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Innovative Designs for Natural Ventilation in High-Rise Buildings

高层建筑自然通风的创新设计

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Kevin is an Associate Director with Windtech and has extensive experience in undertaking wind tunnel studies and research in the field of wind engineering. This includes having presented numerous research papers in the field of natural ventilation for residential and commercial developments. Kevin has also been an adjudicator on design panel juries to assess the performance of developments with respect to wind, natural ventilation and solar effects. He also has particular expertise in undertaking and resolving wind related issues for existing buildings such as wind-noise, wind entry and stack effects.

凯文是澳风载建筑工程咨询公司的副总监，拥有风洞试验和风工程研究的丰富经验，包括在民用和商业建筑自然通风领域发表的多篇论文。凯文担任设计委员会的委员，负责评估项目在抗风，自然通风和太阳能效应等方面的表现。他还拥有在现有建筑风噪，风入口，以及烟囱效应等领域的专业经验。

Tony is a Director at Windtech with over 25 years' experience as a researcher and consultant in wind engineering, including supervising over 2000 studies for high-rise buildings. His experience includes sensitivity studies of parameters which affect wind tunnel results, interference effects between neighboring slender buildings and dynamic response of tall buildings with complex modal behavior.

He is on the Australian and New Zealand Standards Wind Loading sub-committee, executive committee of the Australasian Wind Engineering Society (AWES) 1998-2006 and has been part of the drafting of AWES-QAM-01(2000) and current update.

托尼是澳风载建筑工程咨询公司的总监，拥有风工程领域的25年以上的研究和咨询经验，包括指导2000多高层建筑的研究。他在影响风洞试验结果的敏感性参数研究，修长临近建筑的相互作用，具有复杂模态的高层建筑的动态响应等领域具有经验。

他是澳大利亚和新西兰风荷载分委员会委员，在1998-2006年担任澳大利亚风工程学会执行委员，参与AWES-QAM-01(2000)的撰写和更新工作。

Abstract

Consideration of energy efficient design strategies has become one of the primary considerations by leading architectural firms during the conceptual design phases and is an essential element for sustainable design. Architects are realizing that consideration of natural ventilation at the concept design phase enables an effective natural ventilation strategy without compromising the elegance of the design or function.

This paper discusses how design approaches for high-rise residential towers can consider the influence of the local climate on the design approach taken for a development, including orientation of apartments and openings, internal layouts and thermal comfort of occupants. The case studies presented are based on the Greenland Centre, located in the Sydney CBD, which will be the tallest residential tower in the Sydney CBD, and the Aspire Tower development which will be the tallest tower in Australia and the Southern Hemisphere once complete. These two case studies provide alternative approaches to harnessing the local climate to provide natural ventilation for the occupants, while providing comfortable communal and private spaces.

Keywords: Wind Tunnel Testing, Natural Ventilation, Innovative Design

摘要

在概念设计阶段考虑高效节能的设计已经成为领先建筑设计公司重点考虑的范畴之一。高效节能对于可持续设计是非常重要的。建筑师现在已经意识到在概念设计阶段考虑自然通风是一个有效的自然通风策略并且不用在建筑设计或建筑功能上做出妥协。

本文讨论了当地气候是如何影响并作为因素考虑进高层住宅项目设计方法中的，这些设计包括房间和窗户朝向，室内布局和使用者温度舒适度。文章中的实例为即将成为悉尼市中心最高建筑物的绿地中心和即将成为澳大利亚以及南半球最高建筑的Aspire塔。这两个实例列举了如何利用当地气候为居住者提供自然通风以及舒适的公用和私人空间的不同设计方法。

关键词: 风洞实验，自然通风，创新设计

Introduction

The design direction and considerations for current and future high-rise developments are increasingly molded by the sustainable viability of their design. The success of a project is now not purely measured by it's scale or height, but by the efficiency of the overall design and the impact it has on the environment (Jin et al, 2013). This changing focus is due to the increased negative stigma associated with wasteful and incoherent projects with respect to environmental concerns. While there is an also considerable benefit for both the environment and the end client/user associated with a sustainable design, including decreased operating costs and higher asset value (Jin et al, 2013, SmartMarket Report 2013). Sustainable high-rise designs are not only being driven by social reflectance, but also governmental regulations/restrictions as well as the end clients own input (SmartMarket Report 2013). Power consumption limits are now being

