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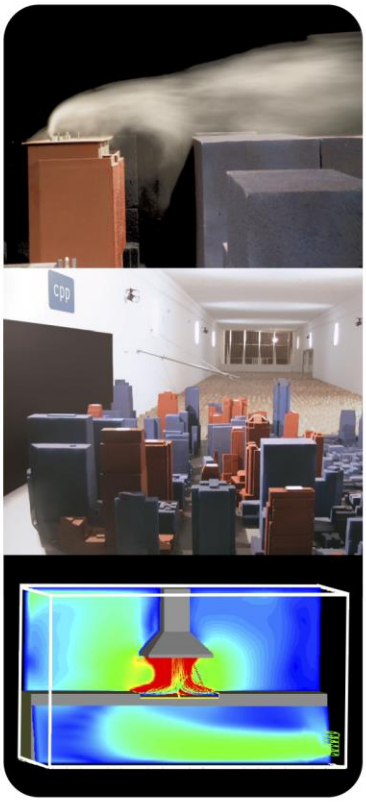
WIND ENGINEERING AND AIR QUALITY CONSULTANTS

Final Report



Qualitative Wind Assessment for:
26 Elizabeth Street
Liverpool NSW 2170, Australia

Prepared for:
Binah Developments Pty Ltd
c/- Rothelowman Architects
2/171 William Street
Darlinghurst NSW 2010
Australia

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CPP Project: 12575

Prepared by:
Andrew Nguyen, Project Engineer
Joe Paetzold, Engineering Manager

CPP
Unit 2, 500 Princes Highway
St. Peters, NSW 2044, Australia
info-syd@cppwind.com
www.cppwind.com

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1 INTRODUCTION

Cermak Peterka Petersen Pty. Ltd. has been engaged by Binah Developments Pty Ltd to provide a qualitative assessment of the impact of the proposed 26 Elizabeth Street development in Liverpool on the wind environment surrounding the development site.

The development site is located in a region generally dominated by low-rise development, Figure 1. The proposed building comprises a single prismatic tower with stepped podiums that will rise to a height of approximately 113 m from ground level, Figure 2, and will be taller than most surrounding buildings thus is expected to have some impact on the local wind conditions. The extents are discussed in this report.

Figure 1: Development site plan (Google Earth, 2018).

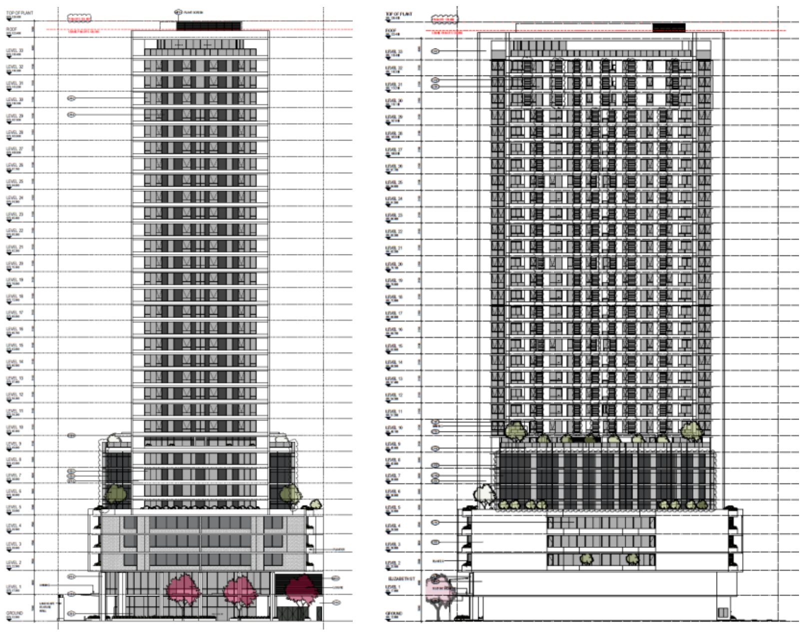

Figure 2: North elevation (left) and west elevation (right) (Rothelowman, 2019)

