow for exhaust fans to be utilised, further enhancing ventilation during times when there was little or no wind present.

2.2 Macquarie University Library

Macquarie University Library is currently under construction and is part of the Macquarie University campus in North Ryde, NSW. The development consists of a 4 level development on top of a single storey common podium across the site. The development consists of the university library on the ground level and first floor with study areas and classrooms in the levels above.

2.2.1 Natural Ventilation Requirement

Macquarie University Library has a main predominant opening located on the eastern aspect of the development which is set-back underneath the main tower section of the building. The requirements from the client for the development were to optimise the mechanical ventilation system of the development based on the known opening locations. The library was to be accessible 24hrs a day. However the configuration of openings would vary depending on the time of day. This required the consideration of both daytime and night-time scenarios. Due to the high traffic that is expected through the library, the main opening was expected to effectively remain open during the day, which in turn would substantially affect the load on the mechanical system, depending on the time of day and month of the year.

2.2.2 Testing Setup

Testing for the natural ventilation performance of the development consisted of instrumenting a 1:300 scale model of the development which was placed in a surrounds model which incorporated the surrounding buildings and topographical effects for 400m in all directions. This was then placed in Windtech’s boundary layer wind tunnel and tested for 36 wind directions. Pressure sensors were placed at all proposed openings to internal library area located on the development.

2.2.3 Discussion

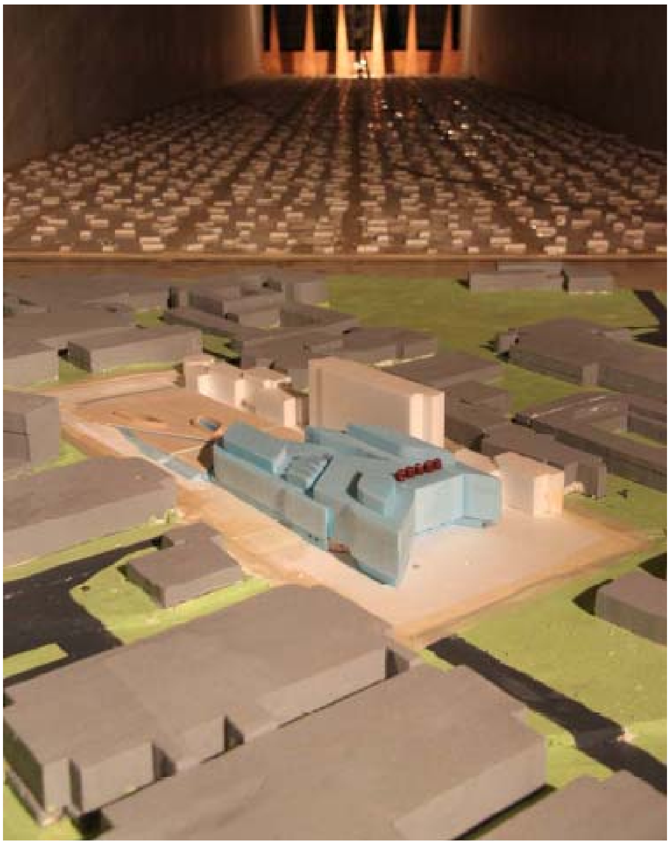

Fig. 2: Wind tunnel model for Macquarie University Library, North Ryde

A detailed analysis was undertaken for the local climate conditions for North Ryde, this included looking at wind speed and direction, temperature and humidity for one whole year (2006), this was based on data from Kingsford Smith Airport for the wind data and Sydney Olympic Park for the climate data which is the closest weather station to the site. Although wind data is also obtained at Sydney Olympic Park, it was found to be significantly affected by the surrounding stadiums at Homebush which meant that the wind speed and direction data cannot be based on the recordings from that weather station.

For this study, the client required the mean flow rates at hourly intervals for each opening location for both configuration of opening case over a year. With this information and also the humidity and temperature data which we analysed and provided, the client was able to efficiently design the proposed mechanical system for the library. This was because with the data provided for the site, the mechanical engineer was able to optimise the design performance of the cooling rates and temperature requirements depending on the time of the year. By knowing the flow direction and rate through the openings to the library, the control system for the design was able to be set for expected external temperatures for specific times of the day and year and also rate at which the warmer or cooler external air would be entering the library and effectively need conditioning.

3 CONCLUSION

Sustainable building design is becoming a more important issue for existing and future buildings, with significant effects of lease and sale price. By designing a new development with the intention for smart design, not only the overall retail value of the development is effected but also the carbon footprint and running coast of the development in the long term. Utilising natural ventilation for commercial building to reduce the reliance or need for HVAC systems or optimise the control design of these systems will have a significant impact. Taking into account the building location, surrounds, local wind climate, opening locations and sizes as well as internal layouts, are all key factors for sustainable design utilising natural ventilation for commercial buildings.

4 REFERENCES

[1] CoStar Group, Inc (2008). "Commercial Real Estate and the Environment" http://www.costar.com/uploadedFiles/Partners/CoStar-Green-Study.pdf

[2] NSW Department of Planning (2002). State Environmental Planning Policy No. 65 — Design Quality of Residential Flat Development. Residential Flat Design Code, Part 3 – Building Design, Page 87