Lendlease

Integrated Acute Services Building (IASB) Addition, Randwick Campus Redevelopment

Wind Desktop Study

Wind Engineering

Issue 05 | 12 August 2019

Job number 260936-20

Arup
Arup Pty Ltd ABN 18 000 966 165

Arup
Level 10 201 Kent Street
PO Box 76 Millers Point
Sydney 2000
Australia
www.arup.com

ARUP

Document Verification

ARUP

Job title		Integrated Acute Services Building (IASB) Addition, Randwick Campus Redevelopment		**Job number** 260936-20	
Document title		Wind Desktop Study		**File reference**	
Document ref		Wind Engineering			
Revision	**Date**	**Filename**	POW_Hospital Road_Wind_REP_20190517.docx		
Issue 01	17 May 2019	**Description**	Initial release		
			Prepared by	Checked by	Approved by
		Name	Graeme Wood		
Issue 02	05 Jul 2019	**Filename**	POW_IASB_Wind REP_20190705.docx		
		Description	Updated with client requests		
			Prepared by	Checked by	Approved by
		Name	Graeme Wood	Sina Hassanli	Graeme Wood
Issue 03	11 Jul 2019	**Filename**	POW_IASB_Wind REP_20190711.docx		
		Description	Updated with client editorial requests		
			Prepared by	Checked by	Approved by
		Name	Graeme Wood	Graeme Wood	Graeme Wood
Issue 04	16 Jul 2019	**Filename**	POW_IASB_Wind REP_20190716.docx		
		Description	Updated with client editorial requests		
			Prepared by	Prepared by	Prepared by
		Name	Graeme Wood	Graeme Wood	Graeme Wood
Issue 05	12 Aug 2019	**Filename**	POW_IASB_Wind REP_20190812.docx		
		Description	Updated with client editorial requests		
			Prepared by	Prepared by	Prepared by
		Name	Graeme Wood	Graeme Wood	Graeme Wood

Issue Document Verification with Document ✓

Executive Summary

Lendlease (LLB) have engaged Arup to provide a qualitative wind engineering assessment for the proposed Integrated Acute Services Building (IASB) Addition as part of the Randwick Campus Redevelopment. This report follows on from the previous wind assessment report prepared for the SSD 9113 by Arup dated 27 March 2018.

This report is an addendum to the Acute Services Building, Randwick Campus Redevelopment wind assessment report previously submitted under SSD 9113 Prince of Wales Extension Stage 1 dated 27 March 2018. The content of this report relates only to the additional core scope elements of the Integrated ASB Addition.

In this report Arup have provided qualitative advice for the impact of the proposed development on the pedestrian level wind comfort. The changes to the approved ASB as a result of the proposed IASB Addition would not significantly impact the advice provided in the previous report on the wind conditions on the helipad, impacts of helicopter rotor wash, façade and structural loading, or exhaust dispersion.

It is Arup's opinion that all locations in and around the proposed IASB Addition would meet the pedestrian safety criterion. From a wind comfort perspective, some locations are expected to experience elevated wind speeds compared with the approach flow, however, comfort levels are considered suitable for the intended use of the space and classified as suitable for pedestrian walking.

Contents

References

Tables

Figures

Appendices

Appendix A

Wind Engineering - Supporting Material

A1 Wind Climate

A2 Wind Flow Mechanisms

A3 Wind Speed Criteria

A4 Reference Documents

1 Introduction

Lendlease (LLB) have engaged Arup to provide a qualitative wind engineering assessment of the impact of the IASB Addition on the pedestrian level wind conditions. The scope of the IASB Addition proposal includes:

- UNSW Eastern Extension (Base Building only),
- associated modifications within the ASB
- lowering a portion of Hospital Road, and
- landscaping.

This report outlines the assessment and subsequent recommendations for wind engineering services related to pedestrian wind comfort and safety.

2 Wind Assessment

2.1 Site Description

The proposed development is located in the centre of Randwick, between the current Randwick Hospital Campus to the east and the University of New South Wales, Kensington Campus to the west, Figure 1. The site is surrounded by low-rise domestic dwellings to the north and south and medium-rise buildings to the east and west. The typography surrounding the site is essentially flat from a wind perspective.

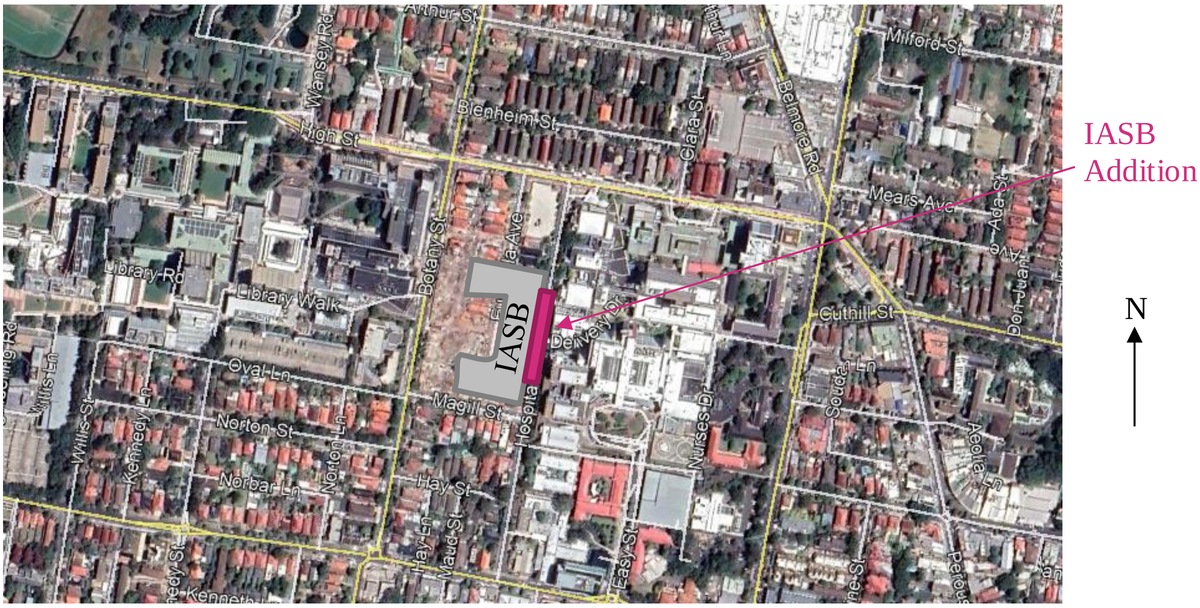

Figure 1 - Aerial view showing urban context (Google Earth, 2019)

The proposed change to the development from the previous assessment includes additional massing along Hospital Road to form the UNSW Eastern extension, the lowering a portion of Hospital Road, and associated landscaping, Figure 2 and Figure 3.