序言

现在和未来的高层建筑设计方向和考虑因素越来越着重于设计是否具有可持续性。如今建筑的成功不仅是他的规模或高度，还有整体设计的效率和建筑对环境的影响(Jin et al, 2013)。这样的转变是因为人们对于环境的关心导致那些浪费和不协调的项目遭到越来越多的负面评价。进行可持续的高层建筑设计不仅仅是由社会的反馈推动，并且也由政府的法律法规和终端用户本身推动 (SmartMarket Report 2013) 。现在的开发项目都被加上了能耗限制用于鼓励创新设计，这些设计更着重于可持续能源的使用方法。有关高效的建筑设计将会有更高的财政收益和其对使用者的健康和效率的文章都广为发表 (Brager，2013) 。

可持续设计的一个重点就是将建筑设计的能更好的利用当地环境，也就是利用太阳、风、气温和位置。本文重点研究高层住宅建筑对减少对机械通风的依靠并利用当地气候进行自然通风的设计发展。这只是一个项目中利用当地气候进行设计的一小部分。我们对两个现有的高层建筑设计

imposed on new development sites to encourage more attention on sustainable energy usage, while the increased financial return associated with efficient building design and the impact on occupant health and performance is widely published (Brager, 2013).

One of the focal areas for sustainable development has been to design the structure in such a way that captures and harness the local environment, namely the sun, wind, temperature and locality. This paper looks into the design development of residential high-rise structures to reduce the reliance on mechanical ventilation through the harness of the local climate for natural ventilation. This is only one piece of the design puzzle to consider for the local climate of a project. Two current high-rise case studies have been investigated as to how natural ventilation has been integrated as a design feature for the overall project. Each case study answers the question of how to provide adequate natural ventilation from different design direction, highlighting that designing for the local environment creates opportunities and not limitations when considered early and thoughtfully, with appropriate party's involvement.

Natural Ventilation Design

Natural ventilation has been considered in the design of buildings for centuries. This ranged from the location of settlements adjacent to water bodies and taking advantage of the cooling sea breezes. Through to the architectural features such as the badger, a multi-directional wind catcher design developed in the Persia and Gulf regions, with the inclusion of porous clay pots used to help humidify and cool the incoming air as it enters the building. The traditional ventilation design considered the development holistically, from the locality of the building through to the how the building's form interacts with its surroundings.

Advancement of technology due to industrial development, including the introduction of mechanical ventilation, seemed to erase centuries from our intuitive design basis. The primary focus shifted to being purely centered on the efficiency and profit generated by a project, with little to no concern for the sustainability or impact on the environment by the development. This approach was aimed at providing a utopian world of a near perfectly controllable environment for occupants, however shifting away from the sustainable holistic approach. Building designs were aimed at maximizing the net leasable area for the owner (Langdon and Kalita, 2006), while internal layout structures were driven by the workers usage type, collaborative or isolated work and level of autonomy of the worker (Shpuza, 2006).

Society slowly separated the consideration of the design of a building from its locality, with the concept that an identical building design could essentially be constructed at numerous locations around the world. This issue of focusing purely on the building's architectural form, without its sense of place was highlighted by Kent (2012) who stated that buildings such as 41 Cooper Square in New York City and the Central Library in Seattle, while impressive buildings in their own right, did not relate to the surroundings in which they were located.

Some recent project trends however have been incorporating natural ventilation as a design feature for the project, highlighting the ecological features of the development. This includes such buildings as the Mode-Gakuen Spiral Towers in Japan (Flahiff 2009), the Post Tower in Germany, Manitoba Hydro Place in Canada and 1 Bligh Street in Sydney (Wood and Salib 2013). These buildings have incorporated into the architecture, provisions to capture the prevailing winds and/

实例进行了深入研究。这会让我们了解潜在的自然通风设计方法是如何整合进整个项目中的设计特点的。两个实例从不同角度和观点回答了如何提供适当的自然通风。需要强调的是，若有适当的对象在足够早的时间和足够的考虑情况下，利用当地环境进行设计会制造而不是限制机会。

自然通风设计

自然通风在建筑设计方面的运用已经有几个世纪了。这包括从在水边定居并利用海风降温到有建筑特色的槽 (一个在波斯湾区域设计出的多方向集风口) 以及利用多孔陶罐为空气增湿并引导空气进入建筑里。传统的通风设计考虑的非常周全，这包括从建筑的方位到建筑是如何与其环境相互影响的。

由于工业发展导致的科技进步 (包括引进机械通风) 似乎抹去了我们数世纪以来的设计直觉。主要重点变成了一个项目的效率和效益，而很少或者并不关心项目的可持续性和对环境造成的影响。这样的设计着重于为居住者建立一个近乎能完美控制环境的乌托邦，但是却渐渐远离了整体可持续性的设计方案。建筑设计曾经的目的在于为业主最大化可出租净面积 (Langdon and Kalita, 2006)，而室内布局构造是由工作者使用类型，合作或独立工作以及工作者的自主程度决定的。

