PEDESTRIAN WIND ENVIRONMENT STATEMENT

QUADRANGLE SITE, CASTLECRAG

WF735-02F01(REV2)- WS REPORT.DOCX

JULY 22, 2021

Prepared for:

Greencliff

Level 10/488 Kent Street

Sydney NSW, 2000

WINDTECH Consultants Pty Ltd
Head Office: 607 Forest Road, Bexley, NSW 2207, Australia
P +61 2 9503 0300 **E** reception@windtechglobal.com **W** www.windtechconsult.com

DOCUMENT CONTROL

Date	Revision History	Issued Revision	Prepared By (initials)	Instructed By (initials)	Reviewed & Authorised by (initials)
September 25, 2020	Initial.	WF735-01 (rev0)	MB	TR	BU
September 30, 2020	Updated treatment figure.	WF735-01 (rev1)	MB	TR	TR
July 09, 2021	Updated treatments.	WF735-02 (rev0)	AFM	TR	TR/BU
July 21, 2021	Updated treatments.	WF735-02 (rev1)	AFM	TR	BU
July 22, 2021	Typos.	WF735-02 (rev2)	AFM	TR	BU

EXECUTIVE SUMMARY

This report presents an opinion on the likely impact of the proposed Quadrangle development located at 100 Edinburgh Road, Castlecrag 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 has 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 prepared by FJMT and dated July 03, 2021. 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. 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 development has incorporated several design features and wind mitigating strategies and is expected to be suitable for the intended use for the majority of the outdoor trafficable areas. However, there are some areas that are exposed to the prevailing winds. 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

- Retention of the existing trees located to the north (Edinburgh Road) and to the south of the site.
- Inclusion of the proposed trees and landscaping along Edinburgh Road and throughout through-site link.
- Inclusion of the proposed trees at the south of the site.
- Inclusion of the proposed support columns along the northern façade of the development, ensuring that they are off-set from the façade by 0.15-0.25m.
- Inclusion of the proposed balustrades to either side of the lift enclosure at the south. These balustrades are recommended to be impermeable and 1.2m high.

Communal Rooftop Terrace

- Inclusion of the proposed perimeter landscaping, capable of growing to a height of 1.2-1.5m.

Private Balconies and Terraces

- Inclusion of the proposed standard height impermeable balustrades on corner balconies.

Note that for the landscaping to be effective in wind mitigation throughout the year, species are recommended to be of a densely foliating evergreen species.

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 their applicable criteria.

CONTENTS

1	Introduction	1
2	Description of the Development and Surroundings	2
3	Regional Wind	4
4	Wind Effects on People	5
5	Results and Discussion	6
	5.1 Ground Level Areas	6
	5.2 Communal Rooftop Terraces	9
	5.3 Private Balconies and Terraces	9
6	References	11
7	Appendix – Wind Effects Glossary	12
	7.1 Downwash and Upwash Effects	12
	7.2 Funnelling/Venturi Effect	12
	7.3 Gap Effect	13
	7.4 Sidestream and Corner Effects	13
	7.5 Stagnation	13

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.

Note that this report is based on the specific design as shown in the drawings of the planning proposal, prepared by FJMT and dated July 03, 2021. 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 THE DEVELOPMENT AND SURROUNDINGS

The site is located at 100 Edinburgh Road, Castlecrag, and is bounded by Edinburgh Road to the north, Eastern Valley Way to the west and low rise residential and commercial buildings to the south and east. The buildings surrounding the subject development are predominately low-rise residential and commercial buildings.

A survey of the land topography indicates minimal elevation changes along Edinburgh Road, however there is a south to north upward slope along Eastern Valley Way.

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 superimposed for each wind direction.

The existing site consists of a 1-2 storey retail building. The proposed redevelopment is a 3 storey mixed-use residential building with amenities.

