Edgecliff Central Pty. Ltd.

Edgecliff Tower

Environmental Wind Assessment

Wind

Revision 01 | 23 June 2021

This report takes into account the particular instructions and requirements of our client.

It is not intended for and should not be relied upon by any third party and no responsibility is undertaken to any third party.

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Executive summary

Arup have been commissioned by Edgecliff Central Pty. Ltd. to provide an experienced-based impact assessment of the proposed Edgecliff Tower development136-148 New South Head Road, Edgecliff, on the pedestrian level wind conditions for comfort and safety in and around the site.

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 walking, with locations on the south-west corner being at the upper end of this classification. All locations are expected to meet the safety criterion. These wind conditions would be considered suitable for the intended use of the space.

Benefits of the design from a pedestrian level wind perspective include the articulated, curved design of the tower to reduce the impacts of downwash flow, and the recessed Heritage Plaza Forecourt at ground level.

To quantify the qualitative advice provided in this report, numerical or physical modelling of the development would be required, which is best conducted during detailed design.

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

This qualitative environmental wind assessment report has been prepared on behalf of Edgecliff Central Pty. Ltd. in support of a planning proposal for the Edgecliff Tower (the site) located at 136-148 New South Head Road, Edgecliff.

The proposed mixed-use development includes commercial, retail, and residential spaces, with medical and community facilities and a basement carpark.

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

2 Site description

The proposed Edgecliff Tower site is located on the north-east corner of the intersection of New South Head and Darling Point Roads, Edgecliff, Figure 1. The site is generally surrounded by low-rise buildings in all directions, with nearby isolated medium- to high-rise buildings to the south/south-east and north respectively. The site is located on complex topography from a wind perspective, dropping steeply to the north-east, south-west, and west, dropping gently to the north, while rising gently to the south-east.

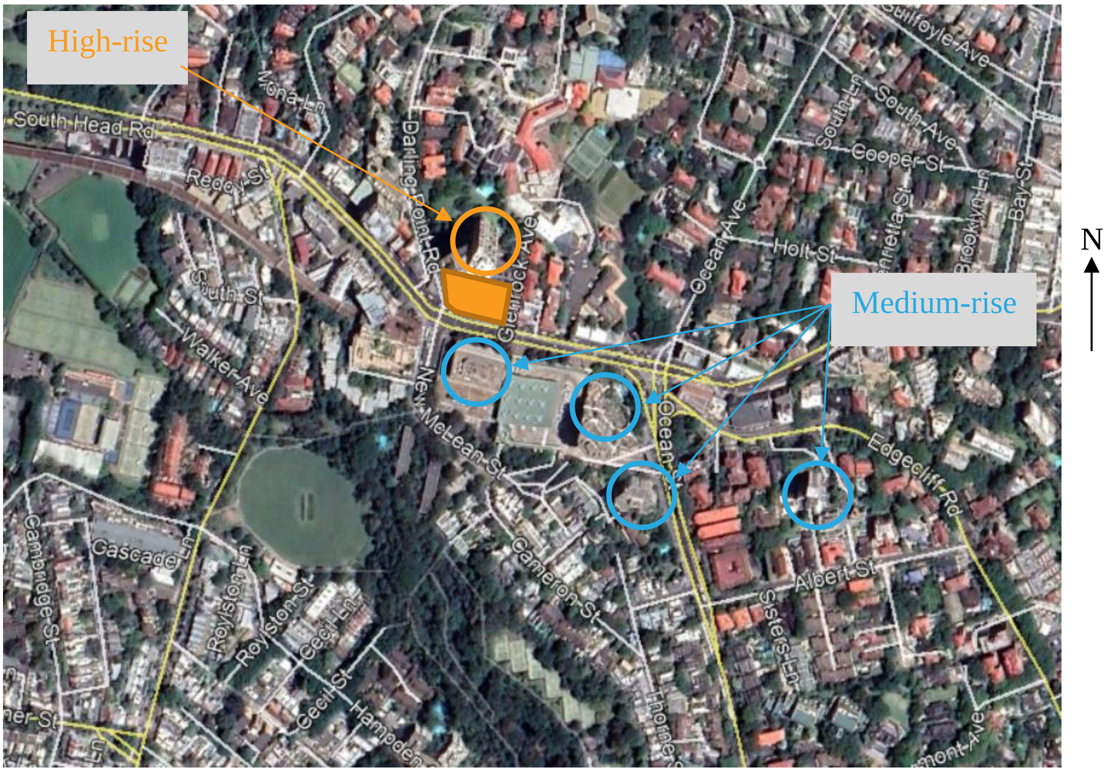

Figure 1 Site location (source: Google Maps 2019)

The proposed development consists of a mixed-use two- to four-storey podium rising above ground level with an eight-storey residential tower, Figure 2. A two-storey heritage building is being retained on the south-west corner of the site (at the intersection of Darling Point and New South Head Roads) and is connected to the new construction. A new terrace is proposed for the rooftop of the heritage building. There are outdoor terraces/decks/private open spaces proposed for the new construction on Level 2 (north-east and southern aspect), Level 3 (north-eastern and southern aspect) and Level 4 (multiple aspects). Balconies are proposed for the residential levels (Levels 3-11).

