Health Infrastructure

Campbelltown Hospital

Environmental Wind Assessment

Wind

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Job number 259083-01

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Executive summary

Arup have been commissioned by Health Infrastructure to provide an experienced-based impact assessment of the proposed Campbelltown Hospital development on the pedestrian level wind conditions for comfort and safety in and around the site.

It is Arup's opinion that the wind conditions in and around the site, although impacted by the proposed development, are suitable for the intended use. Local amelioration would likely be required if any outdoor café-like spaces are proposed.

There are no obvious internal flow issues, however, it is important that internal flow paths are considered as the design progresses. For example, direct flow paths between north and south openings in the public circulation space should be avoided.

The proposed building is expected to impact and be impacted by helicopter operation. It is important that strict operational procedures are developed and implemented to ensure pedestrian and patient comfort and safety during helicopter operation.

Contents

Disclaimer

This assessment of the site environmental wind conditions is presented based on engineering judgement. In addition, experience from more detailed simulations have been used to refine recommendations. No detailed simulation, physical or computational study has been made to develop the recommendations presented in this report.

1 Introduction

Health Infrastructure have engaged Arup to provide a qualitative environmental wind assessment for the impact of the proposed Campbelltown Hospital redevelopment on pedestrian wind comfort and safety on the ground level.

To quantify the qualitative advice provided in this report, numerical or physical modelling would be required.

2 Wind assessment

2.1 Local wind climate

Weather data recorded at Camden Airport by the Bureau of Meteorology has been analysed for this project. The analysis is summarised in Appendix 1. Strong prevailing winds for the site are from the south-west and north-west quadrants. This wind assessment is based on these wind directions. A general description on flow patterns around buildings is given in Appendix 2.

2.2 Specific wind controls

Wind comfort is generally measured in terms of wind speed and rate of change of wind speed, where higher wind speeds and gradients are considered less comfortable. Air speed has a large impact on thermal comfort and are generally welcome during hot summer conditions. This assessment is focused on wind speed in terms of mechanical comfort.

There have been many wind comfort criteria proposed, and a general discussion is presented in Appendix 3.

Campbelltown City Council has no specific wind controls or assessment criteria. The wind controls used in this wind assessment for pedestrian comfort and distress are based on the work of Lawson (1990) as described in Figure 14 and Table 1. The benefits of these criteria over many in the field are that they use both a mean and gust equivalent mean (GEM) wind speed to assess the suitability of specific locations. The criteria based on the mean wind speeds define when the steady component of the wind causes discomfort, whereas the GEM wind speeds define when the wind gusts cause discomfort.

Table 1 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

In relation to the Campbelltown wind climate 5% of the time the mean wind speed exceeds 7 m/s at 10 m height in open country terrain. This corresponds to approximately 5 m/s at ground level, which would be classified as suitable for ‘pedestrian standing’.

2.3 Site description

The proposed building is located to the south of the existing Campbelltown Hospital Blocks A and B, Figure 1. The large scale topography surrounding the site is complex with large scale undulations. More locally, the topography drops to the north-west and rises to the south-east. The site is surrounded by low-rise buildings and wooded open areas.

The proposed development consists of one large building of irregular plan form rising to various heights above ground level, Figure 2 and Figure 3.