社会慢慢的将建筑方位从设计依据中分离出来，以为在世界各地都能用同样的设计修成建筑物。这样做完全只考虑到了房屋的建筑形式，并没有考虑到建筑的地理位置。肯特 (Kent，2012) 强调就如纽约的库珀广场41号 (41 Cooper Square New York) 和西雅图中央图书馆 (Central Library Seattle) 就本身而言是令人叹为观止的建筑，但和其周边的环境没有任何联系。

近期一些项目有将自然通风融入设计特色的趋势，其强调了项目的生态特点。这些项目包括了日本名古屋Mode学园螺旋塔(Flahiff 2009)、德国邮政塔、加拿大马尼托巴水电局大楼和悉尼布莱街1号大厦(Wood and Salib 2013)。这些建筑融入了建筑设计规范用于使用主要风和或利用热驱动烟囱效应来产生室内通风。这些设计规范包括了大型室内天井、外部散热特点和通过建筑的朝向利用上当地的气候。

标准

大多数项目的自然通风性能要求一般没有任何规定，通常是主观而不是客观的。这样的情况正因政府部门出台的可持续性政策慢慢改变。本文中提及的两个实例 (都座落于澳大利亚新南威尔士州) 都受到州政府出台的住宅项目规定条例监管。此条例概述了用于达到自然通风的住宅用房设计准则 (Planning NSW， 2002) 。这些条例的目的在于让住户能直接呼吸新鲜空气并且为其提供更舒适的居住温度。此条例概述了住宅建筑中至少有60%的居住面积有自然空气对流用于减少对机械通风的依靠，也就是说将公寓的通风口开在相对朝向或者毗连朝向 (开口位于不同的气压区) 的地方。

佩蒂和洛菲尔 (Peddie and Rofail，2011 2013) 通过不同风气候的各种国际标准对适用于自然通风的标准进行过详细评估。这些标准强调了在设计中需要考虑空气质量和舒适温度参量，以确保自然通风是机械通风的有效的替代。此评估中也提到了从空气质量方面来看，需要大约每小时两次房间空气体积的换气，为居住者提供明显的降温感觉和作为机械通风的有效替代，需要有速度为0.4m/s的50%的内流。

or take advantage of thermal driven stack effect to generate internal ventilation. These provisions include large internal atriums, external fin features and orientation of the buildings form to capture and take advantage of the local climate.

Criteria

Natural ventilation performance requirements for most developments are either not governed by any regulations, or are generally subjective instead of objective in nature. These aspects however have gradually changed with the introduction of sustainability policies by governmental departments. For the two case studies considered in this paper, located within the state of New South Wales in Australia, there are State Government regulations for residential development to achieve natural ventilation, as outlined within the Residential Flat Design Code (Planning NSW, 2002). These requirements are aimed at providing direct access to fresh air and promoting thermal comfort for the occupants of new apartments. The requirements outline that at least 60% of the various residential apartments should ensure the living spaces have access to natural cross ventilation, outlined as apartments with openings located on opposite or adjacent aspects (openings located in different pressure regions), to reduce reliance on mechanical ventilation.

A detailed assessment of various natural ventilation criteria was previously undertaken by Peddie and Rofail (2011, 2013) which was based on various international standards for a range of wind climates. These criteria highlighted the need to consider both the air quality and thermal comfort parameters provided by natural ventilation for the system to be an effective alternative to mechanical ventilation. It was noted that around 2 air changes of the room's volume per hour is typically deemed to be required from an air quality perspective, and a 50-percentile internal flow velocity of 0.4m/s is required to generate a notable cooling sensation for the occupant and be an effective alternative to mechanical ventilation.

Methodology

Natural ventilation through an internal space is driven by the simultaneous pressures at the external openings as well as any internal restrictions along the flow path within the volume. Accurate measurement of the external pressures at the external openings which also takes into account the effects of the surrounding buildings is therefore required.