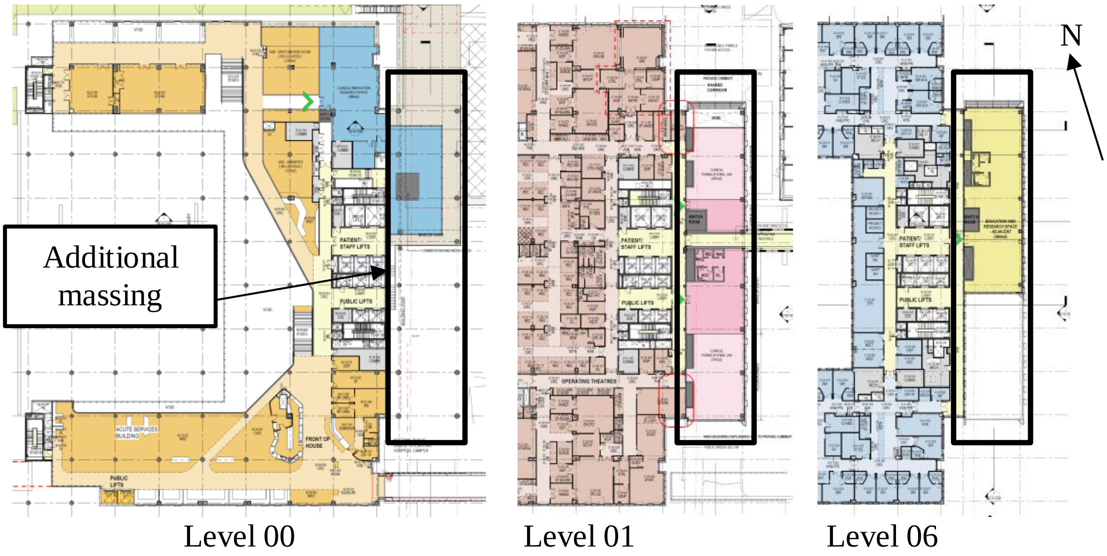

Figure 2: Various floor plans showing additional massing

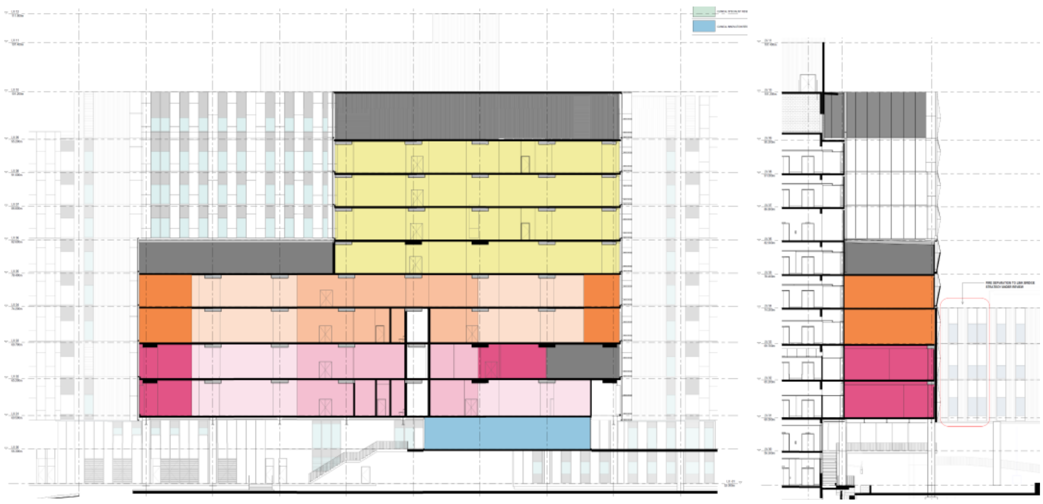

Figure 3: East (L) and south (R) sections showing massing amendments

2.2 Local Wind Climate

Weather data recorded at Sydney Airport by the Bureau of Meteorology has been analysed as the most representative climate analysis to the site. The analysis is summarised in Appendix A1. The prevailing strong wind directions for the Sydney region are from the north-east, south, and west; this wind assessment is focused on these prevailing wind directions. A general description on flow patterns around buildings is given in Appendix A2.

2.3 Pedestrian Wind Comfort

2.3.1 Environmental wind criteria

Wind comfort is generally measured in terms of mean air speed and fluctuations (or gusts), where higher wind speeds are considered less comfortable. Air speeds have a large impact on thermal comfort and are generally welcome during hot summer conditions. This assessment is focused on air speeds in terms of mechanical comfort.

There have been many wind comfort criteria developed and many jurisdictions take different approaches. The relevant standards for environmental wind comfort are discussed in Appendix A3.

The Randwick Development Control Plan 2013 has no specific requirements or regulations focused on the impact on wind conditions in and around the site. In the absence of explicit requirements, the research of Lawson (1990), Table 2, which is the basis for the proposed Central Sydney Planning Strategy 2016-2036, will be adopted as it contains appropriate targets for comfort and safety. Based on these targets along Hospital Road mean wind speeds above 8 m/s for more than 5% would be considered uncomfortable. The corresponding mean wind speed for pedestrian safety is 20 m/s for 0.022% of the time.

All recommendations made in this report aim to minimise the risks that the wind speed criteria, particularly safety, are exceeded.

2.3.2 Predicted Wind Conditions

This section of the report outlines the predicted wind conditions in and around the site based on the local climate, topography, and building form.

