PEDESTRIAN WIND ENVIRONMENT STATEMENT

FIVEWAYS, CROWS NEST

WF803-02F02(REV0)- WS REPORT

DECEMBER 16, 2021

Prepared for:

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DOCUMENT CONTROL

Date	Revision History	Issued Revision	Prepared By (initials)	Instructed By (initials)	Reviewed & Authorised by (initials)
December 16, 2021	Initial.	0	TH	TH	TH

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EXECUTIVE SUMMARY

This report presents an opinion on the likely impact of the proposed development known as FiveWays, located in Crows Nest, on the local wind environment at the critical outdoor areas within and around the subject site. The effect of wind activity has been examined for the three predominant wind directions for the region, namely the north-easterly, southerly, and westerly winds. The analysis of the wind effects relating to the proposed development have been carried out in the context of the local wind climate, building morphology and land topography.

The conclusions of this report are drawn from our extensive experience in this field and are based on an examination of the latest architectural drawings. No wind tunnel testing has been undertaken for the subject development, and hence this report addresses only the general wind effects and any localised effects that are identifiable by visual inspection of the architectural drawings provided (received December 2021). Any recommendations in this report are made only in-principle and are based on our extensive experience in the study of wind environment effects.

The results of this assessment indicate that the subject development benefits from shielding provided by the subject and neighbouring buildings. There are however wind effects due to the interaction of the prevailing winds with the building morphology that can potentially impact the wind comfort and amenity on several of the outdoor trafficable areas within and around the site. It is expected that the wind effects identified in the report can be ameliorated with the consideration of the following treatment strategies into the design of the development:

- Ground Level Trafficable Areas:
    - Densely foliating street trees along the Falcon Street and Alexander Street and Pacific Highway frontages of the development; in particular around the corners of the development.
    - Impermeable awnings along the Falcon Street and Alexander Street and Pacific Highway frontages of the development.
    - Impermeable awnings above the street frontage entrance areas into the various laneways; in particular the entrance areas exposed to down-wash wind effects off the tower facade.
    - Baffle screening or densely foliating vegetation such as trees or shrubs/hedge planting (live or artificial) at the street frontage areas into the various laneways; in particular those from the Pacific Highway frontage of the site that are exposed to the prevailing southerly and westerly winds.
    - Localised wind mitigating devices such as densely foliating vegetation such as trees or shrubs/hedge planting (live or artificial), screening or pergolas within and around areas intended for short duration stationary activities such as outdoor seating etc.
    - Areas intended for short duration stationary activities such as outdoor seating are recommended to be restricted/situated away from the corners of the building as these areas highly susceptibility to adverse wind conditions such as accelerating flows around the building;

in particular the outdoor areas exposed to the prevailing southerly winds which are the strongest for the region.

- Podium Rooftop Communal Outdoor Areas
    - Areas intended for short duration stationary activities such as outdoor seating are recommended to be restricted/situated away from the corners of the proposed tower as these areas highly susceptibility to adverse wind conditions such as accelerating flows around the building; in particular the outdoor areas exposed to the prevailing southerly winds which are the strongest for the region.
    - Compartmentalising the podium areas or providing separation or gateways between different zones will provide opportunity to incorporate wind mitigation elements and an opportunity to provide areas where wind conditions are appropriate for stationary activities.
    - Impermeable balustrades along the perimeter edge of the outdoor trafficable areas; in particular between the proposed tower and along the southern and western boundaries.
    - The proposed planter areas along the perimeter edge of the various outdoor trafficable areas to be populated with densely foliating vegetation such as trees or shrubs/hedge planting; in particular along the southern and western boundaries of the podium.
    - Impermeable awnings along the western tower façade where the prevailing winds are likely to be down-washed onto the podium rooftop than side-stream along the tower.
    - Localised wind mitigating devices such as densely foliating vegetation in the form of trees or shrubs/hedge planting (live or artificial), screening or pergolas within and around areas intended for short duration stationary activities such as outdoor seating etc.
- Level 4-15 Open Tower Corridors:
    - Inclusion of tall impermeable balustrades at least 1.5m high along the southern perimeter edge of the tower corridors.
- Private Balconies:
    - Inclusion of impermeable intertenancy screens between the private balconies.
    - Inclusion of impermeable along the exposed perimeter edges of the private balconies.