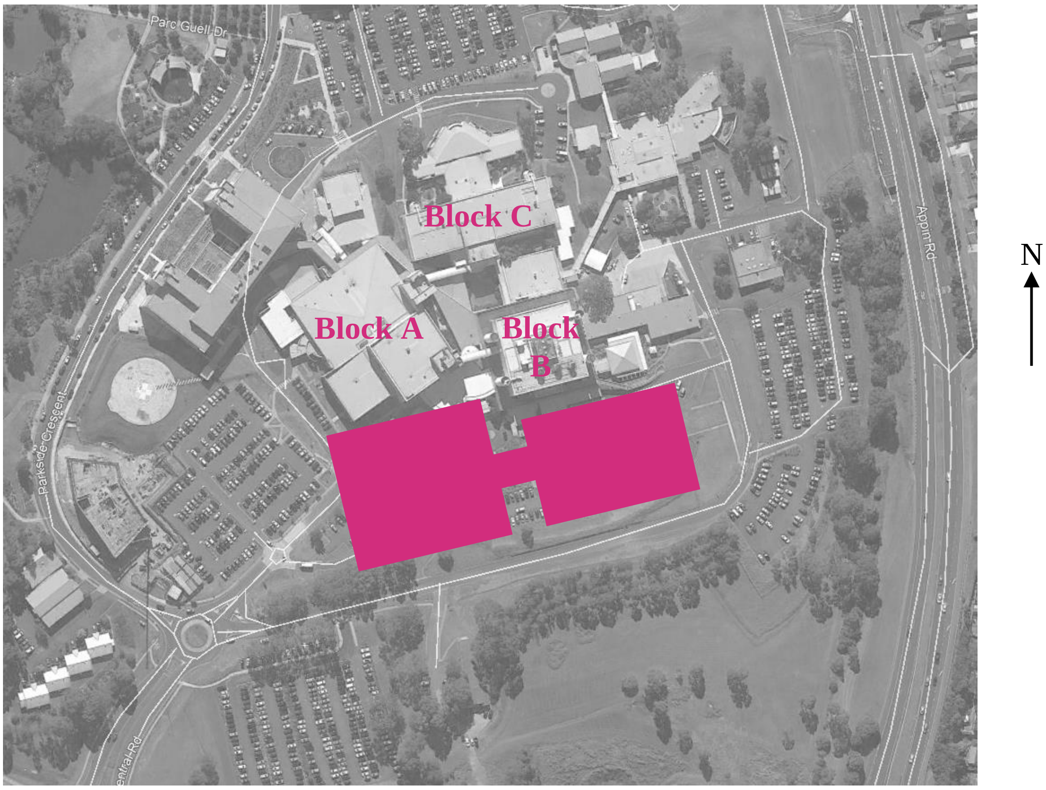

Figure 1 Site location (source: Google Maps, 2016)

Figure 2 Level 2 (T), Level 3 (C), and Level 6 (B) floor plans

Figure 3: North elevation (T), south elevation (B)

2.4 Predicted wind conditions on ground plane

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 proposed redevelopment is significant compared with the surrounding buildings, and will therefore have an impact on the local wind conditions.

Winds from the south quadrant

Winds from the south will impact on the broad face of the compound building form. Winds from this direction are slightly ameliorated by the local topography dropping to the north. The flow will be accelerated about the southern corners. The colonnade along the south façade offers protection to pedestrians in the middle of the façade, but would be expected to increase the wind speed around the south-east corner. The building steps backs above ground level on the west façade so is expected to ameliorate the wind conditions around the south-west corner.

Winds from the west quadrant

Wind from the west are unimpeded on reaching the site and will impact on the wide bluff western façade. The building will induce downwash that will be disturbed by the west façade setbacks at Levels 2 and 5, resulting in ameliorated wind conditions around the south-west corner. The proximity to Block A is expected to cause localised accelerated winds between the proposed building and Block A, but this does not appear to be a heavily pedestrianised area.

General Observations

The main southern entrance is well located in the centre of the façade and there are no obvious short-circuit paths for wind to flow between closely spaced openings.

Summary

Qualitatively, integrating the expected directional wind conditions around the site with the wind climate, it is considered that wind conditions at the majority of locations around the site would be classified as suitable for pedestrian standing activities, with some slightly windier and calmer locations around the building. A summary of the predicted wind conditions at locations around the proposed development is presented in Figure 4, any locations not marked are classified as suitable for pedestrian standing.

Figure 4 Predicted wind conditions around the site

It is noted that the proposal does not currently show any outdoor café areas, however local amelioration would be expected to be required for any such areas located outside the areas marked as suitable for pedestrian sitting. These would typically take the form of permanent or temporary porous screens perpendicular to the façade, or more enclosed booths to create localised calm areas.

2.5 Additional advice on Helipad operation

The location of the rooftop helipad on the building is of minor concern, Figure 5. The building massing alters the surrounding flow field and creates areas of high turbulence and wind shear. This can be problematic for helicopter operations. For the prevailing strong wind directions there would be a distinct separated shear layer causing wind shear and turbulence for operations. The helicopter pilot would generally be aware of the local flow conditions around large building and adapt the take-off and landing flight paths accordingly.