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 trafficable areas and pedestrian footpath
- Communal rooftop terrace
- Private balconies and terraces

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 at 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 the winds over a standard open terrain at a height of 10m above ground level. Figure 2 shows a summary of this analysis in the form of a directional plot of the annual and 5% exceedance mean winds for the Sydney region. The frequency of occurrence of these winds is also shown in Figure 2.

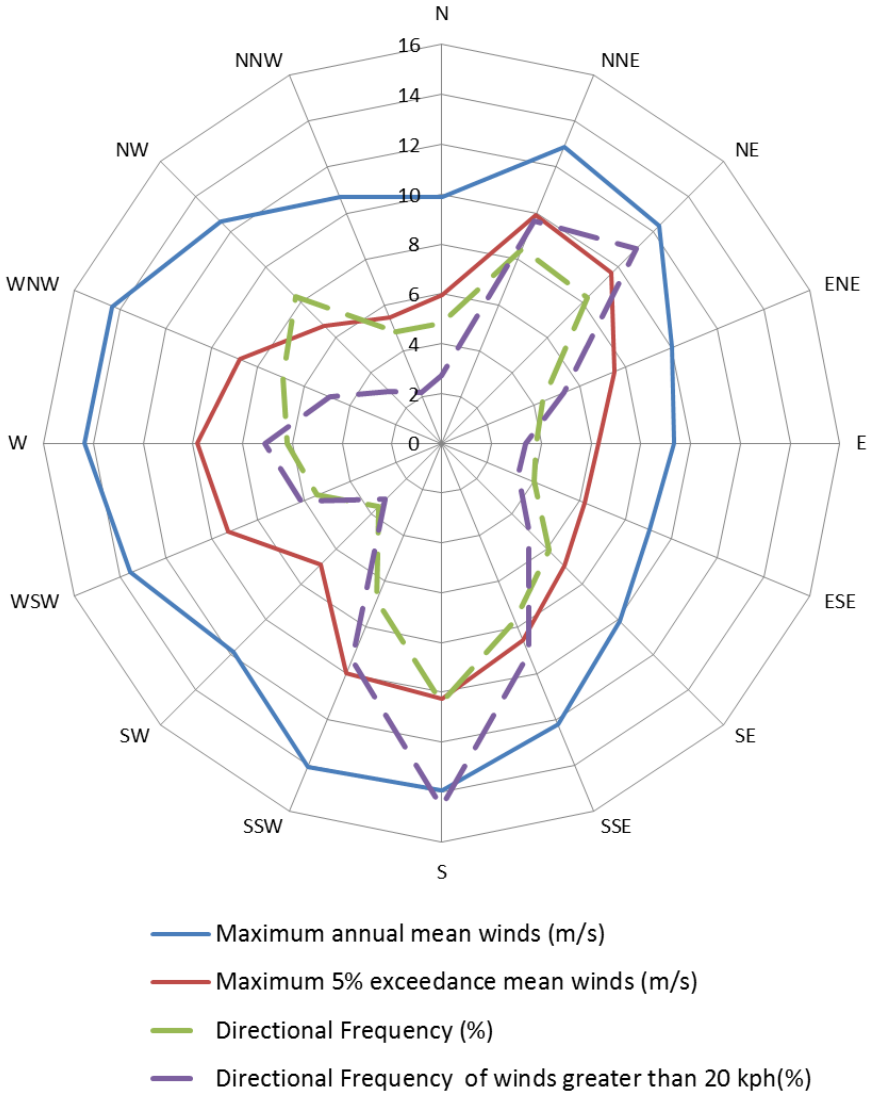

Figure 2: Annual and 5% exceedance hourly mean wind speeds, and frequencies of occurrence, for the Sydney region

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 refer 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 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 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 the Appendix section.

For this assessment, the wind comfort criteria that were considered as part of this assessment were the following:

- Comfortable Walking Criterion (7.5m/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 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 with a 5% probability of exceedance) for stationary activities longer than an hour, e.g. outdoor cinemas, outdoor fine dining etc.