With the inclusion of the abovementioned recommendations in the final design, it is expected that wind conditions for the various trafficable outdoor areas within and around the development will be suitable for their intended uses, and that the wind speeds will satisfy the applicable criteria for pedestrian comfort and safety. Nonetheless, wind tunnel testing is recommended to be undertaken at a more detailed design to quantitatively assess the wind conditions and to optimise the size and extent of the treatments required.

CONTENTS

1 INTRODUCTION

An opinion on the likely impact of the proposed design on the local wind environment affecting pedestrians within the critical outdoor areas within and around the subject development is presented in this report. The analysis of wind effects relating to the proposed development has been carried out in the context of the predominant wind directions for the region, building morphology of the development and nearby buildings, and local land topography. The conclusions of this report are drawn from our extensive experience in the field of wind engineering and studies of wind environment effects.

No wind tunnel testing has been undertaken for this assessment. Hence this report addresses only the general wind effects and any localised effects that are identifiable by visual inspection, and any recommendations in this report are made only in-principle.

2 DESCRIPTION OF DEVELOPMENT AND SURROUNDINGS

The site is located Crows Nest, and is bounded by Falcon Street to the north, Alexander Street to the east and the Pacific Highway to the south-east. The buildings surrounding the subject development are predominately low-rise residential and commercial buildings, with a few mid-rise apartment buildings further to the south along the Pacific Highway corridor. A survey of the land topography indicates a gradual decline in slope towards the east of the site.

An aerial image of the subject site and the local surroundings is shown in Figure 1, with the frequency and magnitude of the prevailing winds is superimposed for each wind direction.

The existing site consists of a cluster of 1-2 storey commercial/retail buildings forming a singular large development. The proposed development is comprised of singular fourteen high residential tower sitting atop of a common four storey high podium.

The critical outdoor trafficable areas associated with the proposed development, which are the focus of this assessment with regards to wind effects, are detailed as follows:

- Ground Level pedestrian footpaths and laneways.
- Podium rooftop communal outdoor area.
- Open tower lobbies.
- Private balconies.

Figure 1: Aerial Image of the Site Location and Prevailing Wind Directions

3 REGIONAL WIND

The Sydney region is governed by three principal wind directions that can potentially affect the subject development. These winds prevail from the north-east, south, and west. These wind directions were determined from an analysis undertaken by Windtech Consultants of recorded directional wind speeds obtained from the meteorological station located at Kingsford Smith Airport by the Bureau of Meteorology (recorded from 1995 to 2016). The data has been corrected to represent winds over standard open terrain at a height of 10m above ground level. The results of this analysis are presented in Figure 2 in the form of a directional plot of the annual and 5% exceedance mean winds for the region. The frequency of occurrence of these winds is also shown in Figure 2.