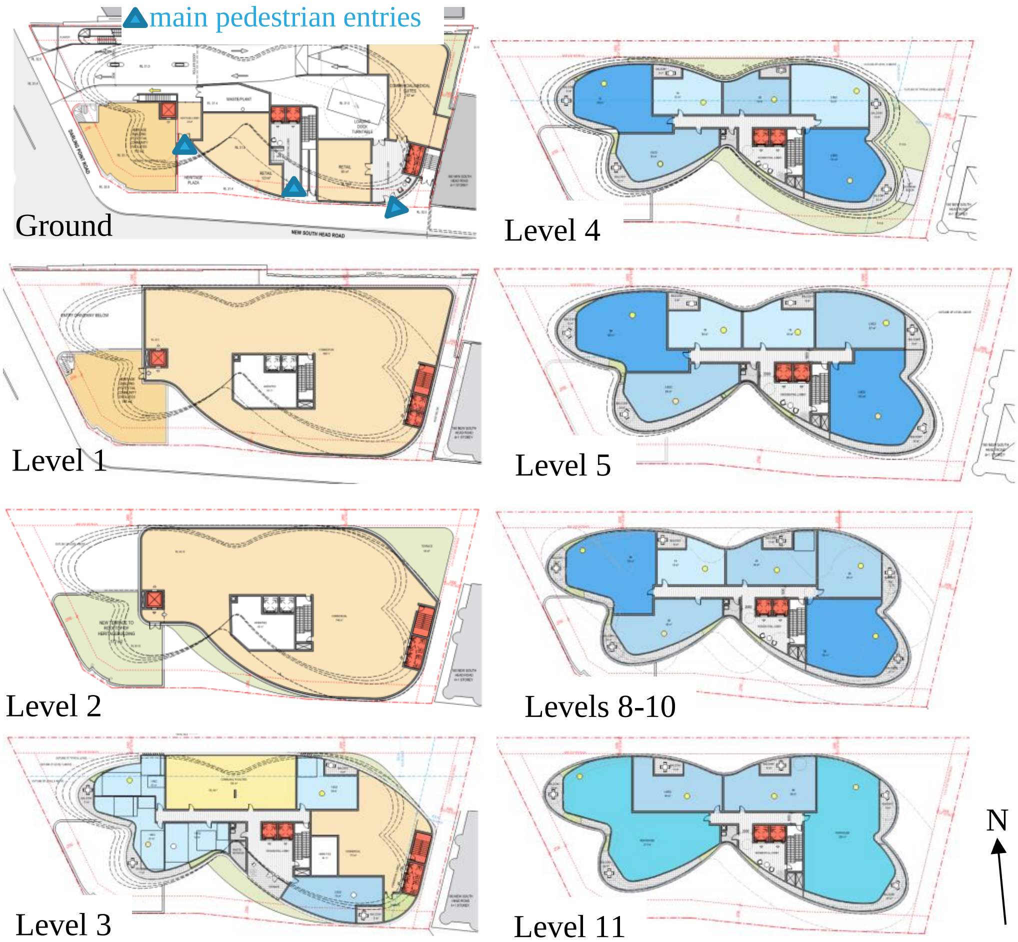

Figure 2: Various floor plans

The tower portion is curved with articulated sections, Figure 3. Due to the curved nature of the tower, the tower setbacks from the podium edge vary: 0-2 m to the north, 1.5-7 m to the east, 0-11 m to the south, and a cantilevered portion of the tower above the heritage building that is setback from the site boundary by approximately 2.7 m to the west.

The north boundary of the site is adjacent to the carpark podium of 3 Darling Point Road, and the east boundary of the site is adjacent to 160 New South Head Road, Figure 2. The main pedestrian thoroughfares are along New South Head (southern) and Darling Point (western) Road frontages, with the main entrances (heritage, residential, and commercial) located on the New South Head Road frontage.

Figure 3: Render – view from the south-west

3 Wind assessment

3.1 Local wind climate

Weather data recorded at Sydney Airport by the Bureau of Meteorology has been analysed for this project. The anemometer is located about 10 km to the south-west of the site. 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 incident wind conditions at the site, due to close proximity to the site and similar distance from the coast.