For rooms with multiple openings, as for the case studies considered for this paper, the ventilation flow rate (m3/s) is dependent on the pressures at the various openings to the internal volume (apartment). The flow rate through an external opening is governed by the pressure differential between the internal volume and the opening location, with the internal pressure driven by the weighted pressures of the various external openings. The flow rate through a typical internal area along the flow path (eg. a door or corridor sectional area) where an occupant would be located can be obtained in this case by simultaneously equating the flow rates at the various associated volume openings (Allard, 2002), while ensuring continuity of mass flow is maintained. The internal flow rate through an apartment is the appropriate measured quantity as this directly reflects the internal air quality due to external air exchange and thermal comfort created by internal air velocity. Windtech have also undertaken full-scale testing to ascertain the reliability of this wind tunnel modelling and analysis technique to verify the natural ventilation performance of typical residential apartments (Peddie and Rofail 2011). The natural ventilation through the apartment was also

方法

室内空间的自然通风是由同步外部开口的气压以及内部体积空气流通路线中的内部限制气压来产生的。考虑到周围建筑影响的对外部开口处的外部气压准确测量是必需的。

有多处通风口的房间 (比如本文中提及的实例)，其通风流速 (m3/s) 是取决于各个通风口和内部体积 (公寓) 的气压。外部通风口的空气流速是根据内部体积和通风口处的气压差决定的，内部室内气压是由各个外部通风口的加权气压决定的。在空气流通路线上 (有住户走动的) 的典型内流流速 (如门或者走廊断面) 可以通过将不同通风口的空气流量同时相等 (Allard，2002)，与此同时确保质量流量的连续性。贯穿一个公寓房的内流流速是适当的测量量，因为这会直接反映出因室外空气交换的室内空气质量和由室内空气速度而产生的热舒适度。Windtech也为确定模型的可靠度进行了全尺寸证实实验，并且通过风洞数据测定了典型住宅公寓的自然通风性能佩蒂和洛菲尔 (Peddie and Rofail，2011)。这次的分析也考虑了公寓自然通风的16个风向，也包括了当地风环境的影响 (包括风速和偶然事件的发生概率)。

$$Q_1 = A_1 C_{d_1} \sqrt{\frac{2(p_1 - p_i)}{\rho}}$$

$$\sum Q_n = 0$$

P_1 通风口1的平均压力

P_i 平均内压

C_d 通风口排风系数

A 通风口面积(平米)

Q 顺着流通路径的通风口1质量流量(立方米/秒)

ρ 空气密度 (公斤/立方米)

对于这次的绿地中心案例分析，我们将电脑流体力学模拟 (CFD) 和风洞模型试验相结合，这样提供了公寓内流路径的可视化效果以及在私人阳台区域设计的烧烤区空气/烟雾详细流线谱和烟雾浓度。从风洞实验中得到的风压值在CFD模型中作为边界条件，用于确保由于周围建筑导致的开口区域的风压变化会被准确考虑到。

案例分析

建筑自然通风设计并不是对建筑设计的另一个限制，但却是之前所提过的另一种潜在的设计特色。

以下两个案例分析都是在澳大利亚的住宅房。设计中的绿地中心项目位于悉尼市中心巴瑟街115号，Aspire塔是西悉尼帕拉玛塔广场重建项目的其中一幢楼。

绿地中心，悉尼巴瑟街115号

绿地中心是一座235米的住宅项目，竣工后将成为悉尼市中心最高的住宅建筑。建筑是由BVN建筑公司和Woods Bagot建筑工作室设计的，此建筑包括了在现有的25层悉尼水利管理局办公楼上加盖。住宅用公寓将会分布在项目的各个朝向，主要的朝向为北、东和西。图1显示了在Windtech风洞实验室中1: 300的建筑模型。图1 绿地中心 (来源: 澳风载建筑工程咨询公司)

澳风载建筑工程咨询公司 (Windtech) 在初步设计理念阶段就为项目提供了此项目的风效。这样做突出了悉尼市中心会影响此项目的关键因素。风工程咨询公司对于高层建筑的早期介入使将来的设计考虑因素融入设计的每次进展，而不是被迫遵守之前提到的规范管理法则。

considered for 16 wind directions as part of this analysis, with the effect of the local wind climate, including wind speed and probability of occurrence accounted for.

$$Q_1 = A_1 C_{d_1} \sqrt{\frac{2(p_1 - p_i)}{\rho}}$$

$$\sum Q_n = 0$$

P_1 mean pressure at Opening 1

P_i mean internal pressure of volume

C_d discharge coefficient of the opening

A openable area of the opening (m^2)

Q mass flow rate along the flow path through opening 1 (m^3/s)

ρ air density (kg/m^3)

For the Greenland Centre case study, a hybrid CFD and wind tunnel modelling technique was used to provide visual understanding of the internal flow paths of the apartments, as well as detail flow patterns and smoke concentration levels from proposed barbeque locations on private balcony areas. The direct pressure measurements obtained from the wind tunnel study were used as boundary inputs for the CFD model to ensure that the effects on the wind pressures at the openings caused by the surrounding buildings were accurately accounted for.