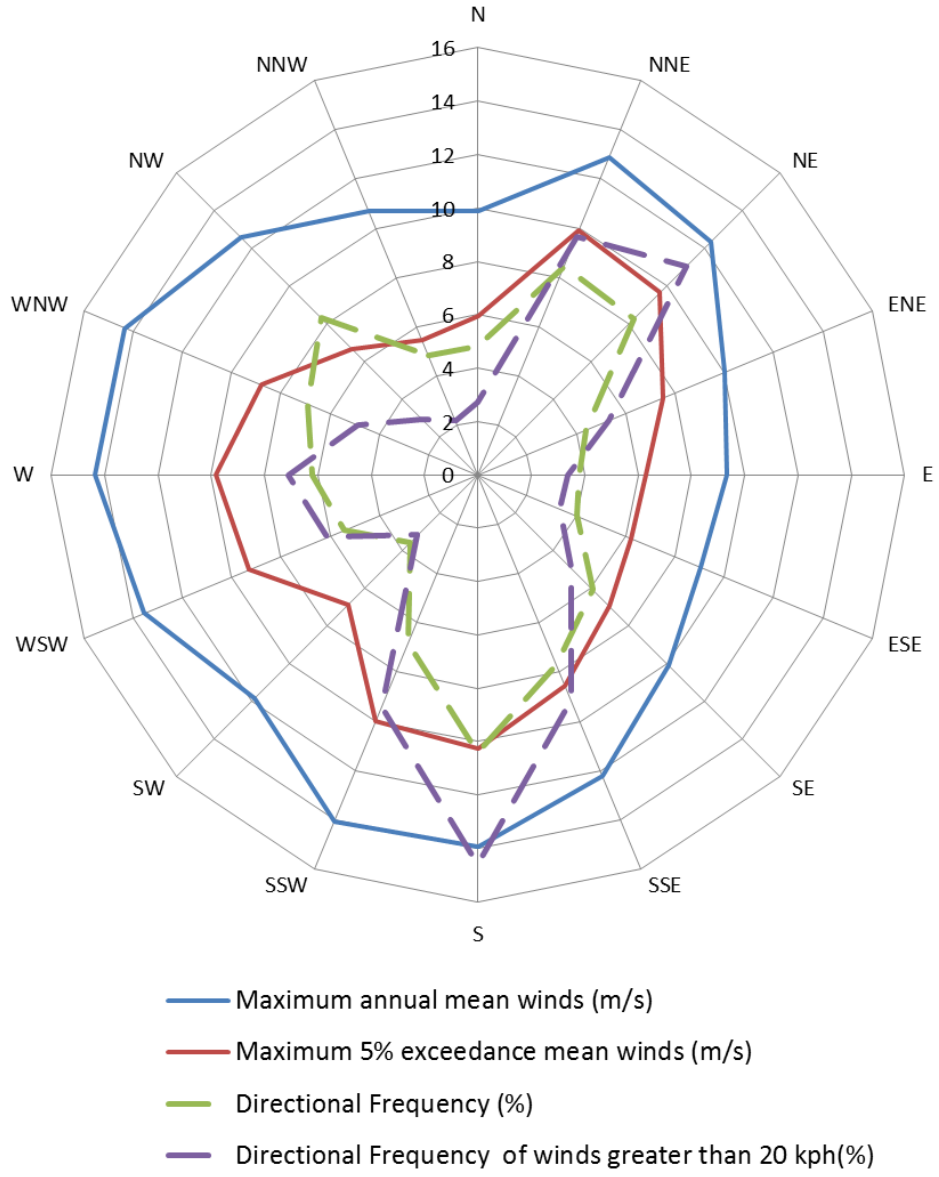

Figure 2: Directional Annual and 5% Exceedance Hourly Mean Wind Speeds (referenced to 10m height in standard open terrain), and Frequencies of Occurrence, for the Sydney Region

4 WIND EFFECTS ON PEOPLE

The acceptability of wind in any area is dependent upon its use. For example, people walking, or window-shopping will tolerate higher wind speeds than those seated at an outdoor restaurant. Various other researchers, such as A.G. Davenport, T.V. Lawson, W.H. Melbourne, and A.D. Penwarden, have published criteria for pedestrian comfort for pedestrians in outdoor spaces for various types of activities. Some Councils and Local Government Authorities have adopted elements of some of these into their planning control requirements.

For example, A.D. Penwarden (1973) developed a modified version of the Beaufort scale which describes the effects of various wind intensities on people. Table 1 presents the modified Beaufort scale. Note that the effects listed in this table refers to wind conditions occurring frequently over the averaging time (a probability of occurrence exceeding 5%). Higher ranges of wind speeds can be tolerated for rarer events.

