Health Infrastructure

# Ryde Hospital Redevelopment (Concept and Stage 1)

Environmental Wind Assessment

Wind

Rel. 3 | 19 July 2022



Job number 286519

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# Document Verification

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| | | Name | Graeme Wood | | Graeme Wood |

**Issue Document Verification with Document** ✓

# Executive summary

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

Integrating the expected wind conditions with the wind climate for all wind directions, the wind comfort conditions would be expected to be classified as suitable for pedestrian standing type activities, with slightly windier locations experienced around building corners crossing into the pedestrian walking classification. These wind conditions would be considered acceptable for the intended use of access in and around the site.

The location of main entrances to the hospital and pedestrian recreational areas would be developed during later design stages.

It is Arup's opinion that all locations within the proposed development would meet the safety criterion.

To quantify the qualitative advice provided in this report, numerical or physical modelling of the development would be required, but are not considered necessary for this development.

# Contents



## Disclaimer

This assessment of the site environmental wind conditions is presented based on engineering judgement. In addition, experience from more detailed simulations has been used to refine recommendations. No detailed simulation, physical or computational, 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 proposed Ryde Hospital development. This report outlines the assessment and subsequent recommendations for wind engineering services related to pedestrian wind comfort and safety on the ground level.

The Ryde Hospital site is located at 1 Denistone Road, Denistone and comprises Lots 10-11 DP 1183279 and Lots A-B DP 323458. It has an area of approximately 7.69 ha and currently accommodates the existing Ryde Hospital Campus.

This report accompanies a State Significant Development Application that seeks approval for the establishment of a maximum building envelope and gross floor area for the future new hospital buildings, and physical Stage 1 Early Works to prepare the site for the proposed development.

For a detailed project description refer to the Environmental Impact Statement prepared by Ethos Urban.

This report addresses the Planning Secretary's Environmental Assessment Requirements (SEARs) as detailed in Table 1.

Table 1: SEARs requirements

| Item | SEARS Requirement Reference | Relevant Section of Report |
|---|---|---|
| 1.0 | **5 Environmental Amenity**<br>Assess amenity impacts on the surrounding locality, including lighting impacts, solar access, visual privacy, visual amenity, view loss and view sharing, overshadowing and wind impacts (including the preparation of a wind assessment where the concept development has a height above four storeys). A high level of environmental amenity for any surrounding residential or other sensitive land uses must be demonstrated. | This entire report forms the required documentation for the Pedestrian Level Wind Assessment in particular Section 3. |

# 2 Site description

The proposed Ryde Hospital redevelopment is located in Denistone on the block bounded by Fourth Avenue, Denistone Road, Florence Avenue, and Ryedale Road, Figure 1.


Figure 1: Site location (source: Google Maps, 2020)

The site is predominantly surrounded by low-rise buildings in all directions. Local wind conditions in such environments are generally dictated by the larger exposed buildings, such as the subject site. Topography surrounding the site drops to the south and west to the railway line from the heavily treed area on the site and is relatively flat to the north and east.

The proposed development consists of a main building of irregular floor plan rising to a maximum height of about 40 m above ground level, and a multi-storey car park rising to about 25 m above ground level, Figure 2 to Figure 5. A 3d aerial view of the proposed redevelopment is illustrated in Figure 6.