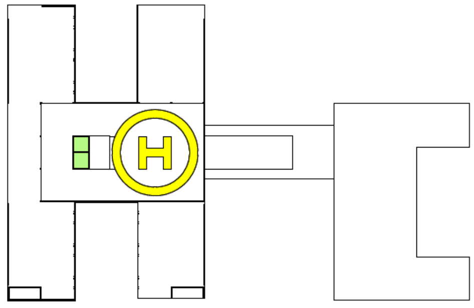

Figure 5 Location of rooftop helipad

In addition to this, the downward moving air generated by the helicopter called rotorwash can cause uncomfortable, even dangerous, wind speeds for pedestrians.

2.5.1 Wind amenity

Arup staff have had experience with field measurements under helicopters at hospitals in NSW where a maximum 0.5 second gust wind speed of about 24 m/s was measured under a typical sized helicopter landing at a hospital. The maximum horizontal wind speed decreased with increased distance from the helipad and height above ground.

It is expected that a gust wind speed of approximately 24 m/s would be expected on the roof helipad during take-off and landing operations. This wind speed is sufficient to blow pedestrians over, strict measures to control roof access during aircraft operations will be imposed by the aviation consultant.

Below the roof helipad, the closest trafficable areas are entrants and exits to the proposed buildings. Wind would be expected to be noticeably elevated in these areas due to helicopter operation. Previous measurements witnessed large rubbish bins being blown over, 6 storeys below the landing helicopter. Management procedures are required to ensure patients, staff and loose items are brought inside during aircraft landing and take-off over any outdoor terraces.

The impact of helicopter rotorwash outflow on surrounding areas is expected to be minimal.

The structural pressure induced by the helicopter rotor wash would be considerably lower than the design structural and cladding pressure for the external building envelope and therefore would not have any issues for the roofs, or windows on the neighbouring façade.

2.5.2 Building induced influence on helipad operation

For helipads located on the roofs of tall buildings, the governing effect is the acceleration of air over the upwind roof edge of the building roof and the subsequent increase in turbulence in the fluctuating shear layer. The vertical mean wind speed and turbulence generated by structures is often the critical parameter for helicopters. The only operational wind criteria near helipads, that we are aware of, is that provided in the United Kingdom Civil Aviation Authority's CAP 437 (Standards for Offshore Helicopter Landing Areas), which suggests a limiting value for the standard deviation of vertical airflow velocity of 1.75 m/s.

Based on Arup's experience on similar sized hospital buildings, the vertical turbulence on approach to the helipad would be in excess of the CAP 437 criterion for a significant number of wind conditions. The flow paths and turbulence levels around the proposed helipad are a complex function of the building geometry, incident wind, and local details. To quantify the wind conditions along the flight paths and to ascertain the probability of time that operations would be influenced, advanced numerical or physical modelling would be required. These measurements would be combined with the climate information to provide specific advice and recommendations to the design team regarding helicopter operations.

3 Summary

Arup have provided qualitative advice for the impact of the proposed development on pedestrian wind comfort. It is Arup's opinion that all locations within the proposed development would meet the safety criterion. From a wind comfort perspective, all the surrounding areas are expected to meet the requirements for the intended use of the space as a transient space. Additional, local amelioration is expected to be required for any outdoor café areas around the development, should they be included in the final design.

To quantify the qualitative advice provided in this report, numerical or physical modelling of the development would be required. Considering the size of the development and the local wind climate, it is unlikely that such an analysis is necessary.

4 References

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Appendix 1: Wind climate

The wind frequency and direction information measured by the Bureau of Meteorology anemometer at a standard height of 10 m at Camden Airport from 1992 to 2017 have been used in this analysis, Figure 6. The arms of the wind rose point in the direction from where the wind is coming from. The anemometer is located about 10 km to the north-west of the site. The directional wind speeds measured here are considered representative of the wind conditions at the site.

It is evident from Figure 6 that strong prevailing winds come from the west quadrant. Strong winds from the south quadrant tend to be cold and are generally associated with large frontal systems that can last several days and occur throughout the year. Winds from the west are the strongest of the year and are associated with large winter weather patterns and smaller-scale convective activity. These winds occur throughout the year and can be cold or warm depending on the inland conditions.