Although this assessment is of a qualitative nature, the abovementioned comfort criteria are considered when assessing the wind environment impacts. All areas are also assessed with consideration of the 23m/s annual gust criterion for safety.

5.1 Ground level areas

The relatively low height of the development benefits the ground level locations by reducing the likelihood of increased downwash winds. As such, most of the trafficable areas and footpaths at ground floor are expected to be similar to existing conditions from a wind perspective. The pedestrian footpath along Edinburgh Road benefits from the proposed trees, landscaping and support columns along the northern façade. Due to the alignment of the streets with the prevailing winds, the development is susceptible to north-easterly and westerly winds side-streaming along the northern façade and footpath. As such, it is recommended to include the proposed street front trees, landscaping, and support columns. For the proposed lower level landscaping to be effective as a wind mitigation device, they should be of a densely foliating evergreen variety. The planting should be spaced such that the foliage is able to interlock between plants (where possible) to ensure its effectiveness during stronger winds.

Furthermore, the proposed street front trees within the site should be densely foliating, of an evergreen variety and capable of growing to a height of 3-6m high and wide.

The through-site link is likely to experience some funnelling effects from the prevailing southerly and north-easterly winds. The winds are expected to accumulate along the northern and southern façades before flowing into the through-site link. As such, it is recommended to include the proposed tree clusters along Edinburgh Road as well as at the south of the development. These trees, coupled with the proposed landscaping, will slow the prevailing winds as they enter the through-site link, mitigating much of the adverse winds within the area. Figure 3 shows the location of the treatments to be retained/included in the proposed design.

The pedestrian footpath along Eastern Valley Way is likely to experience adverse wind conditions from the prevailing southerly winds accelerating up the street towards the north-west corner of the site. The prevailing westerly winds are also expected to impact the Eastern Valley Way footpath by side-streaming along the western facing façade and flowing down the street. As such, it is recommended to retain the street front trees along the western side of the development. The north-western corner of the development is expected to experience corner acceleration from the southerly winds flowing from Eastern Valley Way onto the Edinburgh Road footpath. The columns around the north-western corner as well as along the northern façade are expected to assist in slowing the corner acceleration. These columns are recommended to be included in the final design with an off-set from the façade by 0.15-0.25m so that they act as baffle features for oncoming winds. These treatment measures are summarised below.

Ground Level Trafficable Areas

- Retention of the existing trees located to the north (Edinburgh Road) and to the south of the site.
- Inclusion of the proposed trees and landscaping along Edinburgh Road and throughout through-site link.
- Inclusion of the proposed trees at the south of the site.
- Inclusion of the proposed support columns along the northern façade of the development, ensuring that they are off-set from the façade by 0.15-0.25m.
- Inclusion of the proposed balustrades to either side of the lift enclosure at the south. These balustrades are recommended to be impermeable and 1.2m high.