The massing of the IASB protrudes above the surrounding buildings to the north and south, and receives some shielding for winds from the east and west. As such, the proposed development as assessed in the previous report is expected to generally increase the local airspeeds at ground level in the public areas surrounding the site. The additional proposed massing forming the IASB Addition, to the east of the IASB along Hospital Road is lower in height with minimal additional massing and would only locally influence the wind conditions as is discussed in the following section.

Winds from the north-east

The site is exposed to winds from the north-east with little shielding from topography, or surrounding buildings. As the massing aligns generally north-south, the winds from the north-east will impinge on the north-east corner of the development. The massing change has altered the north-east corner from a sharp edge to a larger recess, Figure 4 below illustrates the massing of the IASB Addition and associate wind flows. This change would be expected to encourage downwash, thereby increasing the wind speeds along the north and east façades. The proximity of the link bridge to the recessed corner significantly complicates the flow pattern, which would be expected to encourage more flow over the top of the link bridge rather than squeezing underneath. The topography dropping to the south would provide further benefit to the wind conditions on the ground plane along Hospital Road.

The highest wind speeds at ground level along Hospital Road would be expected to occur on the raised walkway under the 3 storey pedestrian bridge connecting the new development to the existing hospital. In this constricted area, the incident turbulence would be filtered out of the flow and a relatively constant strong mean wind speed would be experienced. The wind conditions on the pavement along Hospital Road would be slightly better than the raised walkway as discharging airflow would expand and decelerate along the pavement.

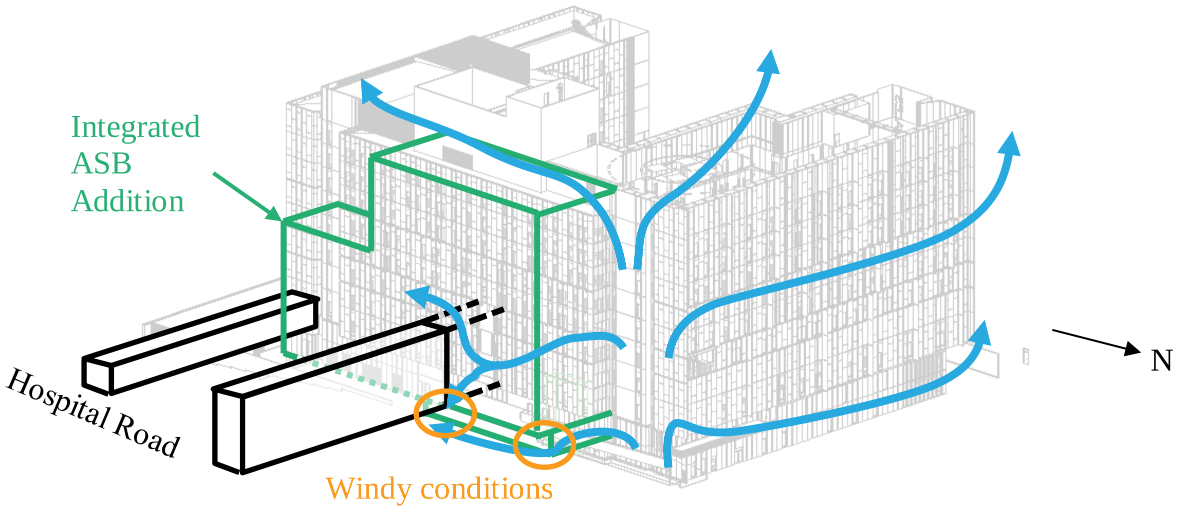

Figure 4 - Wind flow patterns for winds from the north-east, viewed from the north-east

Winds from the south

The proposed development is exposed to winds from the south. The relatively large massing of the approved IASB development would be expected to induce downwash causing increased wind speeds at ground level, particularly around the southern corners.

The proposed additional massing to the east of the ASB is set-back from the south-east corner and steps up with height to the north. The southern edge of the IASB Addition is in the wake of the southern link bridge crossing Hospital Road. These features would encourage flow to stay at a higher level rather than descend to ground level. In comparison with the previous exposed 3-storey bridge scheme, the additional massing would be expected to improve the strongest wind conditions at pedestrian locations along Hospital Road. The wind conditions on the Level -01 walkway under the massing are expected to be relatively strong, but have reduced levels of turbulence. The wind conditions at Hospital Road level would be slightly better due to the protection from the raised terrace.

Winds from the west

The wind conditions along Hospital Road would be unaffected by the proposed IASB Addition massing, as this is in the lee of the building.

Summary

As discussed in the previous submission, the now approved IASB development has a general prismatic U-shaped massing, is relatively exposed, and does not have a significant podium or awning to protect the ground plane from downwash. As such, the overall site would be expected to experience elevated wind speeds compared with the approach flow in certain locations depending on the wind direction.

The reasonably significant IASB Addition massing is expected to slightly change the wind flow patterns for winds from the east quadrant, affecting the pedestrian level wind conditions along Hospital Road. The proposed development would be expected to slightly decrease the strongest wind conditions along Hospital Road compared with the approved IASB, due to the increased blockage and integrated geometry inducing more flow to stay at a higher level away from pedestrians. The windiest conditions would be expected to occur on the raised Level -01 walkway, with slightly improved conditions on the Hospital Road pavement. The wind conditions are expected to be strong and steady rather than turbulent, which makes it easier for stability.

Integrating the expected wind conditions with the wind climate, it is expected that the majority of Hospital Road would be classified as suitable for pedestrian walking from a comfort perspective. All locations would be expected to pass the pedestrian safety criterion.

3 Summary

Arup have provided qualitative advice for the impact of the proposed IASB Addition development on the pedestrian level wind conditions along Hospital Road. It is Arup’s opinion that all locations within the proposed development would meet the safety criterion. From a wind comfort perspective, the area is expected to be fit for the intended purpose as a pedestrian thoroughfare, and classified as suitable for pedestrian walking.

The proposed development would not significantly impact the advice provided in the previous qualitative report on the wind conditions on the helipad, impacts of helicopter rotor wash on raised terraces, façade and structural loading, or exhaust dispersion.