2 LIVERPOOL WIND CLIMATE

The proposed development lies approximately 6 km to the west of the Bankstown Airport Bureau of Meteorology anemometer. To enable a qualitative assessment of the wind environment, the wind frequency and direction information measured by the Bureau of Meteorology at a standard height of 10 m at Bankstown Airport from 1993 to 2017 have been used in this assessment. The corresponding wind rose for Bankstown Airport is shown in Figure 3 and is considered to be representative of prevailing winds at the development site. It is noted from Figure 3 that strong prevailing winds typically approach from the south-east, west and to a lesser extent the north-east quadrants. This wind assessment is focused on these prevailing strong wind directions.

Winds from the south-east, which tend to be cold and humid, are often caused by frontal systems that can last several days and occur throughout the year. Winds from the west tend to be the strongest of the year and are associated with large weather patterns and thunderstorm activity. These winds occur throughout the year, but are reduced in frequency in summer, and can be cold or warm depending on the inland conditions. In coastal Sydney, winds from the north-east tend to be summer sea breezes and bring welcome relief on summer days but dissipate with distance from the coast and are much less frequent further inland.

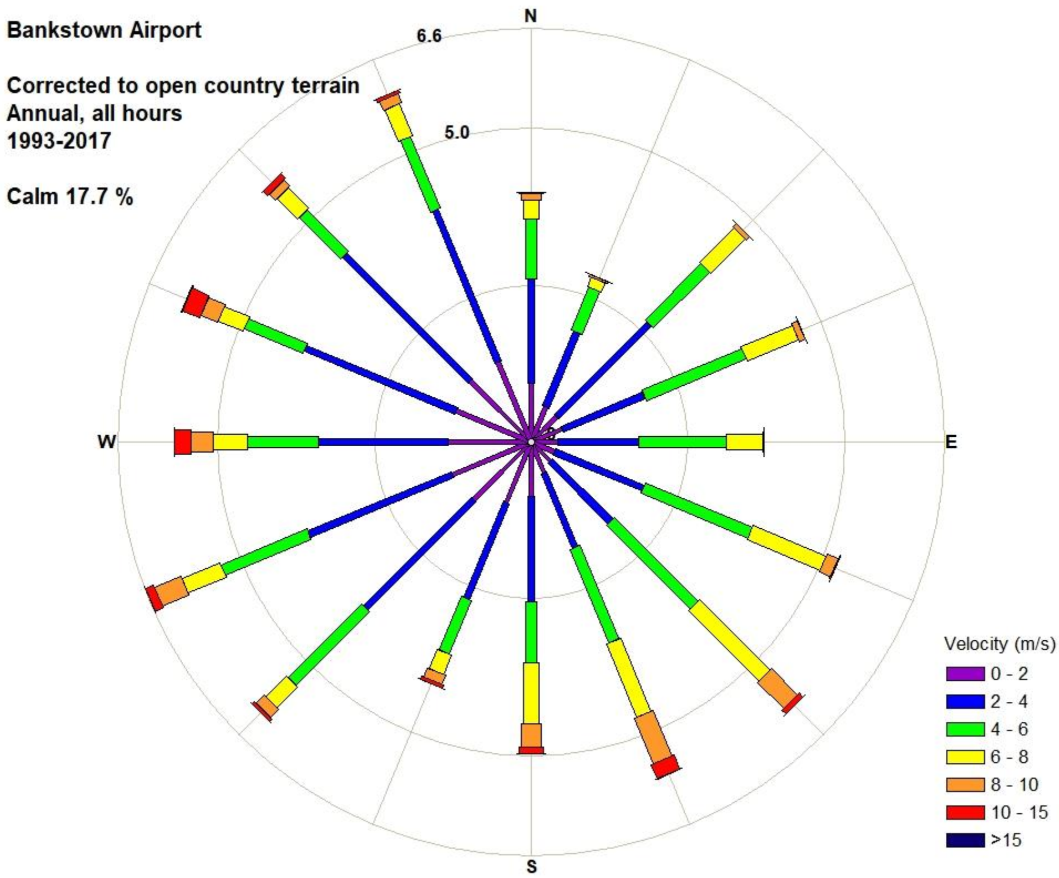

Figure 3: Wind rose for Bankstown Airport.