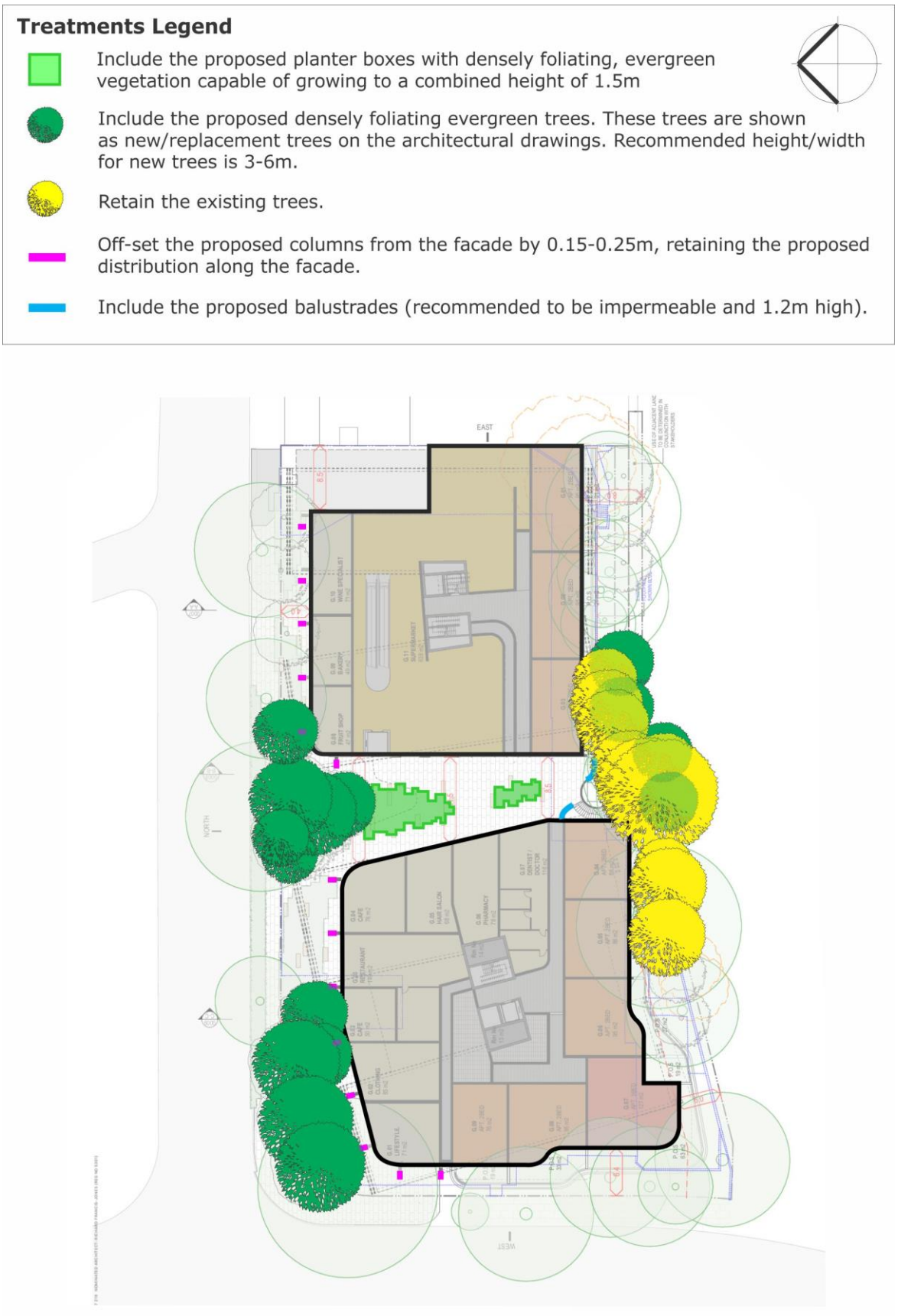

Figure 3: Recommended treatments – Ground level floor plan

5.2 Communal rooftop terraces

The communal rooftop terraces, located on Level 3 of the development, are exposed to the three prevailing winds. These communal terraces benefit from the perimeter landscaping which is likely to slow the direct impact of the prevailing westerly, north-easterly and southerly winds. Perimeter landscaping, as proposed and capable of growing to a height of 1.2-1.5m is recommended.

For the proposed landscaping to be effective as a wind mitigation device, it should be of a densely foliating evergreen variety. The planting should be spaced such that the foliage is able to interlock between plants (where possible) to ensure its effectiveness during stronger winds.

Further to the above, the proposed mechanical plant and photovoltaic panels are also expected to provide some level of protection to the communal roof top terraces.

5.3 Private balconies and terraces

The majority of the balconies of the development are expected to be suitable for their intended use due to the inclusion of various wind mitigation features such as their overall recessed design, impermeable balustrades, impermeable intertenancy screens, and full-height impermeable end screens. These features should be included in the final design.