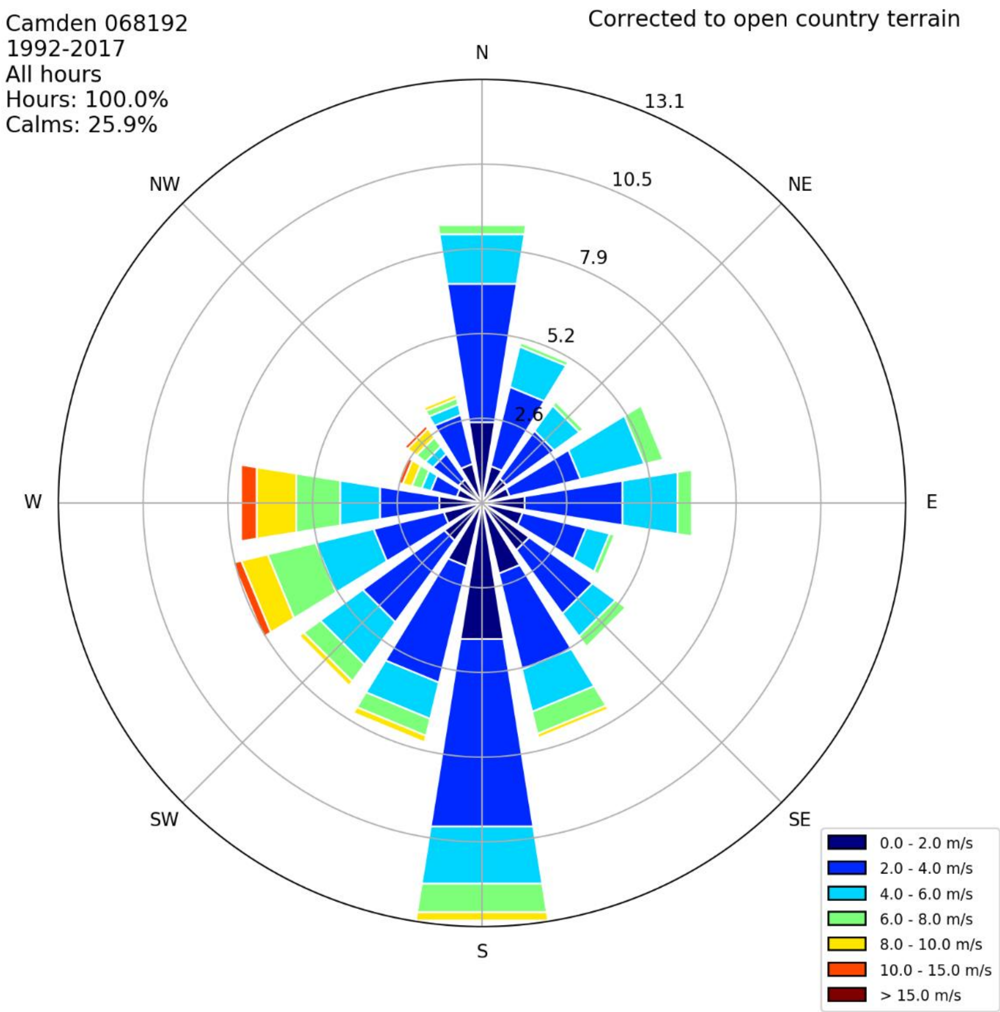

Figure 6 Wind rose showing probability of time of wind direction and speed

Appendix 2: 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 7, 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 7. 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.