References

[1] Arup, (2018), Acute Services Building, Randwick Campus Redevelopment, Report 260936-03, 04 September 2018.

[2] Randwick City Council, (2013), Development Control Plan.

[3] City of Auckland, (2016), Auckland Unitary Plan Operative.

[4] City of Sydney (2016), Central Sydney Planning Strategy 2016-2036.

[5] City of Melbourne (2017), Melbourne Planning Scheme.

[6] Hunt, J.C.R., Poulton, E.C., and Mumford, J.C., (1976), The effects of wind on people; new criteria based on wind tunnel experiments, Building and Environment, Vol.11.

[7] Isyumov, N. and Davenport, A.G., (1975), The ground level wind environment in built-up areas, Proc. 4th Int. Conf. on Wind Effects on Buildings, Cambridge University Press, U.K.

[8] Lawson, T.V., and Penwarden, A.D., (1975), The effects of wind on people in the vicinity of buildings, Proc. 4th Int. Conf. on Wind Effects on Buildings, Cambridge University Press, U.K.

[9] Lawson, T.V., (1990), The Determination of the wind environment of a building complex before construction, Department of Aerospace Engineering, University of Bristol, Report Number TVL 9025.

[10] Melbourne, W.H., (1978), Criteria for environmental wind conditions, J. Wind Engineering and Industrial Aerodynamics, Vol.3, No.2-3, pp.241-249.

[11] Netherlands Standardization Institute, NEN, (2006). Wind comfort and wind danger in the built environment, NEN 8100 (in Dutch) Dutch Standard.

[12] Penwarden, A.D. and Wise, A.F.E. (1975), Wind environment around buildings, Building Research Establishment Report, HMSO.

[13] San Francisco Planning Department, (2015) San Francisco Planning Code Section 148.

[14] Standards Australia (2011), Structural Design Actions Part 2: Wind actions, AS/NZS1170.2:2011.

[15] Standards Australia (2012), The use of ventilation and airconditioning in buildings Part 2: Mechanical ventilation in buildings, AS 1668.2:2012.

[16] Standards Australia (2002), Structural design actions Part 0: General Principals. AS/NZW1170.0:2002.

Appendix A

Wind Engineering - Supporting Material

A1 Wind Climate

The wind frequency and direction information measured by the Bureau of Meteorology anemometer at a standard height of 10 m at Sydney Airport from 1995 to 2017 have been used in this analysis (Figure 5). The arms of the wind rose point in the direction from where the wind is coming from. The directional wind speeds measured here are considered representative of the wind conditions at the site.

It is evident from Figure 5 that strong prevailing winds are organised into three main groups centred about the north-east, south, and west directions.

Strong summer winds occur mainly from the north-east and south quadrant. Winds from the south are associated with large synoptic frontal systems and generally provide the strongest gusts during summer. North-east winds often improve thermal comfort on hot summer days.

Winter and early spring strong winds typically occur from the west quadrants. West quadrant winds provide the strongest winds affecting the area throughout the year and tend to be associated with large scale synoptic events that can be hot or cold depending on inland conditions.

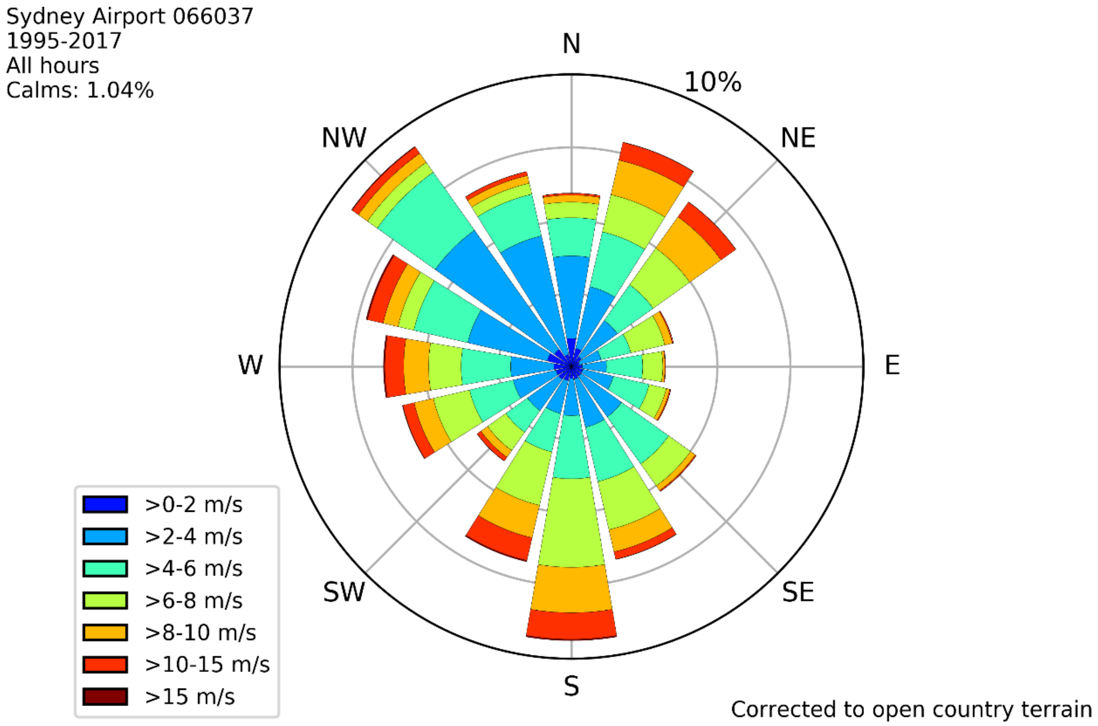

Figure 5 - Sydney airport wind rose

A2 Wind Flow Mechanisms

An urban environment generates a complex wind flow pattern around closely spaced structures, hence it is exceptionally difficult to generalise the flow mechanisms and impact of specific buildings as the flow is generated by the entire surrounds. However, it is best to start with an understanding of the basic flow mechanisms around an isolated structure.