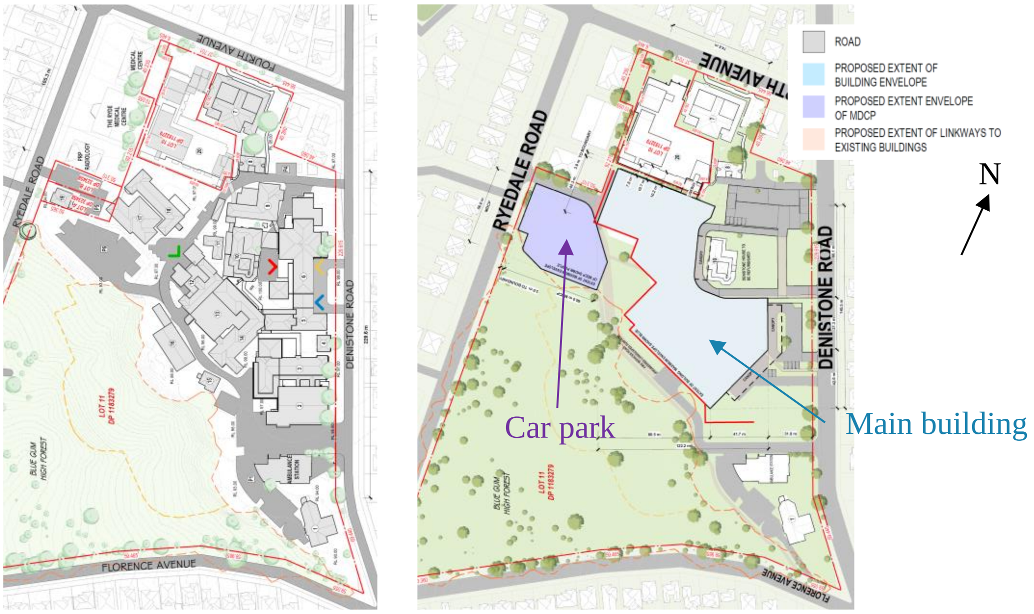


Figure 2: Site layout plan for existing (L) and proposed (R) schemes

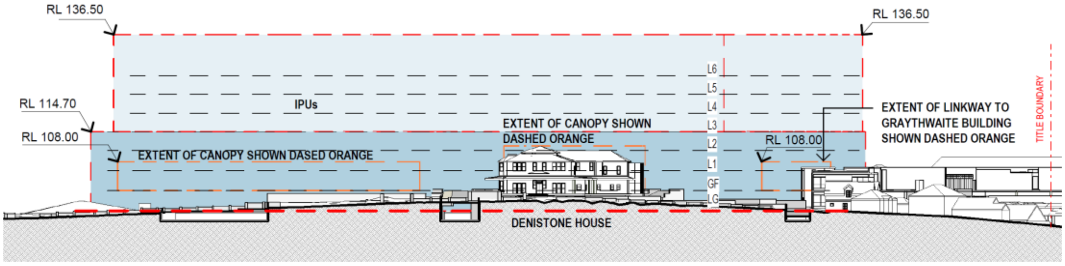


Figure 3: East elevation Denistone Road

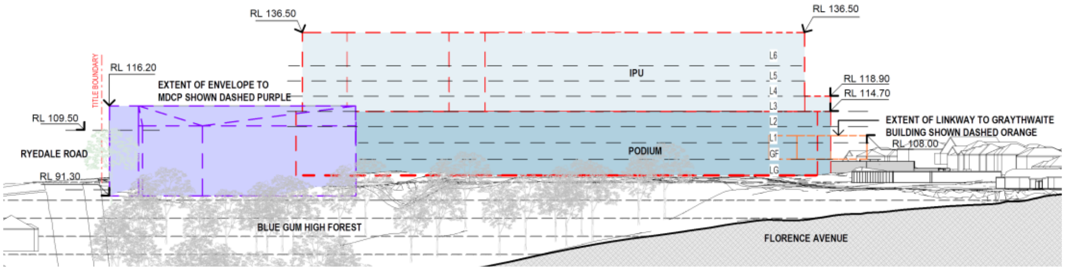


Figure 4: South elevation Florence Avenue

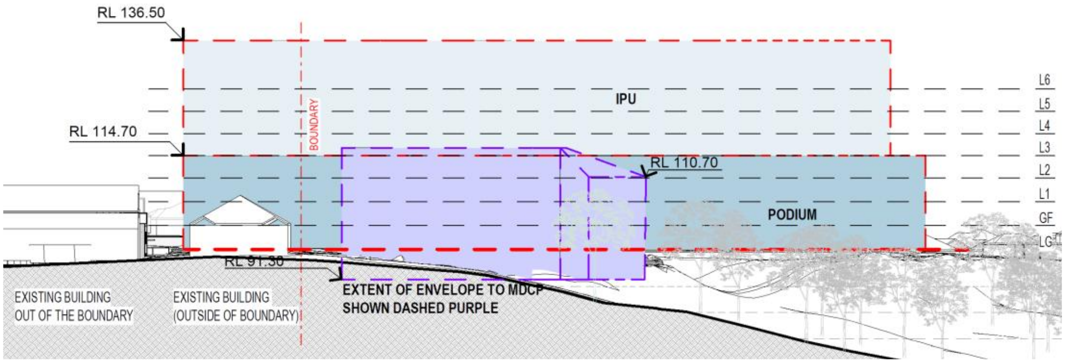


Figure 5: West elevation Ryedale Road

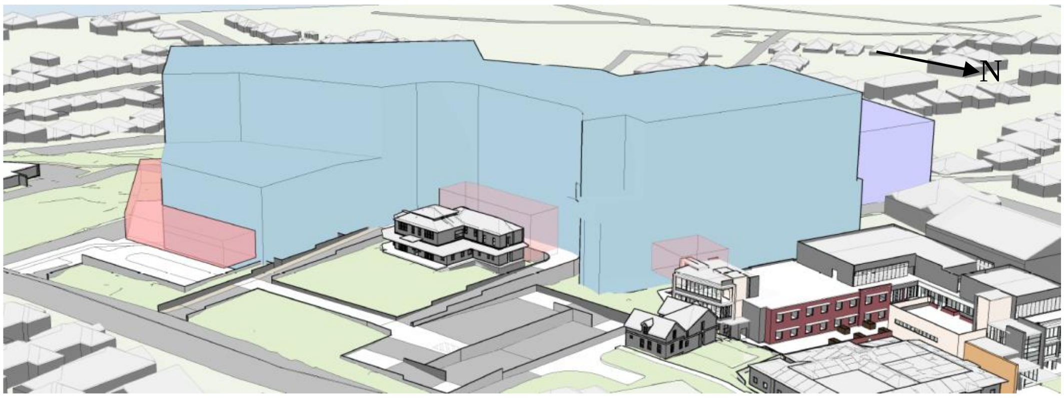


Figure 6: 3d view of concept design maximum building envelope from the north-east

# 3 Wind assessment

## 3.1 Local wind climate

Weather data recorded at Bankstown Airport has been analysed for this project, Figure 7 and Figure 8. The anemometer is located about 10 m above ground level, about 16 km to the south-west of the site, Figure 1. The distance to the coast is similar to the site and considered more appropriate than other anemometers in the Sydney region. 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.