3 ENVIRONMENTAL WIND CRITERIA

It is generally accepted that wind speed and the rate of change of wind velocity are the primary parameters that should be used in the assessment of how wind affects pedestrians. Local wind effects can be assessed with respect to a number of environmental wind speed criteria established by various researchers. 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 remarkably good agreement.

The Liverpool Development Control Plan (LDCP, 2008) contains wind assessment criteria for the City Centre based on the maximum allowable wind velocities for certain areas, specifically:

"1. To ensure public safety and comfort, the following maximum wind criteria are to be met by new buildings:

- 10m/second in retail streets,

- 13m/s in along major pedestrian streets, parks and public places, and

- 16 m/s in all other streets."

It is unclear whether these conditions relate to the mean or gust wind speed and the percentage of time that these can occur. Similar conditions are implemented in the City of Sydney DCP and from discussion with Council are intended to be for serviceability comfort conditions where these relate to a nominal 3 s gust wind speed that should occur for less than 0.1% of the time. With reference to Figure 3, it is evident that the maximum 10-minute mean wind speed at Bankstown Airport exceeds the DCP conditions, and hence without any obstruction to accelerate the flow, the Liverpool area would not meet the conditions as stated in the DCP.

To address the above, this study is based upon the criteria of Lawson (1990), which are described in Table 1 for both pedestrian comfort and distress/safety. The benefits of the Lawson criteria from a comfort perspective is that the 5% of the time event is appropriate for a precinct to develop a reputation from the general public. The limiting criteria are defined for both a mean and gust equivalent mean (GEM) wind speed. 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. wind speed exceeded 5% of the time)	
<2 m/s	Outdoor dining
2 - 4 m/s	Pedestrian sitting (considered to be of long duration)
4 - 6 m/s	Pedestrian standing (or sitting for a short time or exposure)
6 - 8 m/s	Pedestrian walking
8 - 10 m/s	Business walking (objective walking from A to B or for cycling)
> 10 m/s	Uncomfortable
Distress/Safety (max. wind speed exceeded 0.022% of the time, twice per annum)	
<15 m/s	General access area
15 - 20 m/s	Acceptable only where able-bodied people would be expected; no frail people or cyclists expected
>20 m/s	Unacceptable

The wind speed is either an hourly mean wind speed or a gust equivalent mean (GEM) wind speed. The GEM wind speed is equal to the 3 s gust wind speed divided by 1.85.

4 ENVIRONMENTAL WIND ASSESSMENT

The development site is mostly surrounded by low-rise buildings, with the exception of the recently redeveloped Westfield Shopping Centre situated nearby to the north-west. Generally, the wind climate at the development site will largely depend on the size, orientation and proximity of future developments at nearby sites which will change the local wind patterns. The proposed building is taller than most surrounding buildings and may generate wind issues at ground level, however are less likely to eventuate due to potential shielding by future buildings in the vicinity of the development site. It is assumed that neighbouring future buildings will be similarly sized and therefore a wind assessment based on the current surrounding building layout is expected to be a conservative assessment.

Topography surrounding the development site is relatively flat from a wind perspective and unlikely to significantly affect the local wind climate.

Several wind flow mechanisms such as downwash and channelling flow that will be mentioned in the assessment are described in Appendix 1, and the effectiveness of some common wind mitigation measures are described in Appendix 2.