Isolated Building

When the wind hits an isolated building, the wind is decelerated on the windward face generating an area of high pressure (Figure 6), with the highest pressure at the stagnation point at about two thirds of the height of the building. The higher pressure bubble extends a distance from the building face of about half the building height or width, whichever is lower. The flow is then accelerated down and around the windward corners to areas of lower pressure (Figure 6). This flow mechanism is called **downwash** and causes the windiest conditions at ground level on the windward corners and along the sides of the building.

Rounding the building corners or chamfering the edges reduces downwash by encouraging the flow to go around the building at higher levels. However, concave curving of the windward face can increase the amount of downwash. Depending on the orientation and isolation of the building, uncomfortable downwash can be experienced on buildings of greater than about 6 storeys.

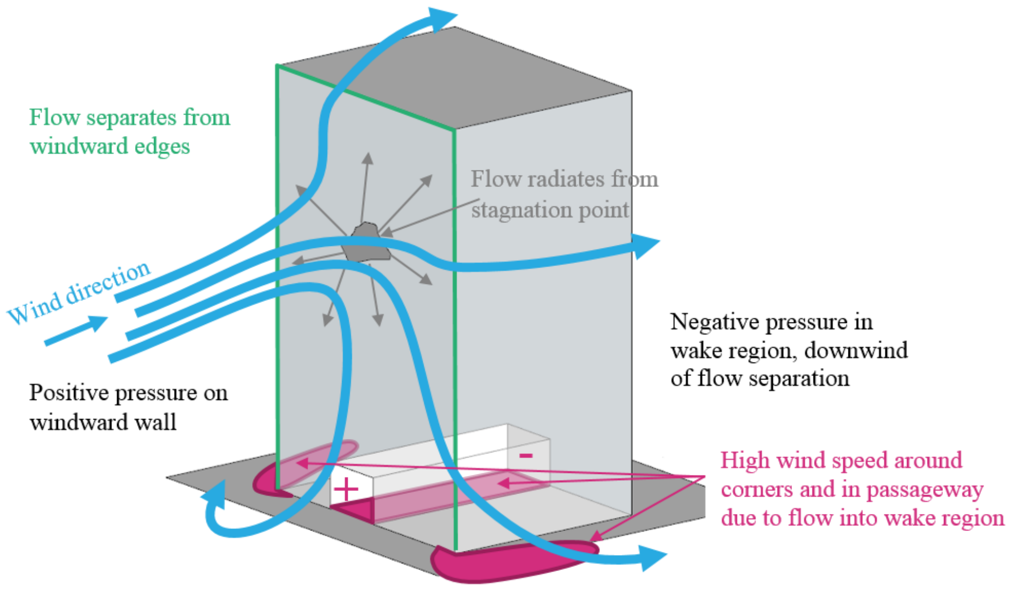

Figure 6 - Schematic wind flow around a tall isolated building

Techniques to mitigate the effects of downwash winds at ground level include the provision of horizontal elements, the most effective being a podium to divert the downward flow away from pavements and building entrances, but this will generate windy conditions on the podium roof (Figure 7). Generally, the lower the podium roof and deeper the setback from the podium edge to the tower improves the ground level wind conditions. The provision of an 8 m setback on an isolated building is generally sufficient to improve ground level conditions, but is highly dependent on the building isolation, orientation to prevailing wind directions, shape and width of the building, and any plan form changes at higher levels.

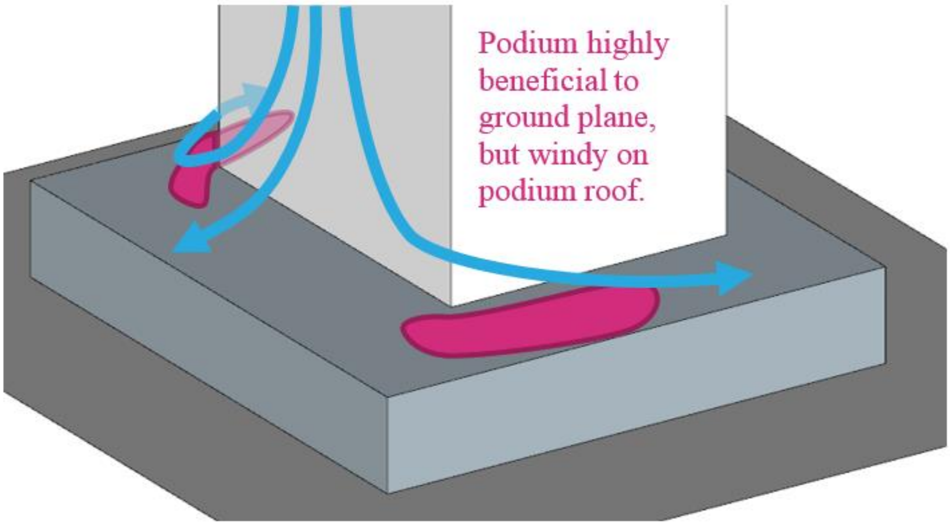

Figure 7 - Schematic flow pattern around a building with podium

Awnings along street frontages perform a similar function as a podium, and generally the larger the horizontal projection from the façade, the more effective it will be in diverting downwash flow (Figure 8). Awnings become less effective if they are not continuous along the entire façade, or on wide buildings as the positive pressure bubble extends beyond the awning resulting in horizontal flow under the awning.