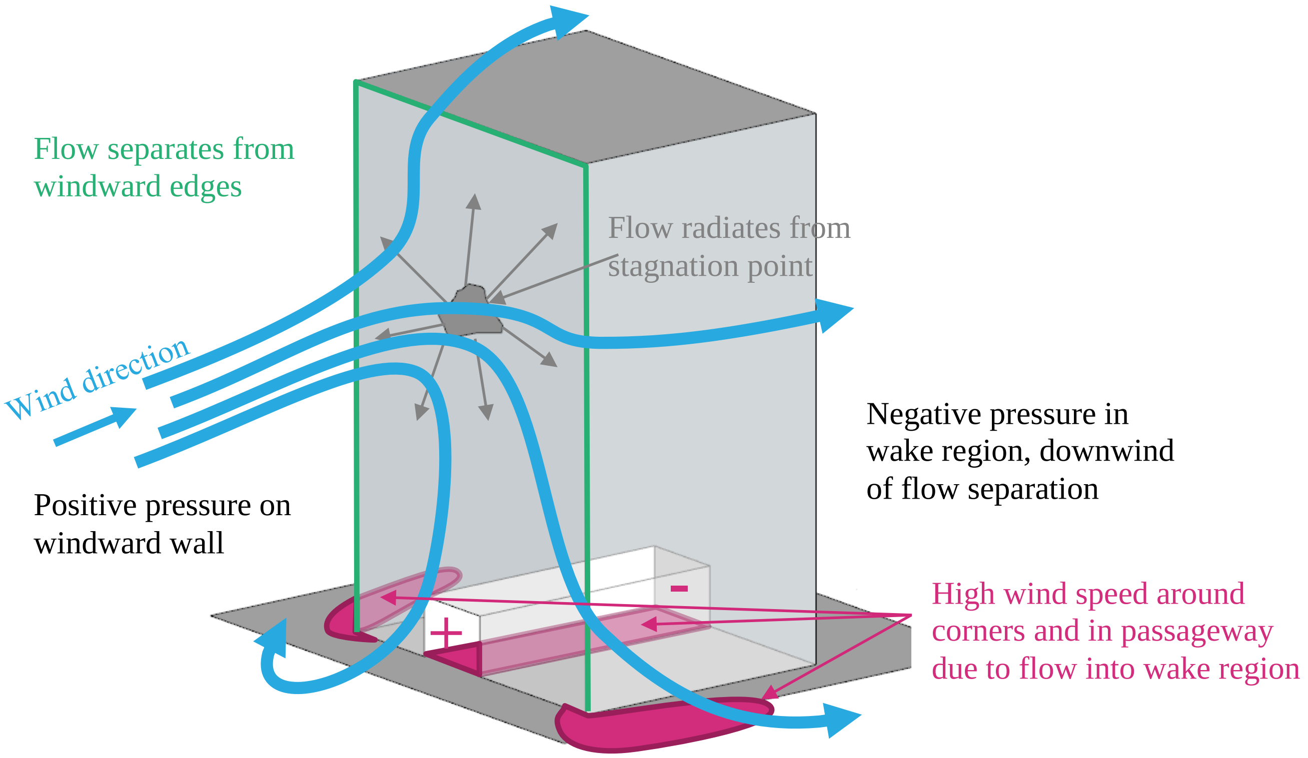

Figure 7 Schematic wind flow around tall isolated building

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 11. 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 level.

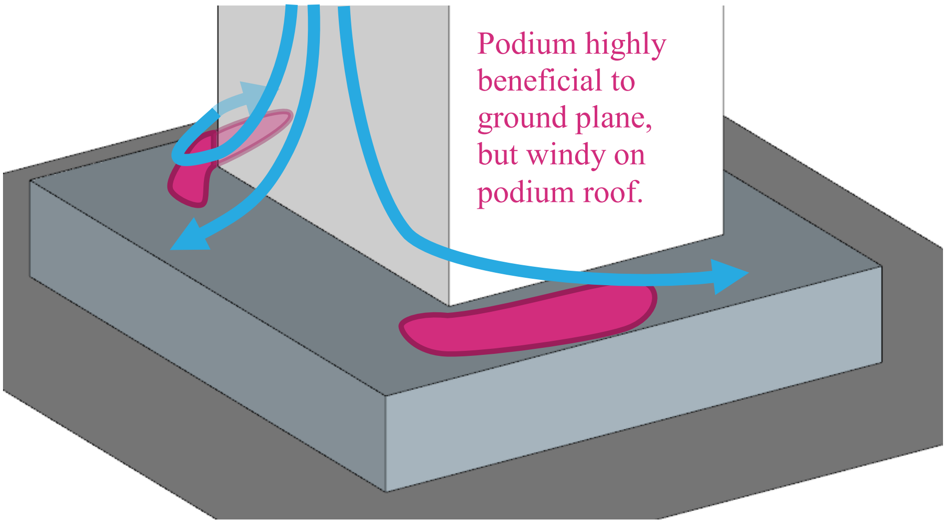

Figure 8 Schematic flow pattern around building with podium

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 9. 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.