Table 1: Summary of Wind Effects on People (A.D. Penwarden, 1973)

Type of Winds	Beaufort Number	Mean Wind Speed (m/s)	Effects
Calm	0	Less than 0.3	Negligible.
Calm, light air	1	0.3 – 1.6	No noticeable wind.
Light breeze	2	1.6 – 3.4	Wind felt on face.
Gentle breeze	3	3.4 – 5.5	Hair is disturbed, clothing flaps, newspapers difficult to read.
Moderate breeze	4	5.5 – 8.0	Raises dust, dry soil and loose paper, hair disarranged.
Fresh breeze	5	8.0 – 10.8	Force of wind felt on body, danger of stumbling
Strong breeze	6	10.8 – 13.9	Umbrellas used with difficulty, hair blown straight, difficult to walk steadily, wind noise on ears unpleasant.
Near gale	7	13.9 – 17.2	Inconvenience felt when walking.
Gale	8	17.2 – 20.8	Generally impedes progress, difficulty balancing in gusts.
Strong gale	9	Greater than 20.8	People blown over.

It should be noted that wind speeds affecting this particular development can only be accurately quantified with a wind tunnel study. This assessment addresses only the general wind effects and any localised effects that are identifiable by visual inspection and the acceptability of the conditions for outdoor areas are determined based on their intended use. Any recommendations in this report are made only in-principle and are based on our extensive experience in the study of wind environment effects.

5 RESULTS AND DISCUSSION

The expected wind conditions affecting the development are discussed in the following sub-sections of this report for the various outdoor areas within and around the subject development. The interaction between the wind and the building morphology in the area is considered and important features taken into account including the distances between the surrounding buildings and the proposed building form, as well as the surrounding landform. Note that only the potentially critical wind effects are discussed in this report. A glossary of the different wind effects described in this report included in Appendix A.

For this assessment, the wind speed criteria for pedestrian comfort that are considered are listed as follows:

- Comfortable Walking Criterion (7.5m/s to 8m/s with a 5% probability of exceedance) for general circulation and pedestrian thoroughfares, e.g. footpaths, private balconies/terraces, through-site links etc.

- Short Exposure Criterion (5.5m/s to 6m/s with a 5% probability of exceedance) for stationary activities generally less than an hour, e.g. waiting areas, communal terraces, main entries, café seating etc.

- Long Exposure Criterion (3.5m/s to 4m/s with a 5% probability of exceedance) for stationary activities longer than an hour, e.g. outdoor cinemas, outdoor fine dining etc.

Note that the lower end of the above ranges reflect the Davenport (1972) criteria and the upper end of these ranges reflect a modified Lawson (1975) criteria. Although this assessment is qualitative in nature, the abovementioned criteria for pedestrian comfort are considered when assessing the wind environment impacts. However, all areas are also assessed with consideration to a pedestrian safety criterion of 23m/s for the annual maximum gust.

5.1 Ground Level Areas

The subject development is surrounded by predominantly low-rise commercial/retail buildings varying between one to five storeys in height. The pedestrian footpaths and laneways within and around the site benefits from the partial shielding provided by these surrounding low- buildings and the subject development from direct wind effects; when these buildings are located upstream of the pedestrian footpath/laneways and prevailing wind directions. Down-wash wind effects off the building façade are expected to be minimal on the pedestrian footpaths due to tower setback from the podium edge and relatively narrow tower projections to the prevailing wind directions. There are however wind effects due to the interaction of the prevailing winds with the building morphology that can potentially impact the wind comfort and amenity on the various pedestrian footpaths and laneways. These are summarised as follows:

- The pedestrian footpath along the Falcon Street frontage of the site is potentially exposed to direct wind effects from the westerly direction travelling along the streetscape. This is due to east-west alignment of Falcon Street and side-streaming along the northern building facade. To a lesser extent is exposure to the prevailing north-easterly winds travelling over Alexander Street and side-streaming along the northern podium façade.

- The pedestrian footpath along the Alexander Street frontage of the site is potentially exposed to direct wind effects from the north-easterly and southerly directions travelling along the streetscape. This is due to north-south alignment of Alexander Street and side-streaming along the eastern podium facade.

- The pedestrian footpath along the Pacific Highway frontage of the site is potentially exposed to direct wind effects from the southerly direction travelling along the streetscape. This is due to north-south alignment of Pacific Highway and side-streaming along the south-western podium facade.