Case Studies

Natural ventilation design is not something that should be viewed as a potential constraint on the design potential of the structure, but instead used as a design inspiration for the project as mentioned previously.

The two case studies considered are both residential tower located in Australia. The proposed Greenland Centre development, located at 115 Bathurst Street is situated within the Sydney CBD, while the Aspire Tower is part of the Parramatta Square redevelopment precinct located in western Sydney.

Greenland Centre, 115 Bathurst Street, Sydney
The Greenland Centre is a 235m high residential tower development and will be the tallest residential building within the Sydney CBD, when completed. The development, designed by BVN Architects and Woods Bagot, consists of a tower extension above the existing 25 level Sydney Water Board office building. Residential apartment will be proposed on all aspects of the development, with the main view points to the north, east and west. Figure 1 shows the 1:300 scale model of the development within Windtech's wind tunnel facility.

Windtech Consultants were involved with providing input on the wind effects on this development from the early concept design stages. This enabled the key factors which would impact the development to be highlighted in the context of its location within the Sydney CBD. Early involvement by the wind engineering consultant for high-rise structures enable potential design considerations to be incorporated into the design, instead of creating a forced adaption to enable compliance with regulatory requirements outlined previously.

Due to the layout of the subject site and apartment sizing desires from potential clientele, the floor plan design of the building lead to the inclusion of four main corner apartments, with single aspect

由于潜在客户要求的公寓户型布局和大小，楼房设计平面图包含了四个角落的公寓，这就留下了不少在北边和南边的单一朝向户型。在规范管理规划的理论上满足自然通风性能的公寓户型数量就不够。此外，客户还要求建造"悉尼"暖房 (如图2所示) 用于为提议中贯穿整座建筑的私人阳台提供适当的无风环境。这样做是用来减少风力，这对于为通风提供适当的空气对流是矛盾的。Windtech在与客户和建筑师的咨询会中原则上强调了在项目中实现预定舒适和通风要求的可能性。这包括了提供悉尼的总体风向，以及周边建筑对于此项目通风的影响和利用建筑设计特点 (包括叶片式墙壁和"悉尼"暖房的通风口位置)。

为了准确测算周围建筑物对此项目的影响，以及"悉尼"暖房设计对于公寓自然通风的可能性，Windtech进行了详细的风洞实验。模拟实验包括将暖房空间空气流通到公寓其他地方的影响列入实验范围。排风到建筑外表凹槽也做了更多的预留空间。通过进行详细的风洞实验也核实了用于空气流通的通风口的位置和大小。外部通风口的位置和大小对于通风效果的影响会由详尽的风洞实验核实。

由于"悉尼"暖房设计的本质特性，Windtech将计算机流体动力学模拟 (CFD) 和风洞实验相结合，用于核实拥有"悉尼"暖房的住宅公寓的室内空气流线谱。此项研究利用从风洞实验中得到的各个通风口位置的同步压力值作为CFD中公寓通风口的边界条件。如图3所示的CFD模型，与通过风洞实验所得到的预期室内空气流速和换气数据相吻合。此CFD模型也直观的展示了暖房中的空气流线谱。

利用风洞实验取得的结果能确保周围建筑对于通风口风压的影响是准确的，并且在有确切的边界条件下CFD模型数据也是准确的 (但CFD无法准确模拟高湍流边界层风流)，并且外流在初步设计中并没有准确的模拟。Windtech也进行了额外的模型研究，用于理解风吹的雨通过通风口进入暖房通风口以及使用者使用区的特性。我们也研究了烧烤产生的烟雾在暖房中的渗透效果并且考虑了烟雾浓度和烟雾在公寓中的流动。