It is evident from Figure 7 that the wind is omni-directional with stronger winds from the south-east and west quadrants. It is evident from Figure 8 that the general wind speed and direction changes throughout the day, with stronger winds during the afternoon and calmer conditions after sunset. The measured mean (50 percentile) wind speed, and the 5% exceedance mean wind speed associated with the comfort criterion for various times are presented in Table 2.

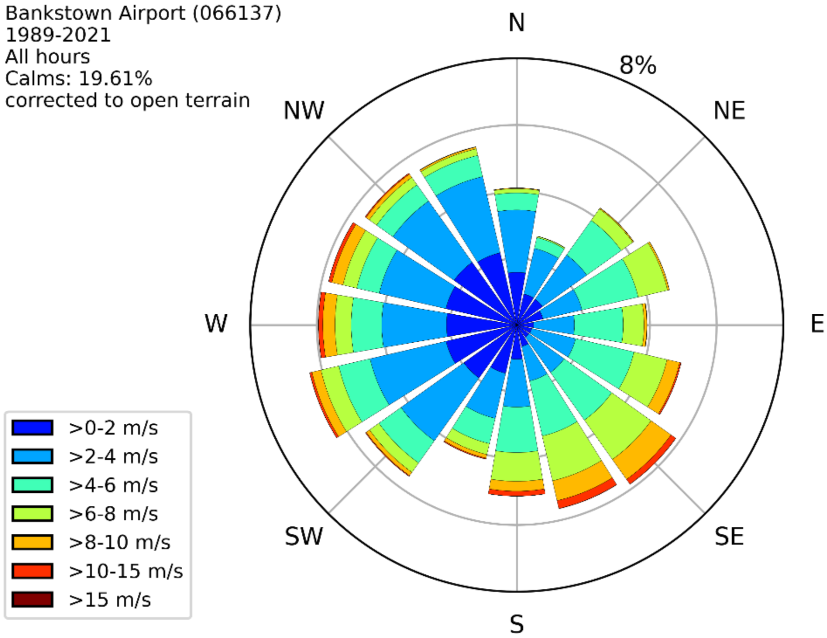


Figure 7: Wind rose showing probability of time of wind direction and speed

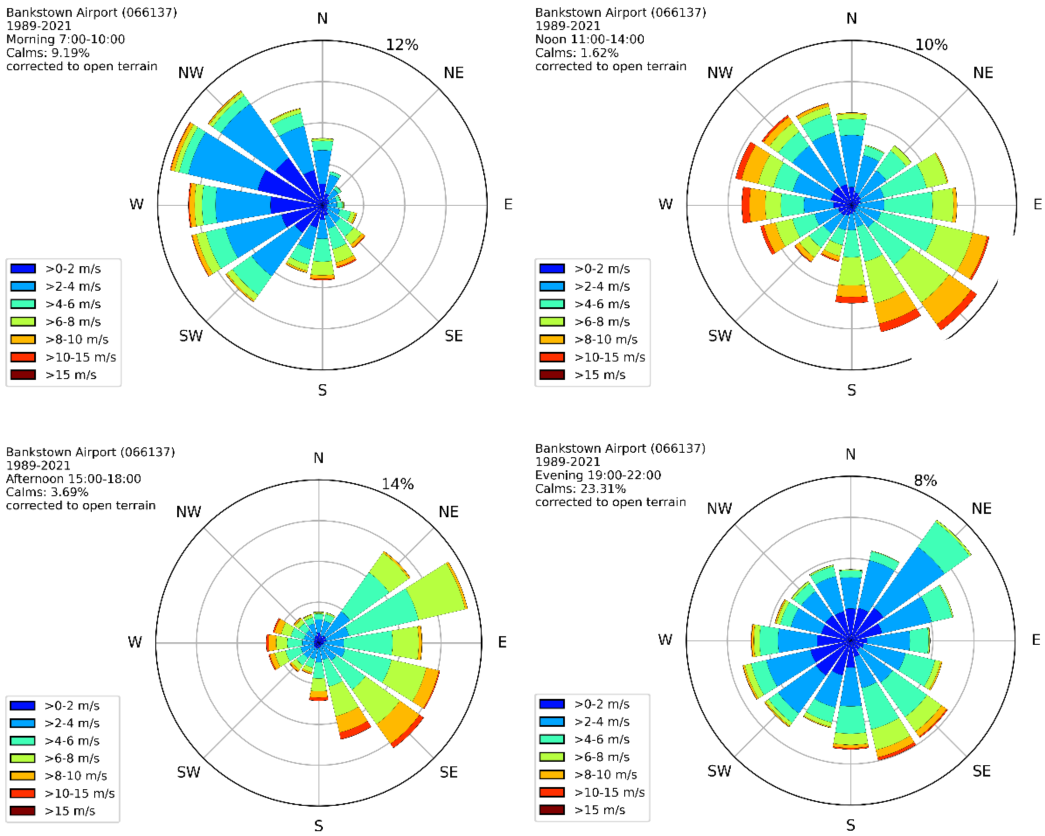


Figure 8: Wind roses for morning 6-11 am (L), afternoon 12-4 pm (C), and evening 5-8 pm (R)

Table 2: Probabilistic wind speed for different time of day

| Probability | All time | 7-10 am | 11am-2pm | 3-6 pm | 7-10 pm |
|---|---|---|---|---|---|
| 50%ile at anemometer | 3.5 | 3.1 | 4.4 | 4.7 | 3.0 |
| 5%ile exceedance at anemometer | 7.8 | 7.0 | 8.9 | 8.8 | 6.6 |
| 5%ile exceedance at ground level at site | 4.9 | 4.4 | 5.6 | 5.5 | 1.2 |

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.