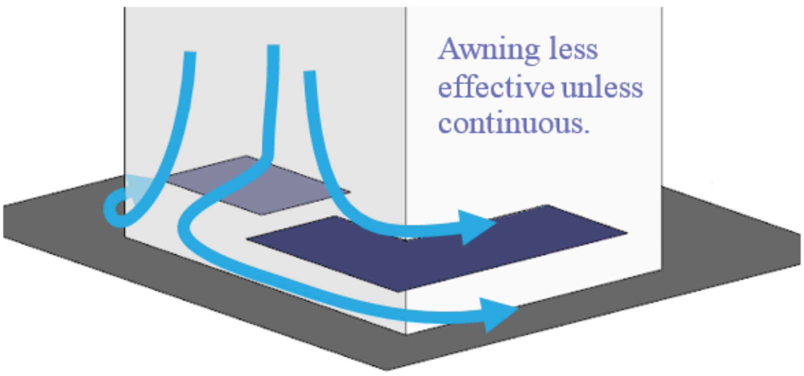

Figure 8 - Schematic flow pattern around a building with awning

It should be noted that colonnades at the base of a building with no podium generally create augmented windy conditions at the corners due to an increase in the pressure differential (Figure 9). Similarly, open through-site links through a building cause wind issues as the environment tries to equilibrate the pressure generated at the entrances to the link (Figure 6). If the link is blocked, wind conditions will be calm unless there is a flow path through the building (Figure 10). This area is in a region of high pressure and therefore there is the potential for internal flow issues. A ground level recessed corner has a similar effect as an undercroft, resulting in windier conditions (Figure 10).

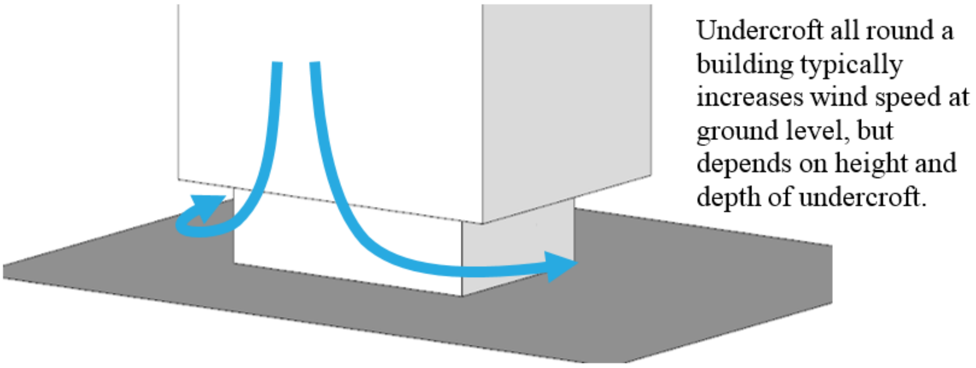

Figure 9 - Schematic of flow patterns around an isolated building with undercroft

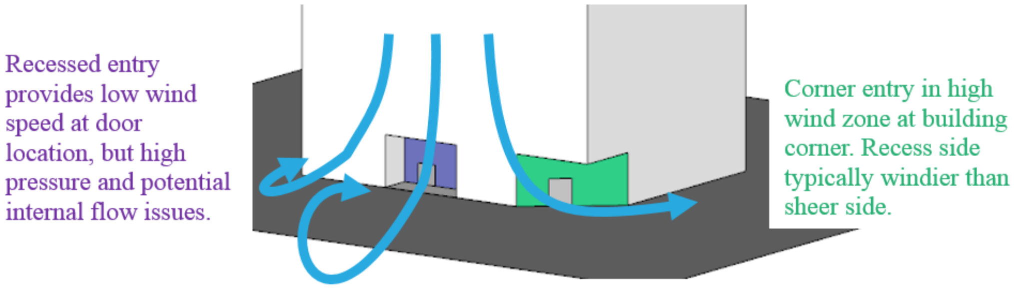

Figure 10 - Schematic of flow patterns around an isolated building with ground articulation

Multiple Buildings

When a building is located in a city environment, depending on upwind buildings, the interference effects may be positive or negative (Figure 11). If the building is taller, more of the wind impacting on the exposed section of the building is likely to be drawn to ground level by the increase in height of the stagnation point, and the additional negative pressure induced at the base. If the upwind buildings are of similar height then the pressure around the building will be more uniform hence downwash is typically reduced with the flow passing over the buildings.

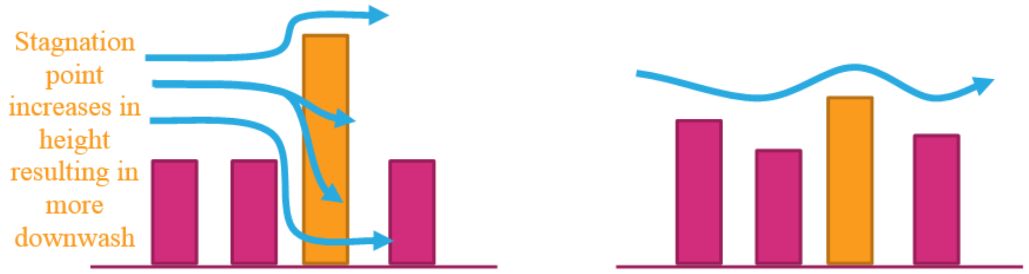

Figure 11 - Schematic of flow pattern interference from surrounding buildings

The above discussion becomes more complex when three-dimensional effects are considered, both with orientation and staggering of buildings, and incident wind direction (Figure 12).

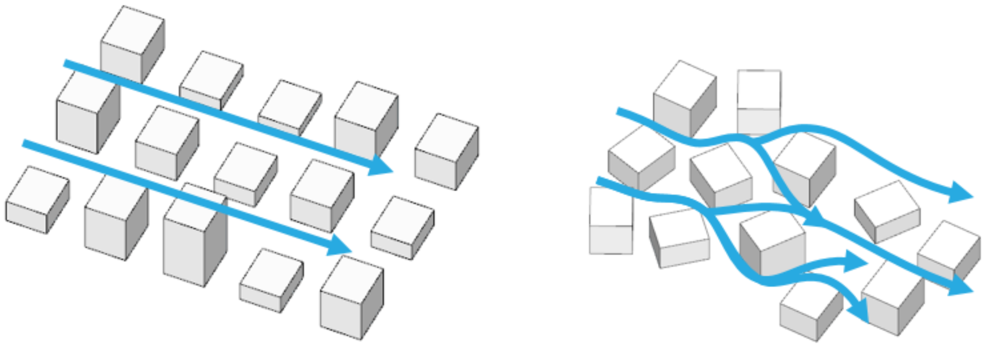

Figure 12 - Schematic of flow patterns through a grid and random street layout

Channelling occurs when the wind is accelerated between two buildings, or along straight streets with buildings on either side (Figure 12 left), particularly on the edge of built-up areas where the approaching flow is diverted around the city massing, and channelled along the fringe by a relatively continuous wall of building facades. This is generally the primary mechanism driving the wind conditions for this perimeter of a built-up area, particularly on corners, which are exposed to multiple wind directions. The perimeter edge zone in a built-up area is typically about two blocks deep. Downwash is more important flow mechanism for the edge zone of a built-up area with buildings of similar height.