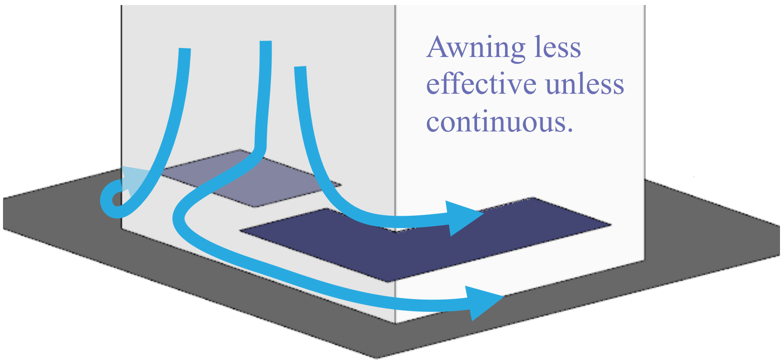

Figure 9 Schematic flow pattern around building with awning

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 10. 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 7. If the link is blocked, wind conditions will be calm unless there is a flow path through the building, Figure 11. This area is in a region of high pressure and therefore the is the potential for internal flow issues. A ground level recessed corner has a similar effect as an undercroft, resulting in windier conditions, Figure 11.

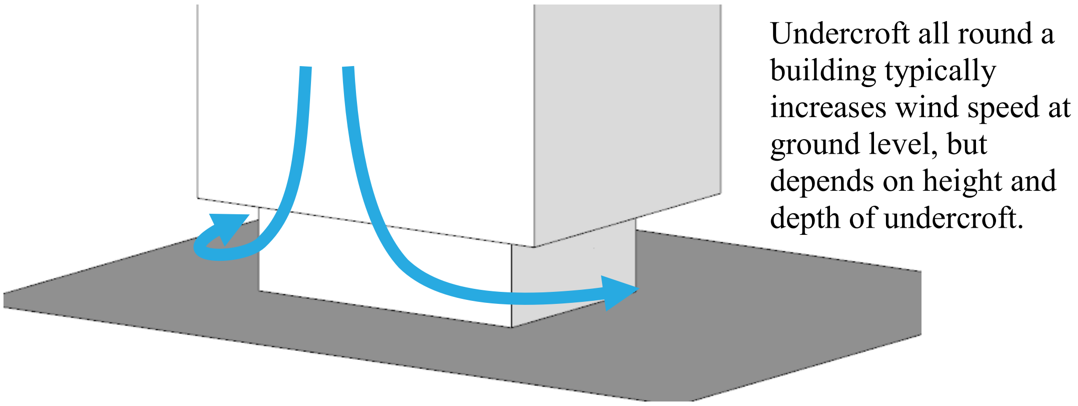

Figure 10 Schematic of flow patterns around isolated building with undercroft

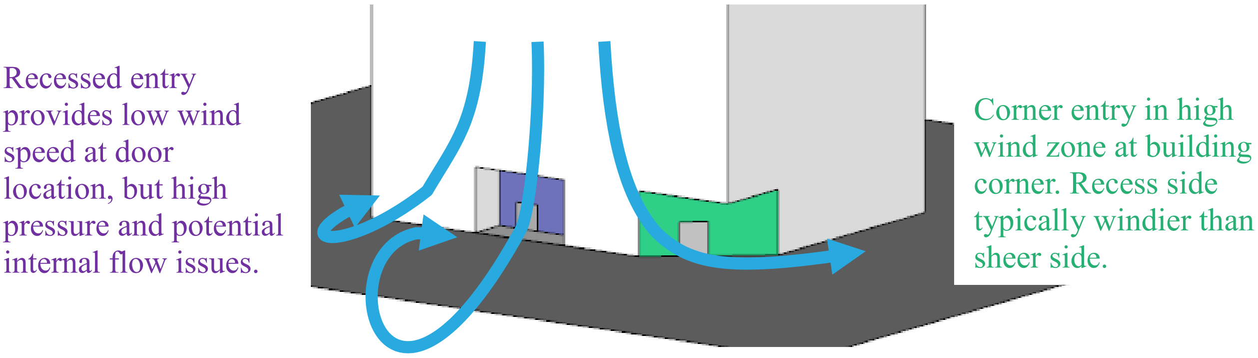

Figure 11 Schematic of flow patterns around isolated building with ground articulation

Multiple buildings

When a building is located in a city environment, depending on upwind buildings, the interference effects may be positive or negative, Figure 12. 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.