The City of Ryde Development Control Plan (DCP) conditions wind tunnel testing, and has wind assessment criteria based on the maximum allowable wind speeds, Figure 9. As the buildings are noted as less than 9 storeys in height, a qualitative wind assessment report is required rather than a quantitative wind-tunnel testing report.

| AREA CLASSIFICATION | LIMITING WEEKLY MAXIMUM GUST-EQUIVALENT MEAN | LIMITING ANNUAL MAXIMUM GUST |
|---|---|---|
| Outdoor dining areas, amphitheatres etc | 3.5 m/s | 10 to 13 m/s |
| Main retail centres and retail streets, parks, communal recreational areas | 5.5 m/s | 13 m/s |
| Footpaths and other pedestrian accessways | 7.5 m/s | 16 m/s |
| Infrequently used laneways, easements, private balconies | 10 m/s | 23 m/s |

Figure 9: City of Ryde DCP wind criteria

The assessment criteria in the DCP are not well defined in terms of percentage of time, but are assumed to be based on the work of Isyumov and Davenport (1975) for the weekly event (1.5% of the time), and Melbourne (1978) for the annual event (0.05-0.1% of the time). The Melbourne (1975) criteria are generally more stringent than Isyumov and Davenport (1975). These criteria are included in Figure 20 and Figure 22 respectively, Appendix 2.

Transferring the measured 1.5% of the time mean wind speed from the anemometer location at 10 m above ground level to ground level at the site, would result in a mean wind speed of about 5 m/s, which would be classified as suitable for pedestrian standing type activities, such as main retail streets and recreational areas. This classification would be considered appropriate for the area.

The target wind classification for the pedestrian walkways around the site would be pedestrian walking (weekly wind speed of 7.5 m/s), with standing required for any public accessible recreational areas and main hospital entrances (weekly wind speed of 5.5 m/s). More stringent requirements may be required for patient accessible external terraces.

## 3.3 Predicted wind conditions on ground plane

This section of the report outlines the predicted wind flow patterns and conditions on the ground plane based on the local climate, topography, and building form.

The inclusion of a 40 m tall building will impact the wind conditions around the site, with some areas getting windier, and others calmer depending on in incident wind direction. The windiest locations generally occur around the windward corners, Figure 12 in Appendix 1 and the location of doorways would be advised to be kept away from the corners, which would be covered during schematic design.

### Winds from the south-east

Winds from the south-east would be channelled by the local topography, and pass along the ridge running south-east to north-west. The incident flow would pass over the roofs of the existing building before impacting on the south-east corner of the main building. Impacting on the corner of the building encourages horizontal flow rather than inducing downwash. The wind conditions at ground level on the south-east façade would be further ameliorated by the articulation of the façade, allowing the accelerated flow to disperse at a higher level, Figure 10.

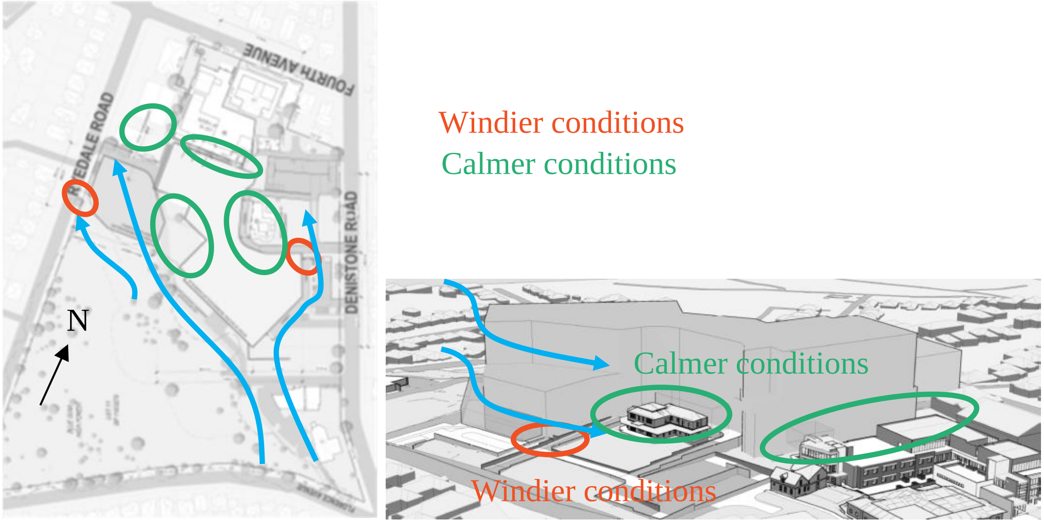


Figure 10: Wind flow patterns for wind form the south-east

## Winds from the west and north-west

Winds from the west and north-west would be accelerated up the local topography to the site on the crest of the ridge. Wind would impinge on the western facades of the car park and Main building. The proximity of the car park and main building would induce pressure driven flow between these buildings. This would be a strong mean flow with reduced turbulence. Pedestrian routes between the two buildings should be remote from the building corners as much as practical to reduce the potential impact on pedestrians.