4.1 Ground Plane

4.1.1 Winds from the South-east

The proposed building, being taller than most surrounding buildings, will be exposed to unimpeded south-easterly winds that will impinge the south-east corner allowing quantities of wind to flow horizontally around the building while reducing downwash generated towards ground level. Winds with a stronger southerly component will downwash from the south façade and into the southern laneway. A benefit of the tower setbacks on levels 5 and 9, Figure 2, is a portion of the downwash from the east and south facades will be contained and redirected by the setbacks away from ground level laneways. Furthermore, the Elizabeth Street frontage will be considerably shielded from south-easterly winds by the proposed building. Therefore, it is expected the local wind environment surrounding the proposed building at ground level will not experience significant impacts and remain similar to the existing conditions.

4.1.2 Winds from the West

Westerly winds will flow largely unimpeded over the nearby low-rise buildings and impinge the west façade generating downwash towards ground level. Before reaching ground level, a quantity of the downwash will be redirected away from ground by the stepped tower setbacks, to an extent reducing the level of impact on the ground level wind environment.

Along the Elizabeth Street frontage, there is potential for downwash from the west façade to generate high wind speeds across the area near the fire stairs and booster pumps located to the north-west of the site, and on the south-west corner, Figure 4. As per the architectural drawings, this area is intended as a transient space for pedestrian traffic and expected wind conditions will be suitable for this use. It is also evident the building entrances are ideally located away from the building corners from a wind perspective.

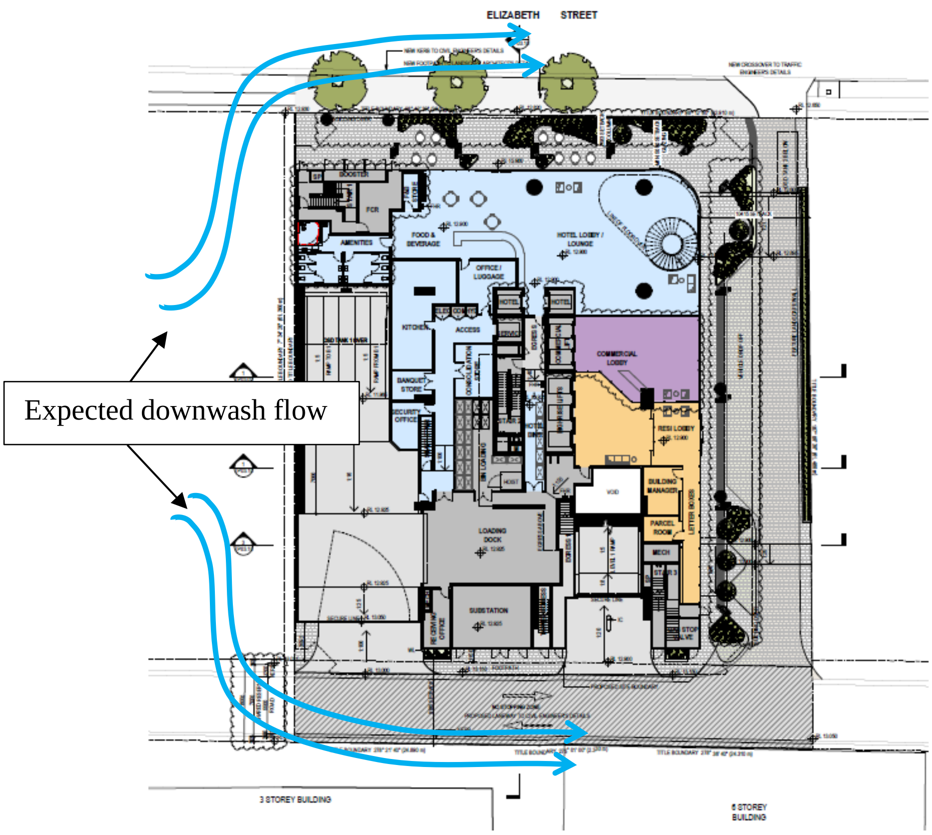

Figure 4: Representation of expected downwash during winds from the west.

Downwash from the west facade during winds from the west has potential to slightly intensify existing channelling winds along Elizabeth Street, however it is expected the impact will be minor. Thus, wind conditions with the addition of the proposed building are expected to remain similar to existing during westerly winds, suitable for transient pedestrian traffic.