As the city expands, the central section of the city typically becomes calmer, particularly if the grid pattern of the streets is discontinued (Figure 12 right). When buildings are located on the corner of a central city block, the geometry becomes slightly more important with respect to the local wind environment.

A3 Wind Speed Criteria

General discussion

Primary controls that are used in the assessment of how wind affects pedestrians are the wind speed, and rate of change of wind speed. A description of the effect of a specific wind speed on pedestrians is provided in Table 1. It should be noted that the turbulence, or rate of change of wind speed, will affect human response to wind and the descriptions are more associated with response to mean wind speed.

Table 1 Summary of wind effects on pedestrians

Description	Speed (m/s)	Effects
Calm, light air	0–2	Human perception to wind speed at about 0.2 m/s. Napkins blown away and newspapers flutter at about 1 m/s.
Light breeze	2–3	Wind felt on face. Light clothing disturbed. Cappuccino froth blown off at about 2.5 m/s.
Gentle breeze	3–5	Wind extends light flag. Hair is disturbed. Clothing flaps.
Moderate breeze	5–8	Raises dust, dry soil. Hair disarranged. Sand on beach saltates at about 5 m/s. Full paper coffee cup blown over at about 5.5 m/s.
Fresh breeze	8–11	Force felt on body. Limit of agreeable wind on land. Umbrellas used with difficulty. Wind sock fully extended at about 8 m/s.
Strong breeze	11–14	Hair blown straight. Difficult to walk steadily. Wind noise on ears unpleasant. Windborne snow above head height (blizzard).
Near gale	14–17	Inconvenience felt when walking.
Gale	17–21	Generally impedes progress. Difficulty with balance in gusts.
Strong gale	21–24	People blown over by gusts.

Local wind effects can be assessed with respect to a number of environmental wind speed criteria established by various researchers. These have all generally been developed around a 3 s gust, or 1 hour mean wind speed. During strong events, a pedestrian would react to a significantly shorter duration gust than a 3 s, and historic weather data is normally presented as a 10 minute mean.

Despite the apparent differences in numerical values and assumptions made in their development, it has been found that when these are compared on a probabilistic basis, there is some agreement between the various criteria. However, a number of studies have shown that over a wider range of flow conditions, such as smooth flow across water bodies, to turbulent flow in city centres, there is less general agreement between the studies. The downside of these criteria is that they have seldom been benchmarked, or confirmed through long-term measurements in the field, particularly for comfort conditions. The wind criteria were all developed in temperate climates and are unfortunately not the only environmental factor that affects pedestrian comfort.

For assessing the effects of wind on pedestrians, neither the random peak gust wind speed (3 s or otherwise), nor the mean wind speed in isolation are adequate. The gust wind speed gives a measure of the extreme nature of the wind, but the mean wind speed indicates the longer duration impact on pedestrians. The extreme gust wind speed is considered to be suitable for safety considerations, but not necessarily for serviceability comfort issues such as outdoor dining. This is because the instantaneous gust velocity does not always correlate well with mean wind speed, and is not necessarily representative of the parent distribution. Hence, the perceived ‘windiness’ of a location can either be dictated by strong steady flows, or gusty turbulent flow with a smaller mean wind speed.

To measure the effect of turbulent wind conditions on pedestrians, a statistical procedure is required to combine the effects of both mean and gust. This has been conducted by various researchers to develop an equivalent mean wind speed to represent the perceived effect of a gust event. This is called the ‘gust equivalent mean’ or ‘effective wind speed’ and the relationship between the mean and 3 s gust wind speed is defined within the criteria, but two typical conversions are:

$$U_{GEM} = \frac{(U_{mean} + 3 \cdot \sigma_u)}{1.85} \text{ and } U_{GEM} = \frac{1.3 \cdot (U_{mean} + 2 \cdot \sigma_u)}{1.85}$$

It is evident that a standard description of the relationship between the mean and impact of the gust would vary considerably depending on the approach turbulence, and use of the space.

A comparison between the mean and 3 s gust wind speed criteria from a probabilistic basis are presented in Figure 13 and Figure 15. The grey lines are typical results from modelling and show how the various criteria would classify a single location.

The current Central Sydney Planning Strategy 2016-2036 wind controls are based on the work of Lawson (1990), described in Figure 13 and Table 2. The safety criterion is based on a 0.5 s gust wind speed of 24 m/s occurring once per annum during daylight hours. The comfort criteria are based on a 5% of the time exceedance during daylight hours.

Table 2 Pedestrian comfort criteria for various activities

Comfort (max. of mean or GEM wind speed exceeded 5% of the time)	
<2 m/s	Dining
2-4 m/s	Sitting
4-6 m/s	Standing
6-8 m/s	Walking
8-10 m/s	Objective walking or cycling
>10 m/s	Uncomfortable
Safety (max. of mean or GEM wind speed exceeded 0.022% of the time)	
<15 m/s	General access
<20 m/s	Able-bodied people (less mobile or cyclists not expected)