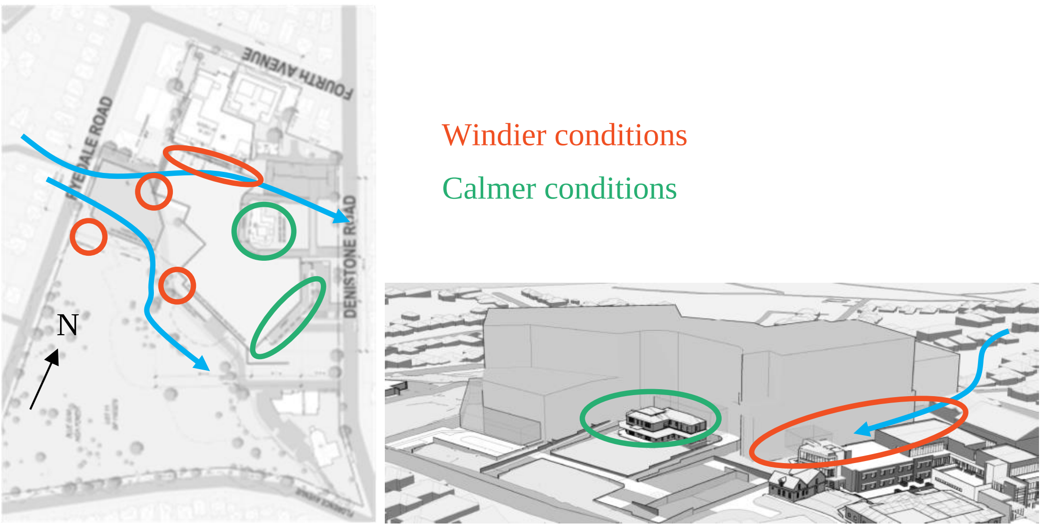


Figure 11: Wind flow patterns for wind form the south-east

# Discussion

Integrating the expected wind conditions with the wind climate for all wind directions, the wind comfort conditions would be expected to be classified as suitable for pedestrian standing type activities, with slightly windier locations experienced around building corners crossing into the pedestrian walking classification. These wind conditions would be considered acceptable for the intended use of access in and around the site.

It is Arup's opinion that all locations within the proposed development would meet the safety criterion.

To quantify the qualitative advice provided in this report, numerical or physical modelling of the development would be required, but is not considered necessary for this development.

# 4 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 12, 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 12. 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.

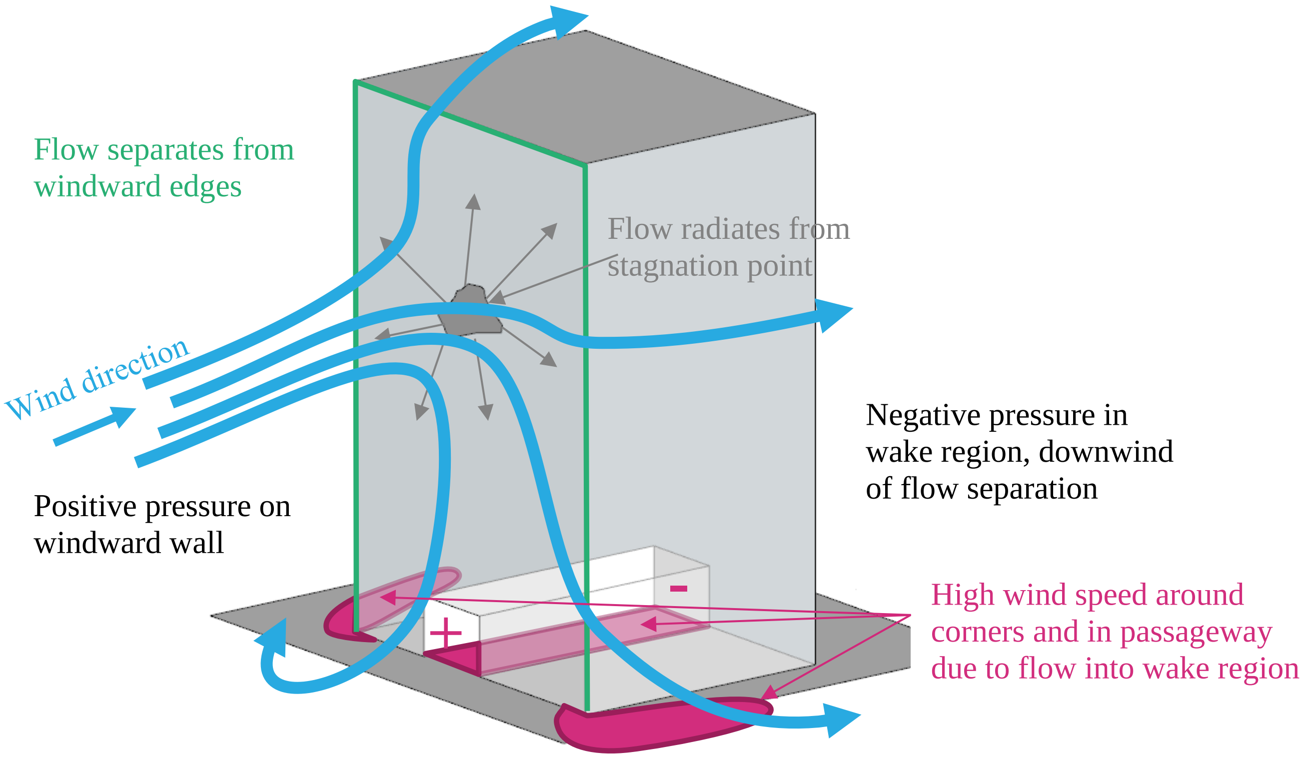


Figure 12 Schematic wind flow around tall isolated building

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.