4.1.3 Winds from the North-east

North-easterly winds will occur less frequently than in areas near the east coast as they dissipate further inland. Notwithstanding, the north-easterly winds will approach largely unimpeded over low-rise buildings and impact the north-east corner of the building, allowing a quantity of the winds to flow horizontally around the proposed building, thereby reducing downwash. A portion of any downwash generated on the north and east facades will be somewhat contained on the tower setbacks and redirected away from ground level. Thus, it is expected downwash generated by north-easterly winds will not significantly impact the existing wind environment surrounding the development site at ground level, where conditions are expected to remain similar to existing.

4.1.4 Summary of Ground Plane Wind Conditions

From a wind perspective, the proposed building is not expected to have any significant impacts to the existing wind conditions around most of the development site at ground level. With consideration of the probability of wind events from all directions, the wind conditions along the Elizabeth Street frontage and the laneways are likely to be classified as acceptable for pedestrian standing or walking under the Lawson comfort criteria, suitable for stationary short-term exposure activities such as bus stops or taxi ranks. The north-west and south-west corners of the site could experience accelerated flow due to downwash during westerly winds, however conditions are expected to remain suitable for transient pedestrian traffic. All locations surrounding the development site would be expected to satisfy the Lawson distress/safety criterion.

The footpath canopy along Elizabeth Street will help protect the immediate area underneath from some of the vertical downwash from the north façade. If there are intentions for the Elizabeth Street frontage at ground level to be used for long-term stationary activities, such as outdoor café seating, localised vertical screening coupled with landscaping would be recommended to help impede horizontal flows to a level that will allow use of the frontage for longer periods of time. It is evident in the latest architectural drawings that landscaping and vertical screening are proposed for seatings areas fronting Elizabeth Street

4.2 Wind Conditions within the Development

Some locations within the upper level terraces may experience high wind velocities due to downwash from the facades and unimpeded approach winds, which may necessitate local amelioration depending on how these areas are to be used.

Most of the Level 9 outdoor terraces will be exposed to horizontal approach winds. Evident in the provided architectural drawings, the seating areas within the terraces will be surrounded by landscaping and planter boxes that will help provide suitable wind conditions. It is recommended the landscaping and balustrades are as tall as possible as they will only protect a small area behind it up to its height. On the eastern side, a number of seating areas are located inset from the terrace which are expected to experience relatively calm conditions during horizontal wind flow.

The Level 9 terraces will also be susceptible to downwash from the facades, however the canopies above the terraces help shield the areas directly underneath.

It is understood that the Level 5 outdoor terrace will only be accessible for maintenance purposes.

The outdoor terraces on Levels 3 and 4, accessible to office staff, are expected to experience wind conditions suitable for short-term stationary activities due to their inset position preventing cross-flows. If calmer conditions are desired, employing temporary overhead cover would be recommended. This can be solid or slightly porous.

It is evident the private balconies throughout the development will be recessed from the building line and away from building corners reducing probability of strong cross-winds, where wind conditions are expected to be suitably calm for their intended purposes.

Plans to utilise double sliding or revolving doors at building entrances would be beneficial from a wind perspective as they will reduce the probability of internal pressure-driven flow within the internal space that can potentially cause stack effects within tower lift cores, discomfort to patrons and disrupt HVAC energy efficiencies. The double sliding doors at the residential lobby, evident in the architectural drawings, will help prevent stack effects within the lift shaft. Furthermore, it is not expected the commercial lifts will experience internal flow issues due to their relatively low heights. It should be noted various other factors other than wind will also influence the necessity of a double sliding or revolving door at building entrances.