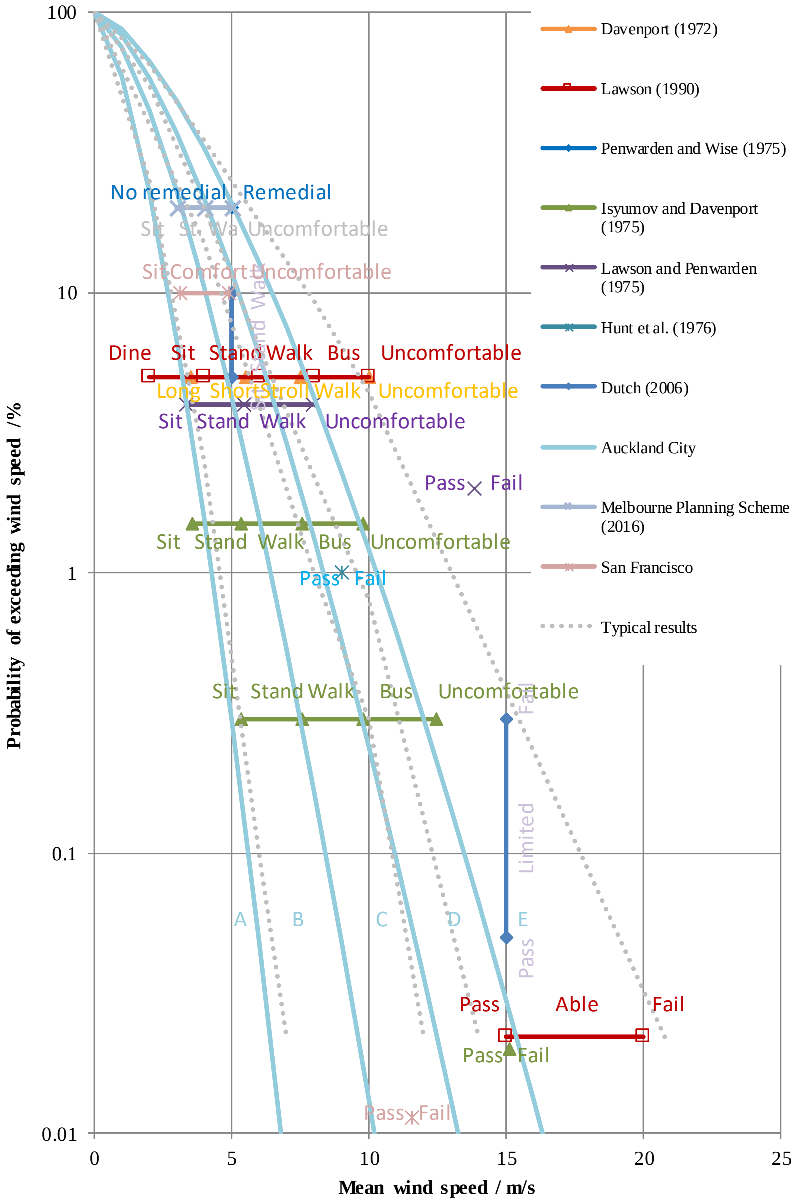

Figure 13 - Probabilistic comparison between wind criteria based on mean wind speed

City of Auckland has control mechanisms for accessing usability of spaces from a wind perspective as illustrated in Figure 15 with definitions of the intended use of the space categories defined in Figure 14.

Category A	Areas of pedestrian use or adjacent dwellings containing significant formal elements and features intended to encourage longer term recreational or relaxation use i.e. public open space and adjacent outdoor living space
Category B	Areas of pedestrian use or adjacent dwellings containing minor elements and features intended to encourage short term recreation or relaxation, including adjacent private residential properties
Category C	Areas of formed footpath or open space pedestrian linkages, used primarily for pedestrian transit and devoid of significant or repeated recreational or relaxational features, such as footpaths not covered in categories A or B above
Category D	Areas of road, carriage way, or vehicular routes, used primarily for vehicular transit and open storage, such as roads generally where devoid of any features or form which would include the spaces in categories A - C above.
Category E	Category E represents conditions which are dangerous to the elderly and infants and of considerable cumulative discomfort to others, including residents in adjacent sites. Category E

Figure 14 - Auckland Utility Plan (2016) wind categories

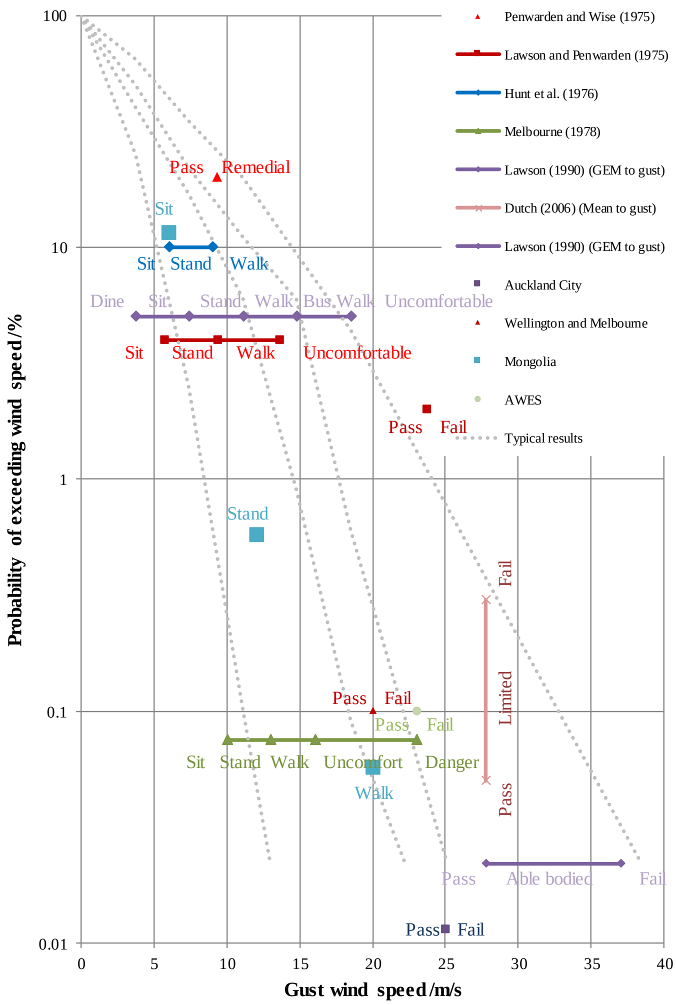

Figure 15 - Probabilistic comparison between wind criteria based on 3 s gust wind speed

A4 Reference Documents

In preparing the assessment, the following documents have been referenced to understand the building massing and features.

UNSW drawings.pdf	15/04/2019 3:34 PM	5,474 KB