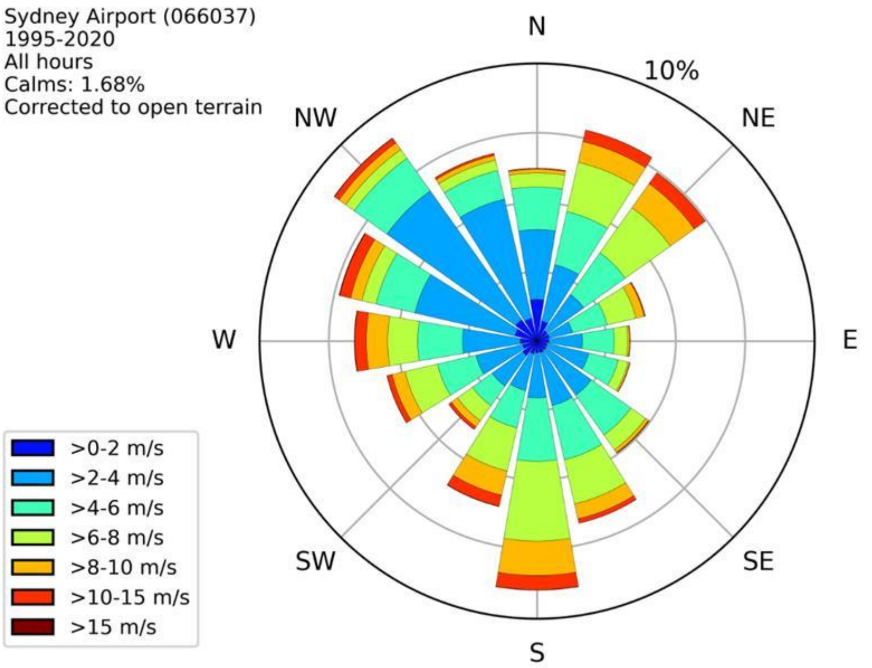

Figure 4: Wind rose showing probability of time of wind direction and speed

It is evident from Figure 4 that the prevailing wind directions are from the north-east, south, and north-west quadrants with stronger winds from these directions.

The measured mean wind speed is 4.5 m/s, and the 5% exceedance mean wind speed is 9.5 m/s.

Strong summer winds occur mainly from the south and north-east quadrants. Winds from the south are associated with large synoptic frontal systems and generally provide the strongest gusts during summer. Moderate intensity winds from the north-east tend to bring cooling relief on hot summer afternoons typically lasting from noon to dusk. These are small-scale temperature driven effects; the larger the temperature differential between land and sea, the stronger the wind.

Winter and early spring strong winds typically occur from the north-west, and 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.

A general description on flow patterns around buildings is given in Appendix 1.

3.2 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 2.

Woollahra Council has no specific wind controls for the site. The wind controls used in this wind assessment are based on the work of Lawson (1990) as described in Figure 13 and Table 1.

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
<20 m/s	Able-bodied people (less mobile or cyclists not expected)

Transferring the measured 5% of the time wind speed to ground level around the site would result in a mean wind speed of about 6 m/s. Form Table 1 these conditions would be classified as on the border of pedestrian standing and walking. From knowledge of the wind conditions in the locale, this would be a considered a correct classification for the area.

3.3 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 overall massing of the proposed development is generally larger than the surrounding buildings, with the exception of the taller nearby buildings to the north, and south-east to south. The proposed development is expected to have some impact on the local wind conditions making some areas calmer and other areas windier depending on the incident wind direction as discussed below.

Winds from the north-east

Winds from the north-east would cross the harbour before accelerating up the local topography from Double Bay before reaching the site. The wind would impinge on the north-east façade of the tower producing some downwash from the narrow face, with the curved tower design encouraging horizontal flow around the corners. The stepped nature of the north façade would direct more flow along the north façade, discharging flow through the open vehicular entrance to the basement car park levels rather than to the south. The downwash from the north-east section of the tower would be redirected by the north-east terraces on Levels 2 - 4 before reaching ground level. These terraces can therefore be expected to be windy during winds from the north-east, with the stepped nature of the terraces providing some localised calmer areas.

Being in the lee of the building, the main ground-level pedestrian routes are not expected to be significantly impacted by winds from the north-east. The Commercial Lobby entrance may be subject to windy conditions due to accelerations around the eastern aspect of the building. It is recommended that the Commercial Lobby entrance is moved to the west as much as possible and/or potentially reconfigure the lobby and adjacent retail space to further move the entrance to the west.