5 CONCLUSION

Cermak Peterka Petersen Pty. Ltd. has provided a qualitative assessment of the impact of the proposed 26 Elizabeth Street project in Liverpool on the local wind environment in and around the development site. Being taller than most surrounding buildings, the proposed development is exposed to prevailing winds in the area, however due to the orientation and tower setbacks the proposed building is not expected to be have a significant impact on the existing wind conditions on the ground plane from a pedestrian comfort and safety perspective. Wind conditions on the ground plane in and around the development site are expected to be classified as acceptable for pedestrian standing or walking from a Lawson comfort perspective and pass the distress/safety criterion.

Local amelioration has been considered for areas intended for long-term stationary or outdoor dining style activities on the upper level outdoor terraces, in the form of localised vertical screening and landscaping, such as plantar boxes, to help achieve suitable wind conditions.

To quantify the wind conditions around the site, a wind-tunnel test would be recommended during detailed design.

6 REFERENCES

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.

Liverpool City Council (2008), “Liverpool Development Control Plan 2008 - Part 4 – Development in Liverpool City Centre”, 25 July 2014.

Melbourne, W.H., 1978, Criteria for Environmental Wind Conditions, Journal of Wind Engineering and Industrial Aerodynamics, Vol.3, No.2-3, pp.241-249.

Standards Australia (2011), Australian/New Zealand Standard, Structural Design Actions, Part 2: Wind Actions (AS/NZS1170 Pt.2).

Appendix 1: Wind flow mechanisms

When the wind hits a large isolated building, the wind is accelerated down and around the windward corners, Figure 5; this flow mechanism is called downwash and causes the windiest conditions at ground level on the windward corners and sides of the building. In Figure 5, smoke is being released into the wind flow to allow the wind speed, turbulence, and direction to be visualised. The image on the left shows smoke being released across the windward face, and the image on the right shows smoke being released into the flow at about third height in the centre of the face.

Techniques to mitigate the effects of downwash winds on pedestrians include the provision of horizontal elements, the most effective being a podium to divert the flow away from pavements and building entrances. Awnings along street frontages perform a similar function, and the larger the horizontal element, the more effective it will be in diverting the flow.

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

Figure 6 shows the wind at mid and upper levels on a building being accelerated substantially around the corners of the building. When balconies are located on these corners, they are likely to be breezy, and will be used less by the owner due to the regularity of stronger winds. Owners quickly become familiar with when and how to use their balconies. If the corner balconies are deep enough, articulated, or have regular partition privacy fins, then local calmer conditions can exist.

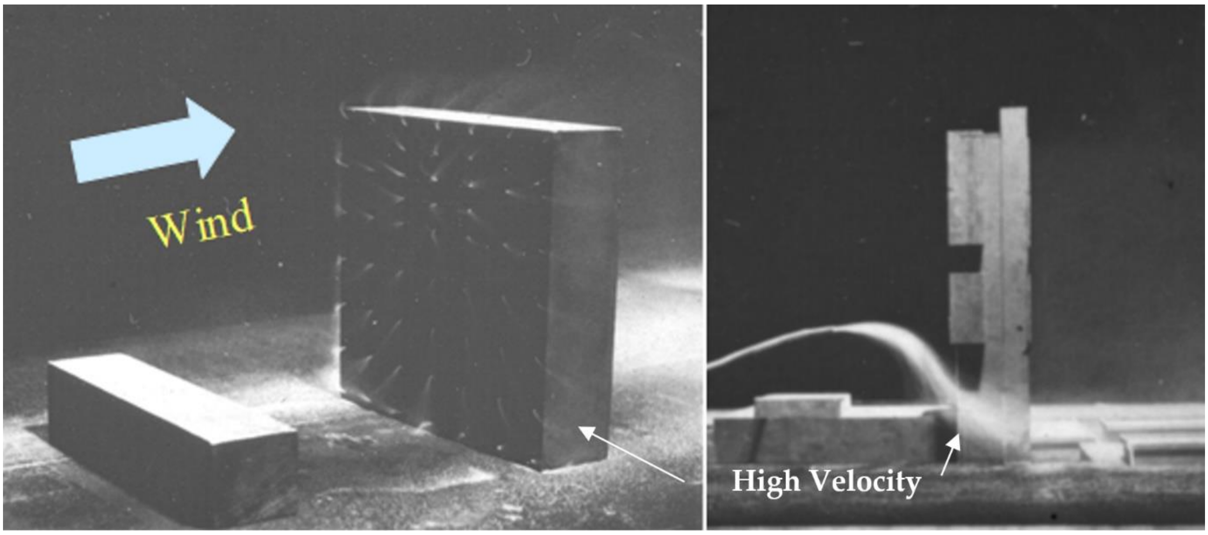

Figure 5: Flow visualisation around a tall building.