- The laneway connecting Falcon Street and Pacific Highway is potentially exposed to funnelling and gap wind effects as the prevailing north-easterly and southerly winds are directed into the laneway by the podium/tower façade respectively.

- The laneway connecting Alexander Street and Pacific Highway is potentially exposed to funnelling and gap wind effects as the prevailing north-easterly and westerly winds are directed into the laneway by the podium/tower façade respectively.

- The various intersections of the pedestrian footpaths and laneway entranceways are also susceptible to corner accelerations as the prevailing winds side-streaming along the podium façade and accelerating around the corners of the building morphology.

It should be noted the potential direct wind effects travelling along the various streets are an existing wind condition for the site due to the alignment of the streets along the prevailing wind directions.

It is expected the following treatment strategies to be effective in mitigating the abovementioned potential wind effects and enhance the local wind conditions along the various ground level pedestrian footpaths within and around the site, hence they are recommended to be considered in the design of the development:

- Densely foliating street trees along the Falcon Street and Alexander Street and Pacific Highway frontages of the development; in particular around the corners of the development.

- Impermeable awnings along the Falcon Street and Alexander Street and Pacific Highway frontages of the development.

- Impermeable awnings above the street frontage entrance areas into the various laneways; in particular the entrance areas exposed to down-wash wind effects off the tower facade.

- Baffle screening or densely foliating vegetation such as trees or shrubs/hedge planting (live or artificial) at the street frontage areas into the various laneways; in particular those from the Pacific Highway frontage of the site that are exposed to the prevailing southerly and westerly winds.

- Localised wind mitigating devices such as densely foliating vegetation such as trees or shrubs/hedge planting (live or artificial), screening or pergolas within and around areas intended for short duration stationary activities such as outdoor seating etc.

- Areas intended for short duration stationary activities such as outdoor seating are recommended to be restricted/situated away from the corners of the building as these areas highly susceptibility to adverse wind conditions such as accelerating flows around the building; in particular the outdoor areas exposed to the prevailing southerly winds which are the strongest for the region.

Densely foliating vegetation is to be of an evergreen species to ensure their effectiveness in wind mitigation throughout the year and the vegetation should be spaced such that the foliage is able to interlock between plants (where possible).

Due to the overall massing of the subject development and the complexity of the building form, wind tunnel testing is recommended to be undertaken as part of the detailed design phase. This will provide a quantitative analysis of the wind conditions and determine the requirement for wind mitigation measures; including the optimisation of the size and extent of the treatments required to ensure suitable wind conditions are achieved at all outdoor pedestrian accessible locations within and around the development.

5.2 Podium Rooftop Communal Outdoor Areas

The build form of the tower can provide some form of shielding to the communal outdoor areas re located downstream of the proposed tower and prevailing wind directions. There are however wind effects due to the interaction of the prevailing winds with the building morphology that can potentially impact the wind comfort and amenity on the podium rooftop. These are summarised as follows

- Direct wind effects from the prevailing wind directions due to the lack of shielding provided by the low-rise commercial/retail buildings on the surrounding streetscapes and the podium rooftop's elevated position.

- Corner wind effects around the corners of the proposed tower; in particular the corner outdoor areas that are exposed to the prevailing wind directions.

- Down-wash wind effects captured off the southern and western tower façades that are redirected onto the podium rooftop below.

It is expected the following treatment strategies to be effective in mitigating the abovementioned potential wind effects and enhance the local wind conditions on the podium rooftop, hence they are recommended to be considered in the design of the development:

- Areas intended for short duration stationary activities such as outdoor seating are recommended to be restricted/situated away from the corners of the proposed tower as these areas highly susceptibility to adverse wind conditions such as accelerating flows around the building; in particular the outdoor areas exposed to the prevailing southerly winds which are the strongest for the region.

- Compartmentalising the podium areas or providing separation or gateways between different zones will provide opportunity to incorporate wind mitigation elements and an opportunity to provide areas where wind conditions are appropriate for stationary activities.

- Impermeable balustrades along the perimeter edge of the outdoor trafficable areas; in particular between the proposed tower and along the southern and western boundaries.