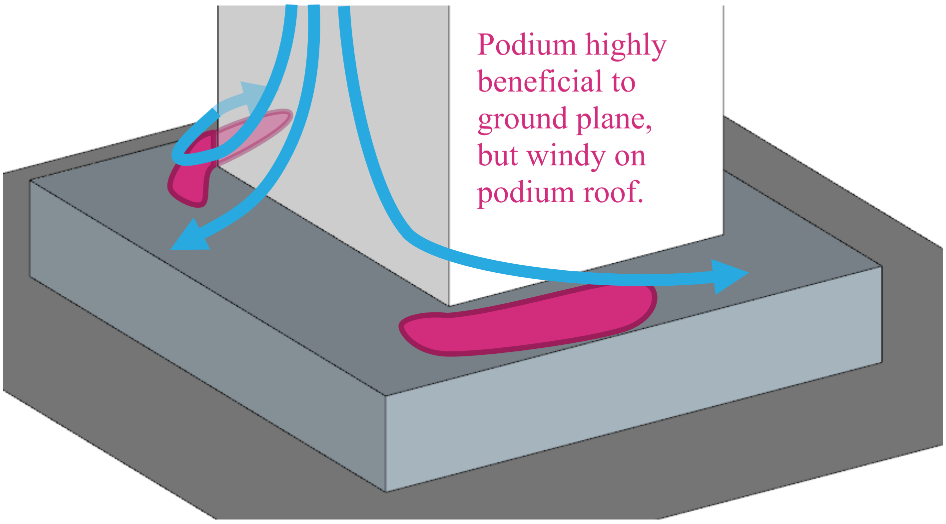


Figure 13 Schematic flow pattern around building with podium

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 14. 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.

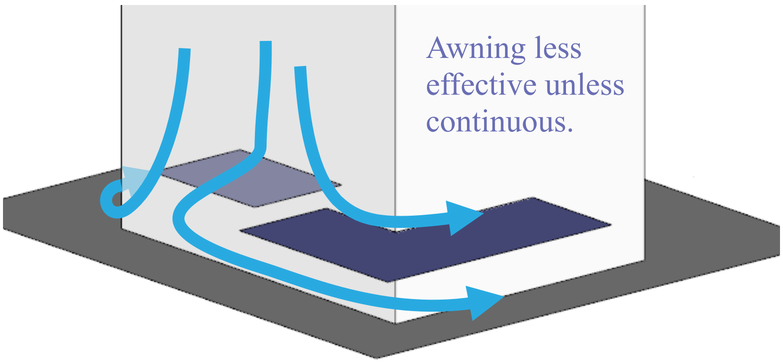


Figure 14 Schematic flow pattern around building with awning

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 15. 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 12. If the link is blocked, wind conditions will be calm unless there is a flow path through the building, Figure 16. 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 16.