Winds from the south

The site is somewhat sheltered from winds from the south, which would accelerate up the local topography. The existing medium-rise building at 203-233 New South Head Road immediately to the south of the site has a broad frontage, which would offer significant shielding to the lower sections of the proposed site for winds from the south. The recessed main entries are well located in the middle of the face in the wake of the neighbouring building.

The broad face of the proposed tower is perpendicular to the incident wind direction. The angled western façade and the curved design would encourage flow to pass around the building horizontally minimising any downwash from the exposed upper levels. Any downwash would be directed in the articulated slots, which for winds from the south would be the main articulation midway along the southern aspect. Except above the Heritage Plaza, the tower is setback from the podium edge by between 3-10 m, which would redirect a component of downwash before reaching ground level. The stepped nature of the podium on the southern aspect across Levels 2 and 3 would further assist with minimising the amount of downwash reaching ground level. The Heritage Plaza is enclosed on three sides so the downwash would stagnate on the ground plane resulting in relatively calm conditions in the Heritage Plaza. Flow would discharge across the roof of the heritage building on the south-west corner of the site, which would be expected to be strong during winds from the south.

Similar to winds from the north-east, the Commercial Lobby entrance may be subject to windy conditions given the proximity to the corner of the building. It is recommended to move the entrance to the west as much as possible.

Winds from the west

Winds from the west are slightly accelerated up the local topography before reaching the site. The western façade of the proposed development is relatively narrow, angled to the incident wind direction, and with the curved corners of the tower would assist in encouraging horizontal flow, thereby minimising downwash. Any downwash would be directed in the main articulated slot on the western façade onto the heritage building terrace roof.

Winds from the west would be expected to accelerate along the entry driveway at ground level under the cantilevered section of the tower. However, it is assumed that this area is for vehicular access only.

The Heritage Plaza forecourt is well-positioned for winds from the west, recessed behind the heritage building, which will provide protection to the Heritage Lobby and Residential Lobby entries. The Commercial Lobby entry is located further along New South Head Road towards the south-east corner of the site and is not expected to be significantly impacted by winds from the west.

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 and walking, with locations around the south-west corner being at the upper end of the walking classification. All locations are expected to meet the safety criterion. These wind conditions would be considered suitable for the intended use of the space.

4 Additional advice

The basement is expected to charge with positive pressure for winds from the west. If the roller door is not solid then the basement will charge with positive pressure and try to vent up the lift shaft. As the lifts run the entire height of the building, it would be recommended to include a lift lobby on all basement levels. If the roller door is solid, then it will have to resist a large wind load.

The main Heritage Plaza Forecourt is a good design and would be expected to have a relatively benign wind climate. The resulting high pressure on the entry doors and potential for internal flow issues is a possible issue, and the heritage lobby may warrant an airlock depending on the internal separation.

The proposed roof terrace to the heritage building is expected to be exposed to winds from the south and west quadrants, particularly due to the local topography. High balustrades (at least 1.8 m) are recommended to provide local protection. Further temporary or permanent local ameliorations would be required to improve the local wind conditions for more stationary activities and would be developed through detailed design.

The corner balconies on the higher residential levels, Figure 2, will be windy where wind has the ability to blow across the balconies, particularly on the western and eastern ends of the towers that are exposed to winds from the west and north-east. For resident usability, it would be strongly recommended to have the ability to close the balconies on all but one face to restrict flow across the balcony. Care should be taken over the design of balconies during detailed design to minimise the potential for Helmholtz resonance, which occurs with a small opening to a larger balcony – like blowing over an empty bottle. Significantly better wind conditions will exist on the inset balconies.

5 References

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Appendix 1: 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 5, 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 5. 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.