Figure 6: Visualisation through corner balconies (left) and channelling between buildings (right).

Appendix 2: Wind Impact Planning Guidelines

It is well known that the design of a building will influence the quality of the ambient wind environment at its base. Below are some suggested wind mitigation strategies that should be adopted into precinct planning guidelines and controls (see also Cochran, 2004).

Building form – Canopies

A large canopy may interrupt the flow as it moves down the windward face of the building. This will protect the entrances and sidewalk area by deflecting the downwash at the second storey level, Figure 7. However, this approach may have the effect of transferring the breezy conditions to the other side of the street. Large canopies are a common feature near the main entrances of large office buildings.

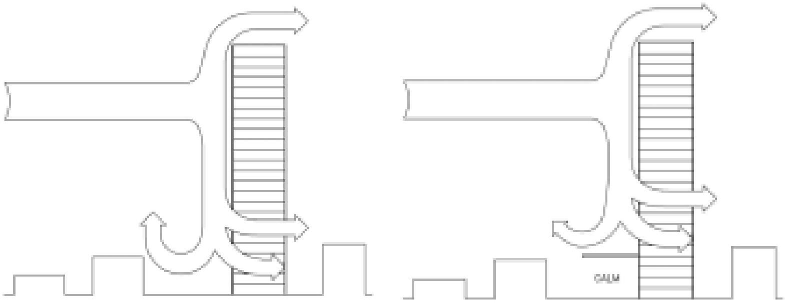

Figure 7: Canopy Windbreak Treatment. (left) Downwash to street level may generate windy conditions for pedestrians. This is particularly true for buildings much taller than the surrounding buildings. (right) A large canopy is a common solution to this pedestrian-wind problem at street level.

Building form – Podiums

The architect may elect to use an extensive podium for the same purpose if there is sufficient land and it complies with the design mandate, Figure 8. This is a common architectural feature for many major projects in recent years, but it may be counterproductive if the architect wishes to use the podium roof for long-term pedestrian activities, such as a pool or tennis court.

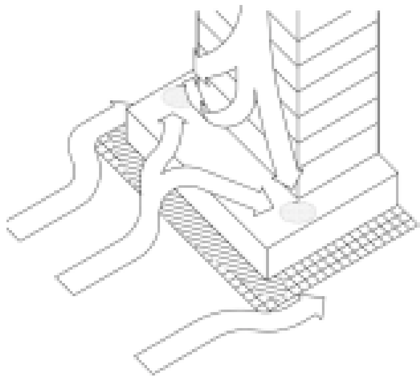

Figure 8: The tower-on-podium massing often results in reasonable conditions at ground level, but the podium may not be useable.

Building form – Arcades

Another massing issue, which may be a cause of strong ground-level winds, is an arcade or thoroughfare opening from one side of the building to the other. This effectively connects a positive pressure region on the windward side with a negative pressure region on the lee side; a strong flow through the opening often results, Figure 9. The uninvitingly windy nature of these open areas is a contributing reason behind the use of arcade airlock entrances (revolving or double sliding doors).

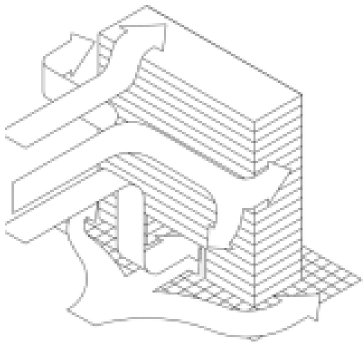

Figure 9: An arcade or open column plaza under a building frequently generates strong pedestrian wind condition.