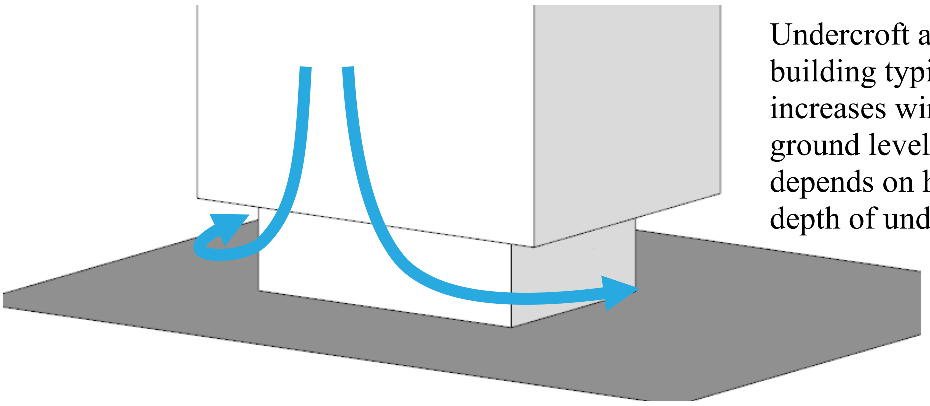


Figure 15 Schematic of flow patterns around isolated building with undercroft

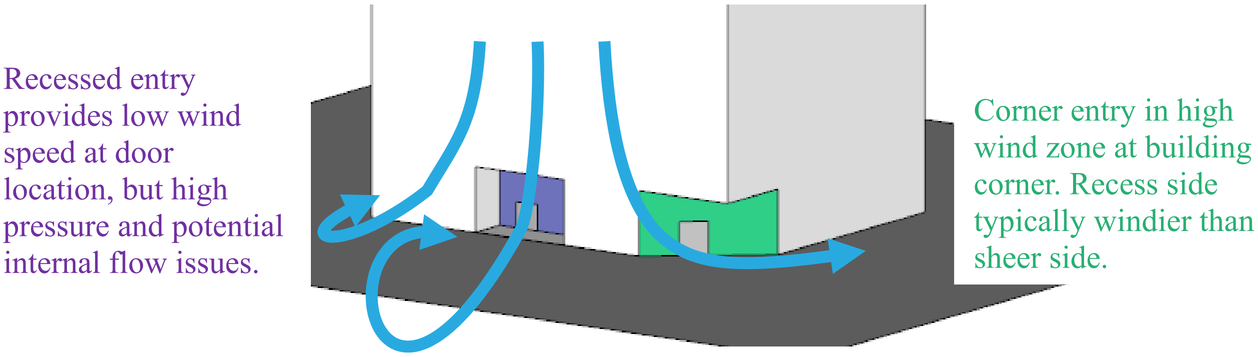


Figure 16 Schematic of flow patterns around isolated building with ground articulation

## Multiple buildings

When a building is located in a city environment, depending on upwind buildings, the interference effects may be positive or negative, Figure 17. 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.

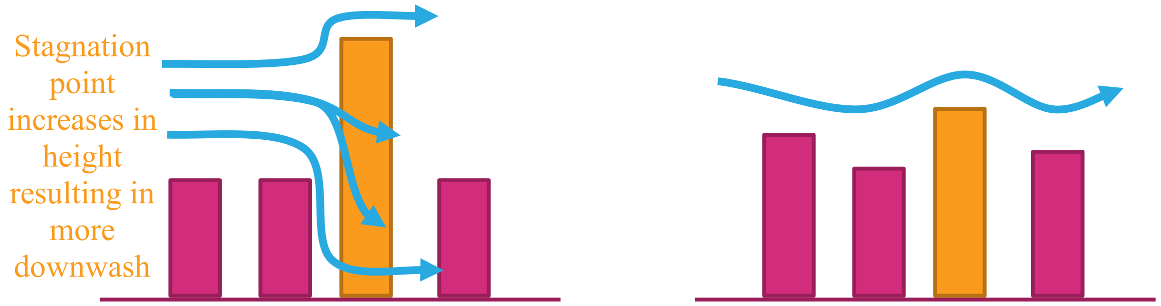


Figure 17 Schematic of flow pattern interference from surrounding buildings

The above discussion becomes more complex when three-dimensional effects are considered, both with orientation and staggering of buildings, and incident wind direction, Figure 18.

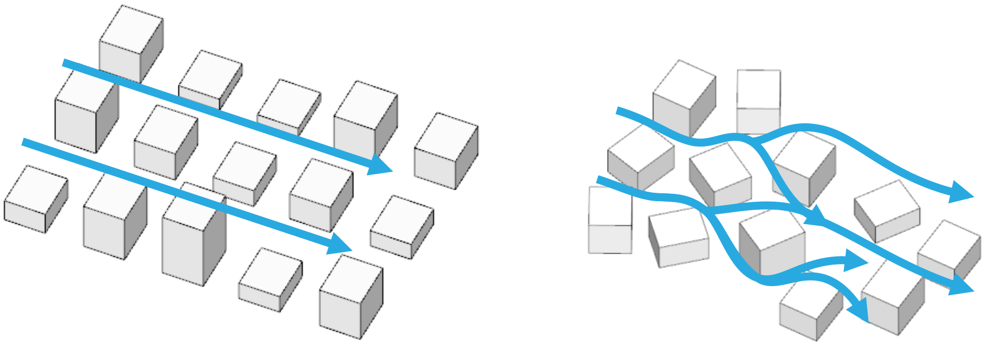

Figure 18 Schematic of flow patterns through a grid and random street layout

Channelling occurs when the wind is accelerated between two buildings, or along straight streets with buildings on either side, Figure 18(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 18(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 19, 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 19. 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.

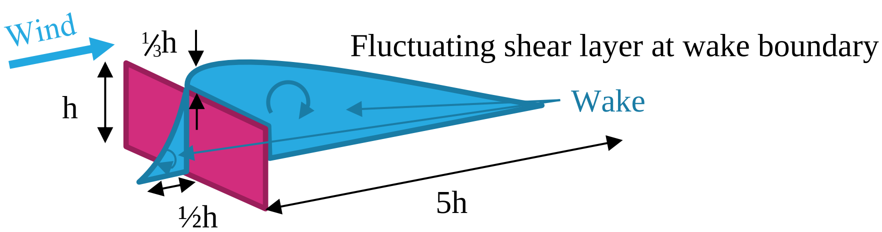


Figure 19: Sketch of the flow pattern over an isolated vertical element

# 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 3. 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 3 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.<br>Napkins blown away and newspapers flutter at about 1 m/s. |
| Light breeze | 2–3 | Wind felt on face. Light clothing disturbed.<br>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.<br>Sand on beach saltates at about 5 m/s.<br>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.<br>Umbrellas used with difficulty.<br>Wind sock fully extended at about 8 m/s. |
| Strong breeze | 11–14 | Hair blown straight. Difficult to walk steadily.<br>Wind noise on ears unpleasant.<br>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:

$$U_{GEM} = \frac{(U_{1\ hour\ mean} + 3 \cdot \sigma_u)}{1.85} \text{ and } U_{GEM} = \frac{1.3 \cdot (U_{1\ hour\ mean} + 2 \cdot \sigma_u)}{1.85}$$

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 20 and Figure 22. 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 20 with definitions of the intended use of the space categories defined in Figure 21.