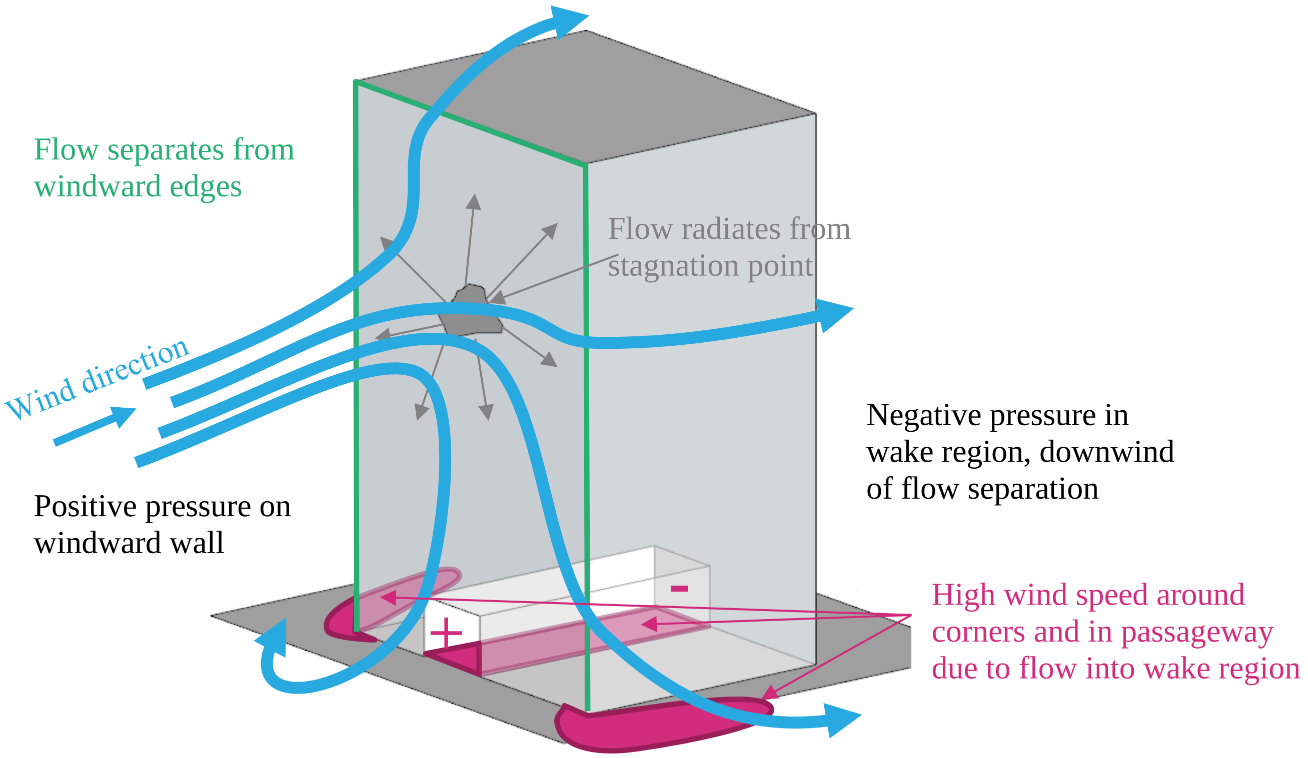

Figure 5 Schematic wind flow around tall isolated building

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.

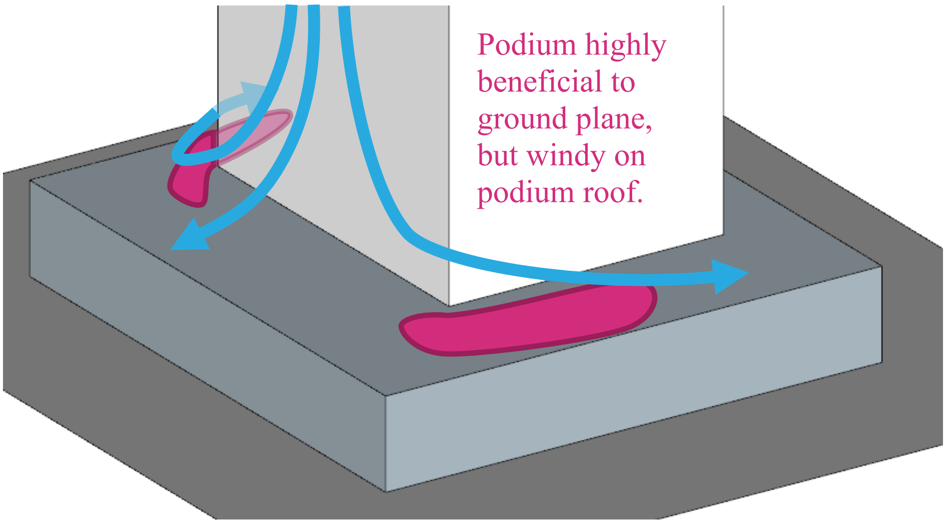

Figure 6 Schematic flow pattern around building with podium

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 7. 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.