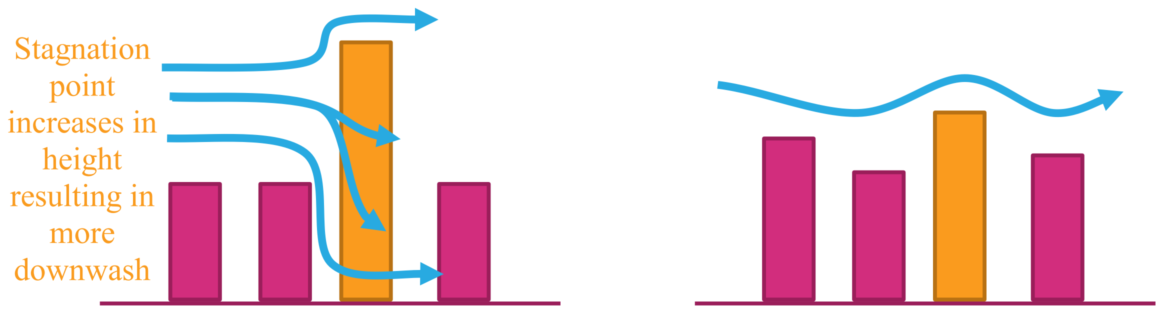

Figure 12 Schematic of flow pattern interference from surrounding buildings

The above discussion becomes more complex when three-dimensional effects are considered, both with orientation and staggering of buildings, and incident wind direction, Figure 13.

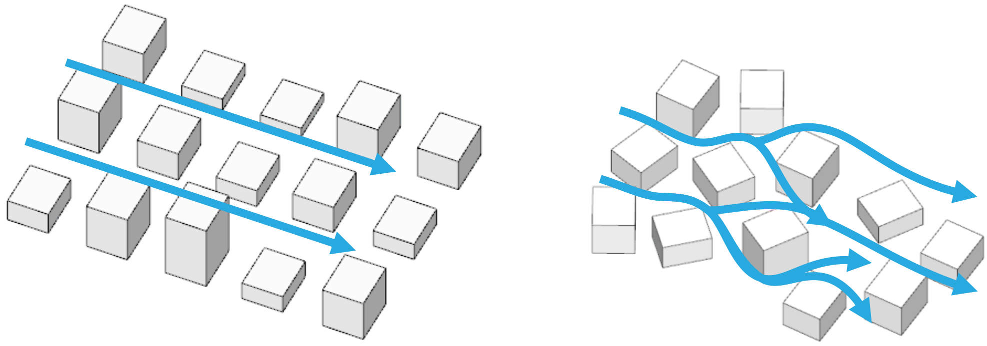

Figure 13 Schematic of flow patterns through a grid and random street layout

Channelling occurs when the wind is accelerated between two buildings, or along straight streets with buildings on either side, Figure 13(L), 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 13(R). 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.

Appendix 3: 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 2. 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 2 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 among. 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:

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

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 14 and Figure 16. The grey lines are typical results from modelling and show how the various criteria would classify a single location. City of Auckland has control mechanisms for accessing usability of spaces from a wind perspective as illustrated in Figure 14 with definitions of the intended use of the space categories defined in Figure 15.