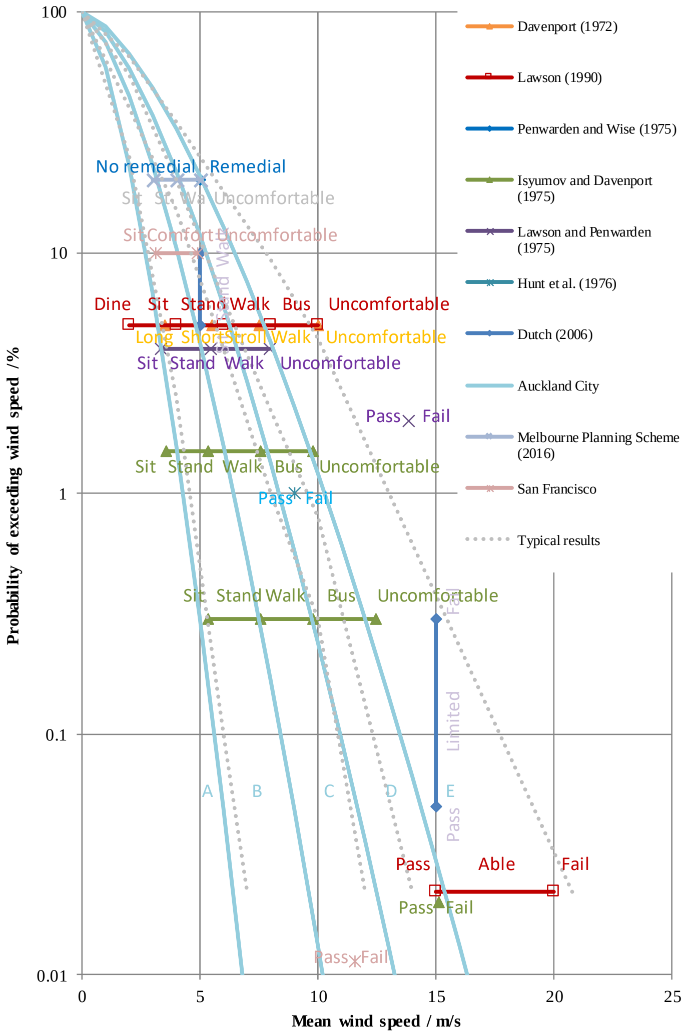


Figure 20 Probabilistic comparison between wind criteria based on mean wind speed

| | |
|---|---|
| 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 21: Auckland Utility Plan (2016) wind categories

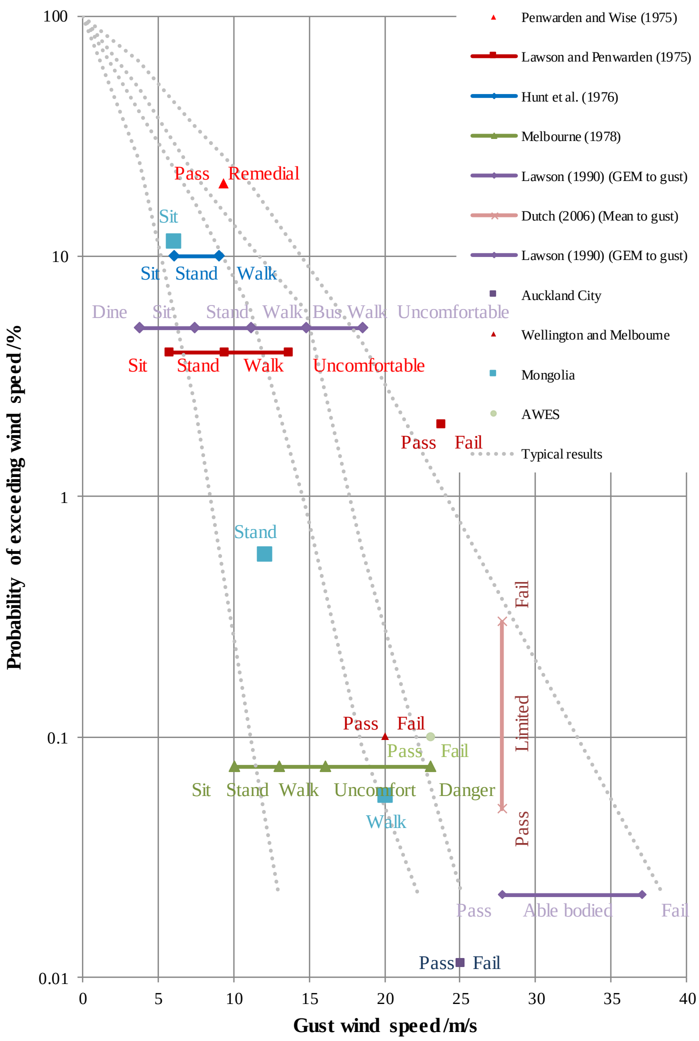


Figure 22 Probabilistic comparison between wind criteria based on 3 s gust wind speed

# Appendix 3: Referenced Documents

STH-AR-SSD1_000[4].pdf
STH-AR-SSD1_009[5].pdf
STH-AR-SSD1_010[5].pdf
STH-AR-SSD1_008[5].pdf
STH-AR-SSD1_011[5].pdf
STH-AR-SSD1_013[4].pdf
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