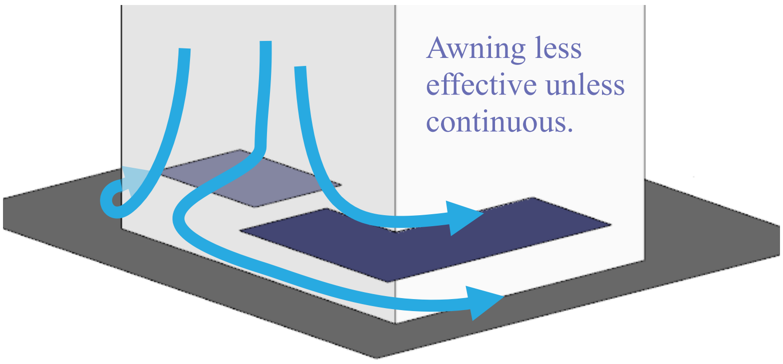

Figure 7 Schematic flow pattern around building with awning

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 8. 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 5. If the link is blocked, wind conditions will be calm unless there is a flow path through the building, Figure 9. 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 9.

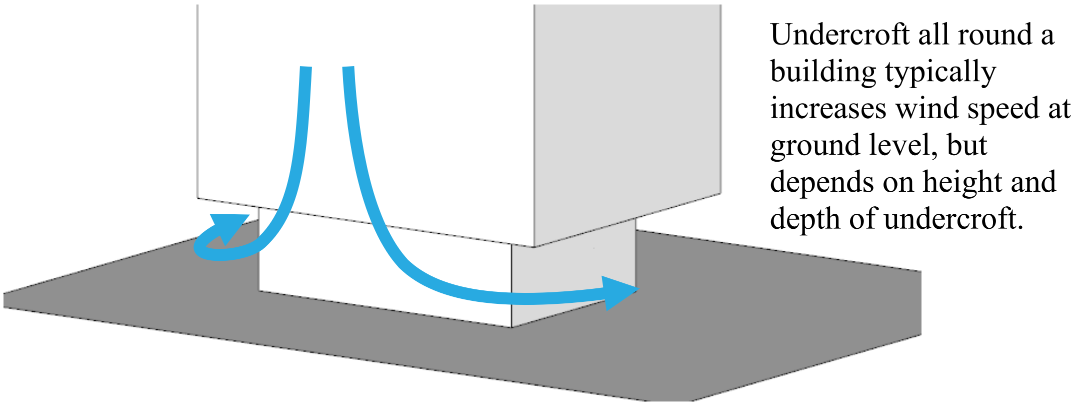

Figure 8 Schematic of flow patterns around isolated building with undercroft

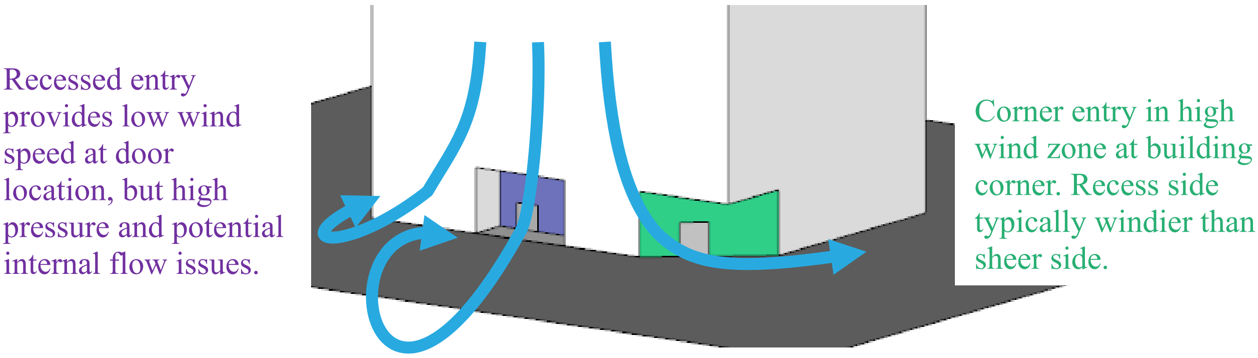

Figure 9 Schematic of flow patterns around isolated building with ground articulation

Multiple buildings

When a building is located in a city environment, depending on upwind buildings, the interference effects may be positive or negative, Figure 10. 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.

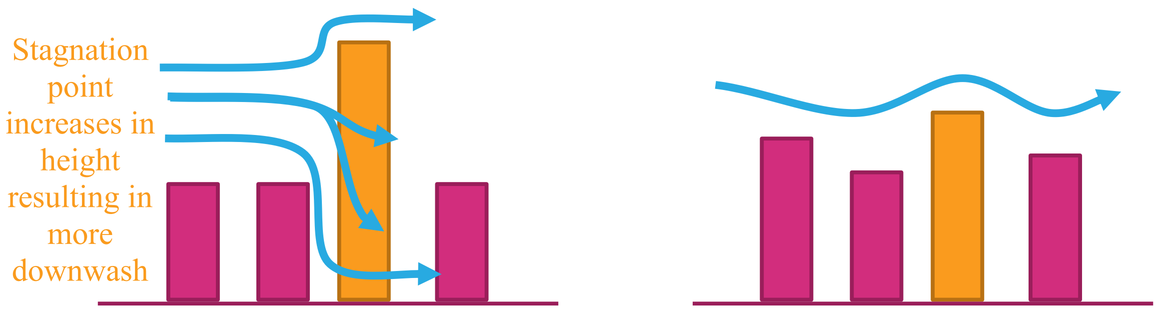

Figure 10 Schematic of flow pattern interference from surrounding buildings

The above discussion becomes more complex when three-dimensional effects are considered, both with orientation and staggering of buildings, and incident wind direction, Figure 11.