Building form – Alcove

An entrance alcove behind the building line will generally produce a calmer entrance area at a mid-building location, Figure 10(left). In some cases, a canopy may not be necessary with this scenario, depending on the local geometry and directional wind characteristics. The same undercut design at a building corner is usually quite unsuccessful, Figure 10(right), due to the accelerated flow mechanism described in Figure 5 and the ambient directional wind statistics. If there is a strong directional wind preference, and the corner door is shielded from those common stronger winds, then the corner entrance may work. However, it is more common for a corner entrance to be adversely impacted by this local building geometry. The result can range from simply unpleasant conditions to a frequent inability to open the doors.

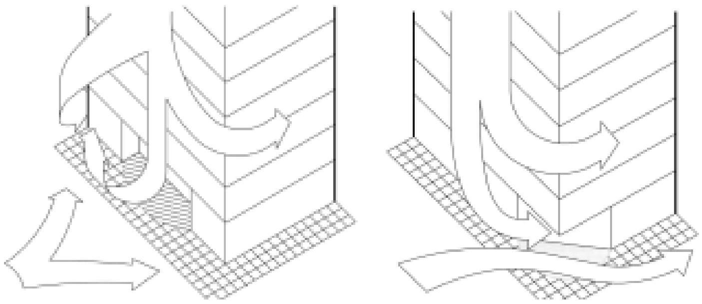

Figure 10: Alcove Windbreak Treatment. (left) A mid-building alcove entrance usually results in an inviting and calm location. (right) Accelerated corner flow from downwash often yields an unpleasant entrance area.

Building form – Façade profile and balconies

The way in which a building's vertical line is broken up may also have an impact. For example, if the floor plans have a decreasing area with increased height the flow down the stepped windward face may be greatly diminished. To a lesser extent the presence of many balconies can have a similar impact on ground level winds, although this is far less certain and more geometry dependent. Apartment designs with many elevated balconies and terrace areas near building ends or corners often attract a windy environment to those locations. Mid-building balconies, on the broad face, are usually a lot calmer, especially if they are recessed. Corner balconies are generally a lot windier and so the owner is likely to be selective about when the balcony is used or endeavours to find a protected portion of the balcony that allows more frequent use, even when the wind is blowing.

Use of canopies, trellises, and high canopy foliage

Downwash Mitigation – As noted earlier, downwash off a tower may be deflected away from ground-level pedestrian areas by large canopies or podium blocks. The downwash then effectively impacts the canopy or podium roof rather than the public areas at the base of the tower, Figure 8. Provided that the podium roof area is not intended for long-term recreational use (e.g. swimming pool or tennis court), this massing method is typically quite successful. However, some large recreational areas may need the wind to be deflected away without blocking the sun (e.g. a pool deck), and so a large canopy is not an option. Downwash deflected over expansive decks like these may often be improved by installing elevated trellis structures or a dense network of trees to create a high, bushy canopy over the long-term recreational areas. Various architecturally acceptable ideas may be explored in the wind tunnel prior to any major financial commitment on the project site.

Horizontally accelerated flows between two tall towers, Figure 6(right), may cause an unpleasant, windy, ground-level pedestrian environment, which could also be locally aggravated by ground topography. Horizontally accelerated flows that create a windy environment are best dealt with by using vertical porous screens or substantial landscaping. Large hedges, bushes or other porous media serve to retard the flow and absorb the energy produced by the wind. A solidity ratio (i.e. proportion of solid area to total area) of about 60-70% has been shown to be most effective in reducing the flow's momentum. These physical changes to the pedestrian areas are most easily evaluated by a model study in a boundary-layer wind tunnel.

References

Cochran L., (2004) Design Features to Change and/or Ameliorate Pedestrian Wind Conditions, Proceedings of the ASCE Structures Congress, Nashville, Tennessee, May 2004.