悉尼帕拉玛塔Aspire 塔
Aspire塔是一个座落于悉尼西部帕拉玛塔广场项目范围内的住宅

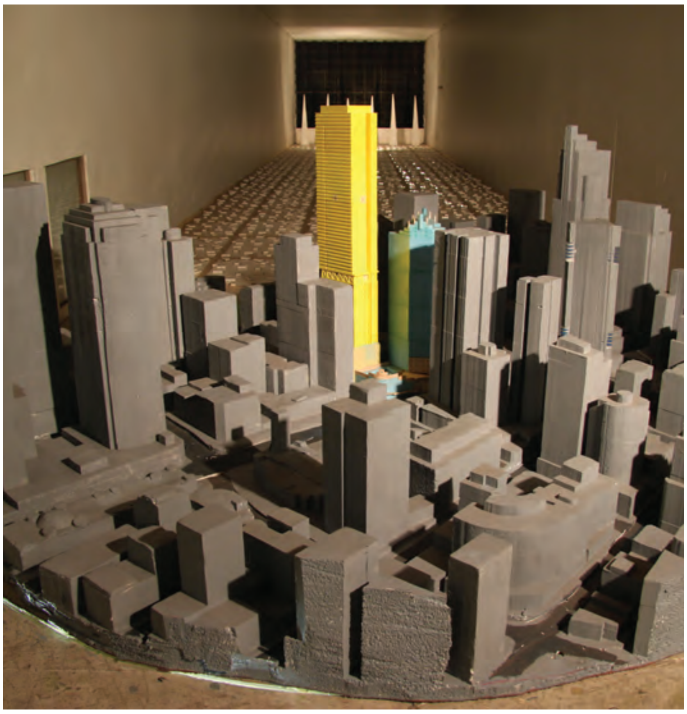

Figure 1. Greenland Centre, 115 Bathurst Street, Sydney. (Source: Windtech Consultants)
图1. 绿地中心 (来源: 澳风载建筑工程咨询公司)

apartments located along the northern and southern aspects. In theory from a regulatory planning perspective, this would results in insufficient number of apartments satisfying for natural ventilation performance. Furthermore, it was desired to include "Sydney" wintergardens, as shown in Figure 2, to provide suitably calm conditions for the proposed private balcony areas through the height of the tower. This feature is aimed at reducing wind conditions, which is contradictory in nature to providing desired airflow for ventilation. In-principle consultation with the client and architects highlighted the potential for the development to achieve both the desired conditions for comfort and ventilation. This included addressing the prevailing winds for Sydney, impact of the adjacent surrounding buildings on the potential for ventilation and utilization of architectural features, including blade walls and location of openings for the "Sydney" wintergardens.

To accurately account for the effects of the surrounding buildings as well as the "Sydney" wintergarden design on the potential for natural ventilation of the apartments, detailed wind tunnel modelling was carried out by Windtech. The modelling included taking into account the effect of the secondary wintergarden volume on the flow through the rest of the apartment. Additional allowance was included for ventilation ducting to architectural recesses in the buildings form. The effect of the location and size of external openings on the ventilation performance was able to be verified by undertaking the detailed wind tunnel modelling.

Due to the intrinsic nature of the "Sydney" wintergarden design, a hybrid Computational Fluid Dynamics (CFD) and wind tunnel study was undertaken to verify the internal flow patterns of the residential apartments which utilized these wintergardens as part of their design. The study utilized the simultaneous pressure measurements at the various opening location obtain from the wind tunnel study, as boundary conditions at the openings to the apartment for the CFD model. The CFD model, as shown in Figure 3, agreed with the calculations made purely utilizing wind tunnel analysis for the expected internal flow speeds and air changes. The CFD model also enabled a further visual understanding of the flow patterns associated with the wintergarden.

Utilizing the wind tunnel results ensured that the effects of the surrounding buildings on the wind pressures at the openings were accurately accounted for. CFD modelling is ideal where boundary conditions can be accurately defined, however highly turbulent boundary layer wind flows would not have been accurately accounted. Additional modelling was also carried out to provide an understanding of the wind driven rain through the wintergarden openings and utilization of the space by the occupants. The infiltration of smoke from the barbeque based on the location within the wintergarden space was also assessed and considered the concentration of smoke levels and its associated movement through the apartment.

Aspire Tower, Parramatta

The Aspire Tower is a residential and hotel building located within the Parramatta Square development precinct, within western Sydney. At 336m, the Grimshaw designed Aspire Tower will become the tallest in Australia and the Southern Hemisphere once complete. The design consists of an eastern and western wing which rotates with height, narrowing to the northern aspect while opening to the south.

The local wind climate for the Sydney region is governed by the north-easterly and southerly winds during the warmer months of the year when natural ventilation of an apartment would be applicable for its location. During the winter months, when the westerly winds are prevalent the temperature falls below that which would be

Figure 2. "Sydney" Wintergarden. (Source: BVN Architects)
图2. "悉尼"暖房 (来源: 澳风载建筑工程咨询公司)