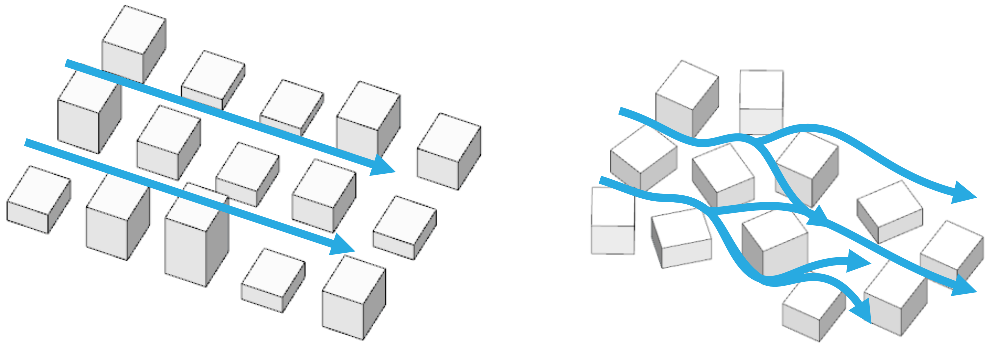

Figure 11 Schematic of flow patterns through a grid and random street layout

Channelling occurs when the wind is accelerated between two buildings, or along straight streets with buildings on either side, Figure 11(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 11(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.

Single barriers and screens

The wind flow pattern over a vertical barrier is illustrated in Figure 12, showing there will be recirculation zones near the windward wall and in the immediate lee of the barrier. The typical extent of these recirculation zones relative to the height of the barrier, h, is illustrated in Figure 12. These regions are not fixed but fluctuate in time. The mean wind speed in the wake areas drops significantly compared with the incident flow. With increasing distance from the barrier the flow pattern will resort to the undisturbed state. Typically the mean velocity and turbulence intensity at barrier height would be expected to be within 10% of the free stream conditions at 10 times the height of the structure downwind from the barrier.

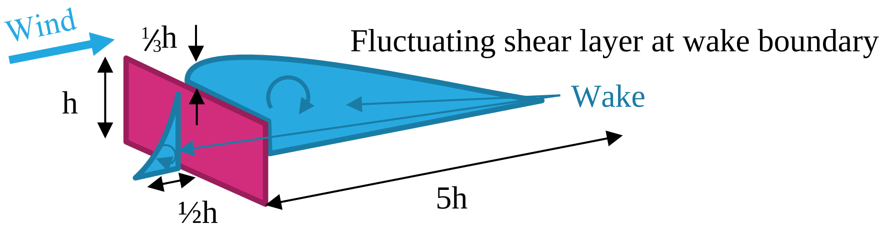

Figure 12: Sketch of the flow pattern over an isolated structure

Appendix 2: 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:

$$\mathrm{U_{GEM}} = \frac{(\mathrm{U_{1\,hour\,mean}} + 3\cdot\sigma_\mathrm{u})}{1.85} \quad \text{and} \quad \mathrm{U_{GEM}} = \frac{1.3\cdot(\mathrm{U_{1\,hour\,mean}} + 2\cdot\sigma_\mathrm{u})}{1.85}$$

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 13 and Figure 15. 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 13 with definitions of the intended use of the space categories defined in Figure 14.