- The proposed planter areas along the perimeter edge of the various outdoor trafficable areas to be populated with densely foliating vegetation such as trees or shrubs/hedge planting; in particular along the southern and western boundaries of the podium.

- Impermeable awnings along the western tower façade where the prevailing winds are likely to be down-washed onto the podium rooftop than side-stream along the tower.

- Localised wind mitigating devices such as densely foliating vegetation in the form of trees or shrubs/hedge planting (live or artificial), screening or pergolas within and around areas intended for short duration stationary activities such as outdoor seating etc.

Densely foliating vegetation is to be of an evergreen species to ensure their effectiveness in wind mitigation throughout the year and the vegetation should be spaced such that the foliage is able to interlock between plants (where possible).

It should be noted the abovementioned wind effects and treatment strategies are also applicable for potential communal outdoor areas located on the proposed tower. For these potential communal outdoor areas, an additional consideration into the design of these spaces is to restrict the outdoor trafficable areas away from the tower perimeter edge to minimise potential up-wash wind effects. Up-wash wind effects are less prevalent on the podium rooftop due to its relatively low position and low-level shielding from the surrounding buildings.

5.3 Levels 4-15 Open Tower Corridors

The open corridors benefit from the shielding provided by the subject building; however, it is potentially exposed to funnelling wind effects from the prevailing southerly direction. It is expected the inclusion of tall impermeable balustrades at least 1.5m high along the southern perimeter edge of the tower corridors, be effective in ameliorating the potential funnelling wind effect.

5.4 Private Balconies

The wind conditions within the various single aspect private balconies along the tower facades that are recessed into the build form are expected to be suitable for their intended uses due to the shielding provided by the tower build form that can create effective stagnation zones within the balconies. The inclusion of impermeable intertenancy screen between balconies and impermeable balustrades along the exposed perimeter edges are expected to be effective in further enhancing the local wind conditions, hence they are recommended to be considered in the final design of the development.

The corner balconies however are susceptible to stronger wind conditions due to their dual aspect nature and exposure direct wind effects and accelerating flows around the tower. The proposed design of the tower and corner balconies provide some form of mitigation to the corner acceleration wind effect. It is expected the inclusion of an impermeable balustrade along the exposed perimeter edge of the corner balconies to be effective in further enhancing the local wind conditions, hence they are recommended to be considered in the final design of the development.

As a general note, the use of loose glass-tops and light-weight sheets or covers (including loose BBQ lids) is not appropriate on high-rise outdoor balconies. Lightweight furniture is not recommended unless it is securely attached to the balcony floor slab.

6 REFERENCES

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APPENDIX A WIND EFFECTS GLOSSARY

A.1 Downwash and Upwash Effects

The downwash wind effect occurs when wind is deflected down the windward face of a building, causing accelerated winds at pedestrian level. This can lead to other adverse effects as corner acceleration as the wind attempts to flow around the building, as seen in Figure A.1.

This can also lead to recirculating flow in the presence of a shorter upstream building, causing local ground level winds to move back into the prevailing wind.

The upwash effect occurs near upper level edge of a building form as the wind flows over the top of the building. This has the potential to cause acceleration of winds near the leading edge, as well as potentially reattaching onto the roof area. This effect causes wind issues particularly near the leading edges of tall building and on the rooftop areas if there is sufficient depth along the wind direction. Upwash is more apparent in taller towers and podia.

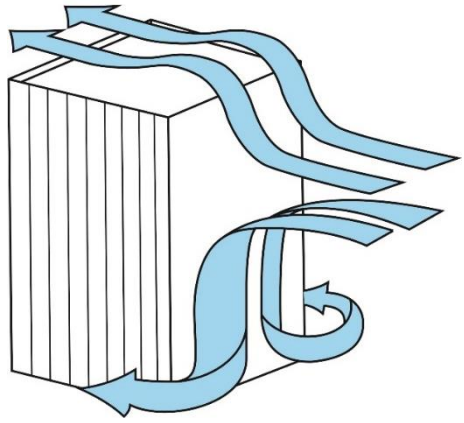

Figure A.1: Downwash Leading to Corner Wind Effect, and Upwash Effects

A.2 Funnelling/Venturi Effect

Funnelling occurs when the wind interacts with two or more buildings which are located adjacent to each other, which results in a bottleneck, as shown in Figure A.2. This causes the wind to be accelerated through the gap between the buildings, resulting in adverse wind conditions and pedestrian discomfort within the constricted space. Funnelling effects are common along pedestrian links and thoroughfares generally located between neighbouring buildings that have moderate gaps between them.