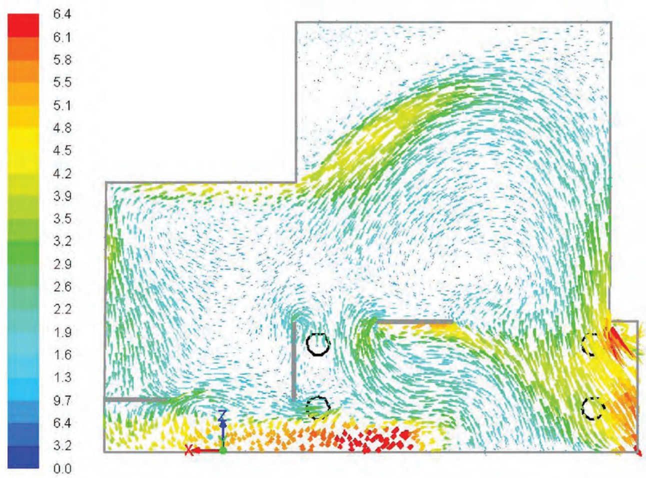

Figure 3. CFD Model of the internal Flow of the "Sydney" wintergardens. (Source: Windtech Consultants)
图3. CFD 的"悉尼冬季花园"内部流线模型 (来源: Windtech Consultants)

和酒店建筑。一旦完成，这座336米由Grimshaw设计公司设计的Aspire塔将成为澳大利亚和南半球最高的建筑。设计包括了东西两侧，其随着高度旋转，建筑北部将缩小但南部将扩大。

悉尼地区风气候是由一年中温暖的数月东北风和南风所主宰的，这时公寓自然通风是可行的。在冬天的数月，当西风是主要风的时候，气温会降到低于所谓居住者适宜温度以下。Windtech通过与建筑师和业主的交流沟通，当地气候条件将会融入建筑的设计中。设计理念包含了14个6层楼高有北边和南边通风口的内部天井。

这些室内天井为建筑提供了14个独立贯穿整栋建筑的公用空间，并且也为建筑每层不同的公寓单位提供空气压力差流通路线。通过这些室内天井与主风的作用，这样做在室内天井里产生了一个正压强。位于朝东和朝西的私人阳台由于塔体周边的流体机制依次设计在负压或者低于正压的区域。为了能够进行对这样布局的自然通风可能性定量评估，Windtech为此项目进行了详细的风洞实验。此项评估保证了由室内天井和私人阳台而产生的压强差能够准确测量。此外，Windtech使用的分析方法也考虑了平行通风口对于室外空气流动的影响。此设计确保增加单向百叶窗可以没

deemed suitable by occupants. Through development between the architect, client and Windtech, consideration of this local climate was incorporated into the design of the tower. The design concept consisted of 14 large internal 6 level height atriums with openings to the northern and southern aspects.

These internal atrium spaces provided 14 separate communal spaces throughout the height of the tower, while also providing a pressure differential flow path for the various residential apartments on each level of the development. By opening the internal atrium space to the prevailing winds enabled a positive pressure to be generated within the internal atrium spaces. The private balcony openings for the residential apartments, located along the eastern and western aspect, were in turn located in either negative or less positive pressure regions due to the flow mechanism around the tower's form. To enable a quantitative assessment of the natural ventilation potential for this arrangement, Windtech undertook detailed wind tunnel modelling for the development. This assessment enabled an accurate measurement of the pressure driven flow between the internal atrium and private balcony areas of the apartments. Furthermore, the analysis technique also considered the effect of the flow potential due to the external apartment openings being situated in parallel. This design also ensures that there are no odor issues with the inclusion of one-way louvers. This ensured the supply air was fed to the various apartments via the central atrium, with the balcony doors become the exhaust locations of the flow. An acoustic detail was developed to ensure adequate attenuation of noise across the intake to the apartment from the atrium space.

By developing the design of this tower in consideration for the prevailing winds for the local climate, the design was able to take advantage and utilize this as a design feature, rotating and opening to provide ventilation within the internal spaces. This account for the local climate enabled the potential for solar access to the various apartments to also be enhanced, reducing reliance on artificial lighting. Narrowing of the tower aspects to the predominate wind directions also assisted in reducing the design winds loads on the structure. Desktop assessment while suitable for simple exposed developments or early conceptual design phases, are not appropriate for more complex situations such as within built up areas or complex building forms / ventilation systems such as these case studies.

Conclusion

The design of our current and future high-rise developments should take into consideration not only the local culture, but the local climate of the subject development as design incentives from the conceptual stage. By considering how the local environment can influence the projects performance at an early stage, with the input of respective specialist consultants, the solution becomes part of the buildings expression instead of being viewed as last minute revision to achieve compliance.