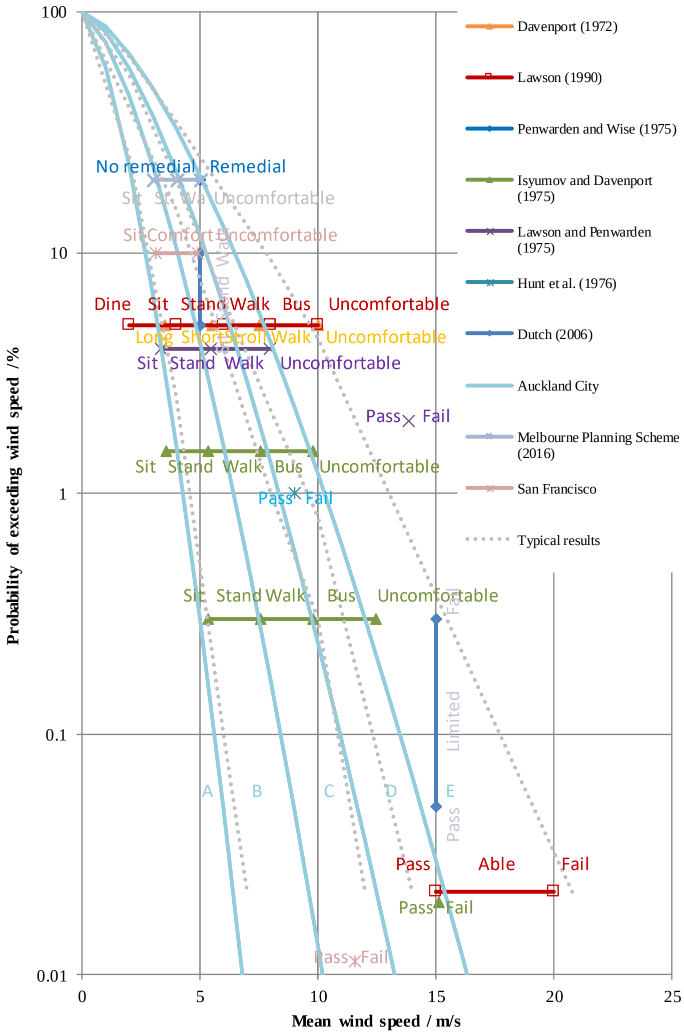

Figure 13 Probabilistic comparison between wind criteria based on mean wind speed

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 14: Auckland Utility Plan (2016) wind categories

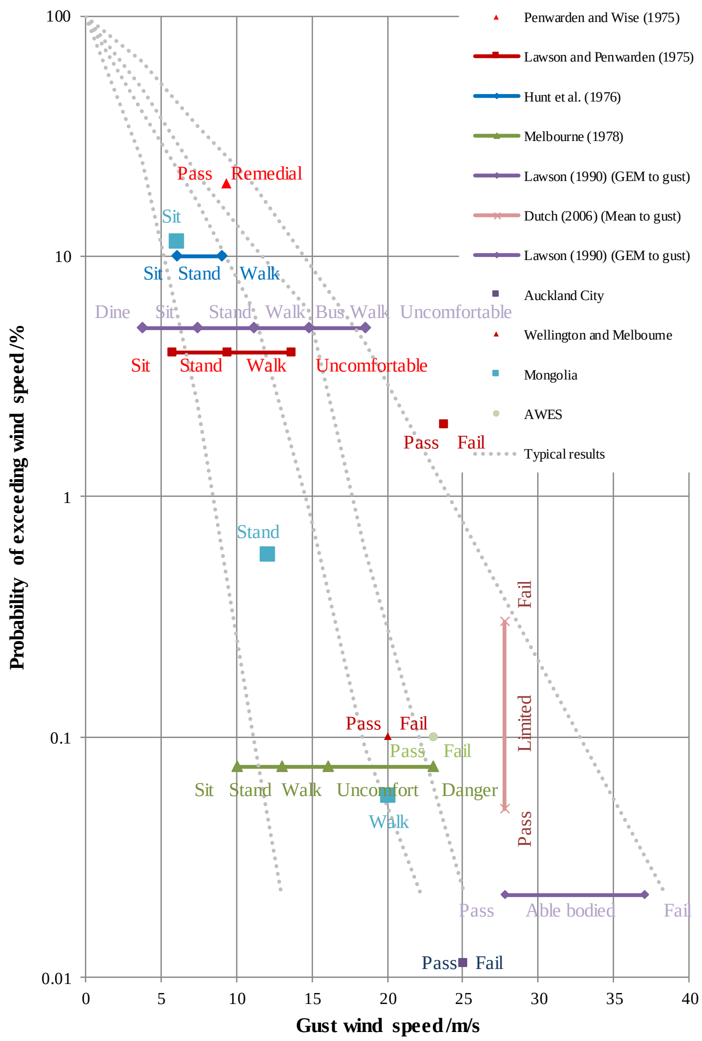

Figure 15 Probabilistic comparison between wind criteria based on 3 s gust wind speed

Appendix 3: Reference documents

In preparing the assessment, the following documents have been referenced to understand the building massing and features. The drawings received are dated 8 June 2021.

- 1_View01.jpg
- 1_View02.jpg
- 1_View05.jpg
- Updated Plans_Mix (002).pdf