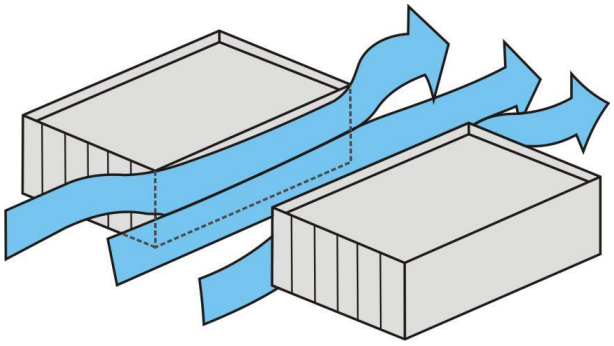

Figure A.2: Funnelling/Venturi Wind Effect

A.3 Gap Effect

The gap effect occurs in small openings in the façade that are open to wind on opposite faces, as seen in Figure A.3. This can involve a combination of funnelling and downwash effects. Presenting a small gap in the façade on the windward aspect as the easiest means through which the wind can flow through can result in wind acceleration through this gap. The pressure difference between the windward façade and the leeward façade also tends to exacerbate the wind flow through this gap.

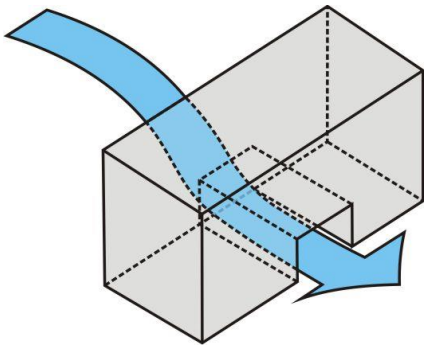

Figure A.3: Gap Wind Effect

A.4 Sidestream and Corner Effects

The sidestream effect is due to a gradual accumulation of wind shearing along the building façade that eventuates in an acceleration corner effect. The flow is parallel to the façade and can be exacerbated by downwash effects as well, or due to corner effect winds reattaching on the façade.

This is shown in Figure A.4. The corner refers to the acceleration of wind at the exterior vertical edge of a building, caused by the interaction of a large building massing with the incident wind, with the flow at the corner being accelerated due to high pressure differentials sets up between the windward façade and the orthogonal aspects. It can be further exacerbated by downwash effects that build up as the flow shears down the façade.

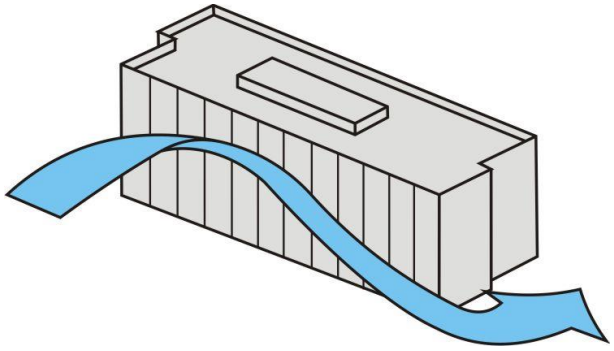

Figure A.4: Sidestream and Corner Wind Effect

A.5 Stagnation

Stagnation in a region refers to an area where the wind velocity is significantly reduced due to the effect of the flow being impeded by the bluff body. For a particular prevailing wind direction, this is typically located near the middle of the windward face of the building form or over a short distance in front of the windward face of a screen or fence. Concave building shapes tend to create an area of stagnation within the cavity, and wind speeds are generally low in these areas.