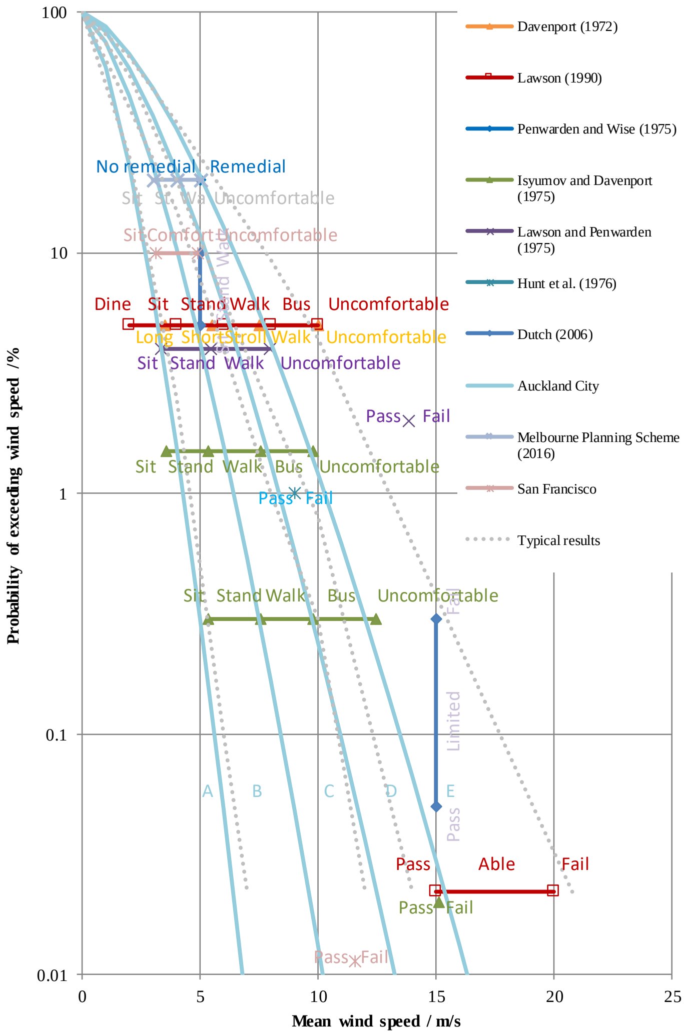

Figure 14 Probabilistic comparison between wind criteria based on mean wind speed

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 15: Auckland Utility Plan (2016) wind categories

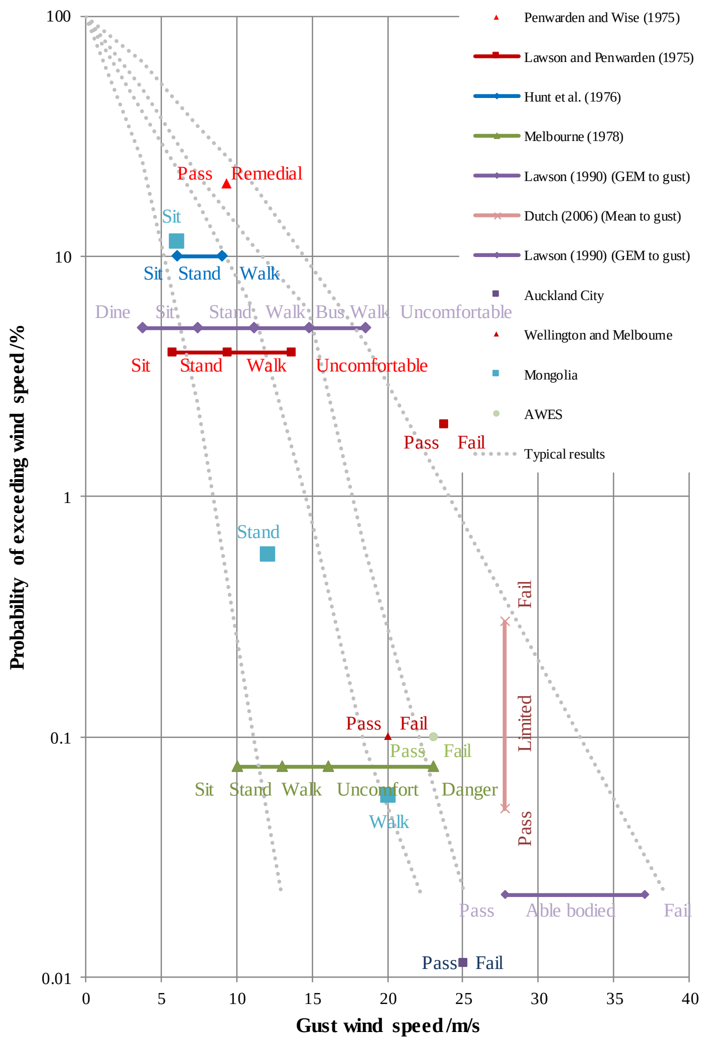

Figure 16 Probabilistic comparison between wind criteria based on 3 s gust wind speed

Appendix 4: Reference documents

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

- SSD-04-007[G].pdf
- SSD-04-006[G].pdf
- SSD-03-006[F].pdf
- SSD-03-003[F].pdf
- SSD-03-002[G].pdf