有气味问题。这样可以确保将阳台门作为空气流通排风口并通过室内天井向各个公寓房中输送空气。另外，Windtech也考虑到了听觉设计，用于减少任何由于室内天井与公寓空气对流而产生的噪音。

通过考虑位于当地气候中主风在设计中的因素，设计将利用主风作为设计特色。对于当地气候的考量也提高了设计师为不同公寓户型的采光可能性。这也可以减少对人工照明的依赖。考虑到主风的影响，缩小塔高处的面积也会减小风力载荷。桌面研究适用于简单空旷的项目或者前期概念性设计阶段，不适用于更加复杂的情况，比如建筑密集区或者复杂的建筑形式/通风系统。

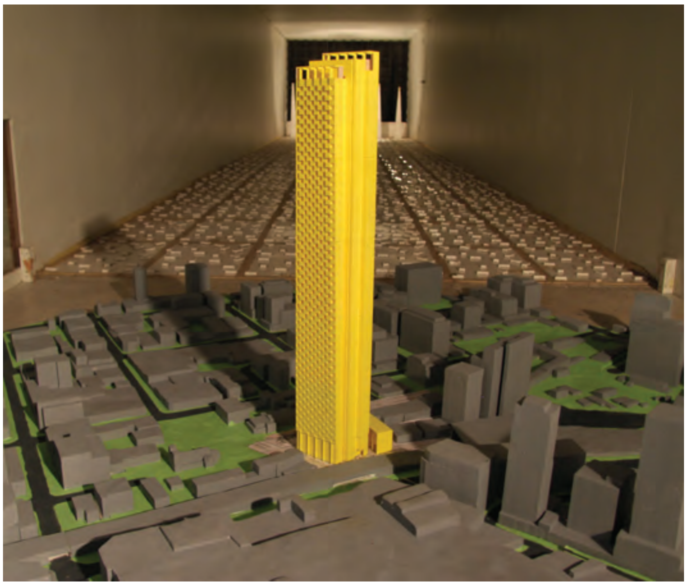

Figure 4. Aspire Tower, Parramatta. (Source: Windtech Consultants)
图4. 帕拉玛塔Aspire塔 (来源: 澳风载建筑工程咨询公司)

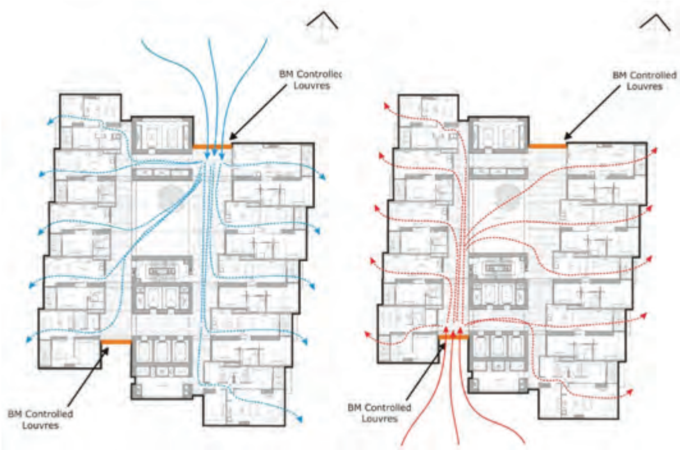

Figure 5. Internal Flow Paths for the Prevailing Winds. (Source: Windtech Consultants)
图5. 主风室内空气流线谱。(来源: 澳风载建筑工程咨询公司)

It has been highlighted that the considerations for natural ventilation to improve a projects sustainability objective need not be limited by a tunnel vision approach. It has been shown through the case studies discussed in this paper that with initial planning and verification through detailed modelling, conditions can be provided for the occupants which exceed design requirements while enhancing the experience for the user. It has been noted that modelling to verify the performance of innovative designs for natural ventilation should be undertaken through proper wind tunnel modelling techniques which have been verified in the field post occupation. Windtech's extensive research in the field of natural ventilation has shown that designing for natural ventilation can be not only effective, but can reliably confirm and ensure the effectiveness of innovative architectural design forms that aim to achieve exceptional natural ventilation.

结论

我们现在和未来的高层建筑设计不仅需要考虑本地文化，而且还需要在概念设计阶段就将项目当地气候作为设计因素。在设计初期通过了解当地环境是如何影响项目执行效果并且采纳专业顾问的意见，能将设计解决方法变成建筑的特色而不是作为最后一刻妥协的办法。

我们也着重讲述了通过自然通风来增加项目的可持续性的目标不要仅限于风洞的方法。文章中所描述的两个实例解释了在初步设计阶段并通过详细的模拟，项目能为居住者提供优于设计要求的条件并且改善使用者的体验。文章也指出用于核实有创意设计性能的模拟需要正确的风洞模拟技术来验证。Windtech在自然通风领域进行了大量的研究证明了自然通风设计不仅有效，并且能够可靠的确保有创意的设计的有效性。

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