The private balconies along the south of the site at ground floor and Level 1 are expected to be suitable for pedestrians, due to the shielding from adjacent buildings. The private balconies along the south of the site at Level 2, however, are likely to experience direct southerly impact. Furthermore, the southerly winds are expected to funnel via the through-site link between the two pavilions and out the ground floor passageway onto Edinburgh Road. The winds accelerating through this area may produce uncomfortable wind conditions, particularly if the area is intended for short-duration stay activities. The proposed trees at the south of the site are recommended to be included to slow the funnelling effect of the southerly winds. It is also recommended to retain the existing trees at the southern end of the site that are expected to provide shielding from the southerly winds to the Level 1 central private balconies.

The Level 1 outdoor spaces between the two pavilions of the development benefit from the shielding of westerly winds by the western pod. The low height of the pavilions on either side of the open spaces is unlikely to create strong funnelling effects and thus the wind conditions within this area are expected to be adequate for their intended use. Inclusion of the proposed 1.8m intertenancy screens is expected to provide further enhancements to the wind conditions within the area.

Due to the relative height and exposure of the subject development with the surrounding buildings, the majority of the balconies are unlikely to experience adverse wind conditions. However, careful attention must be made at the corners of the building form. The proposed

impermeable standard height balustrades are to be included for all corner balconies of the development.

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.

6 REFERENCES

Davenport, A.G., 1972, "An approach to human comfort criteria for environmental conditions". Colloquium on Building Climatology, Stockholm.

Lawson, T.V., 1973, "The wind environment of buildings: a logical approach to the establishment of criteria". Bristol University, Department of Aeronautical Engineering.

Lawson, T.V., 1975, "The determination of the wind environment of a building complex before construction". Bristol University, Department of Aeronautical Engineering.

Lawson, T.V., 1980, "Wind Effects on Buildings - Volume 1, Design Applications". Applied Science Publishers Ltd, Ripple Road, Barking, Essex, England.

Melbourne, W.H., 1978, "Criteria for Environmental Wind Conditions". *Journal of Wind Engineering and Industrial Aerodynamics*, vol. 3, pp241-249.

Penwarden, A.D. (1973). "Acceptable Wind Speeds in Towns", Building Science, vol. 8: pp259–267.

Penwarden, A.D., Wise A.F.E., 1975, "Wind Environment Around Buildings". Building Research Establishment Report, London.

7 APPENDIX – WIND EFFECTS GLOSSARY

7.1 Downwash and upwash effects

The downwash wind effect occurs when wind is deflected down the building's windward facade causing accelerated wind speeds 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 A1. This can also lead to recirculating flow in the presence of a shorter upstream building, causing the local ground level wind flow to move towards 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.

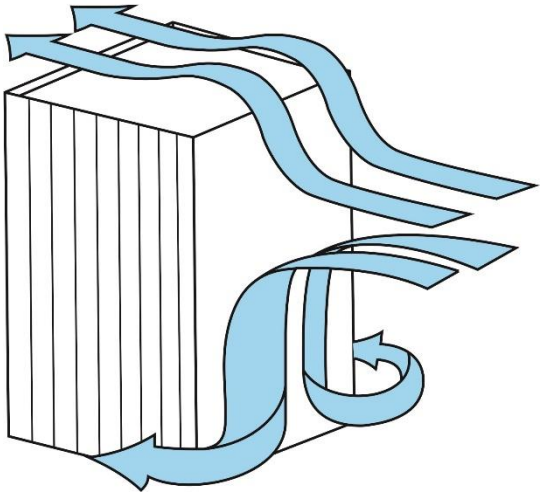

Figure A1: Downwash leading to corner wind effect, and upwash effects

7.2 Funnelling/Venturi effect

Funnelling effects occur when the wind interacts with two or more buildings which are located adjacent to each other and the building form design results in a bottleneck, as shown in Figure A2. This can cause the wind to be forced 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.

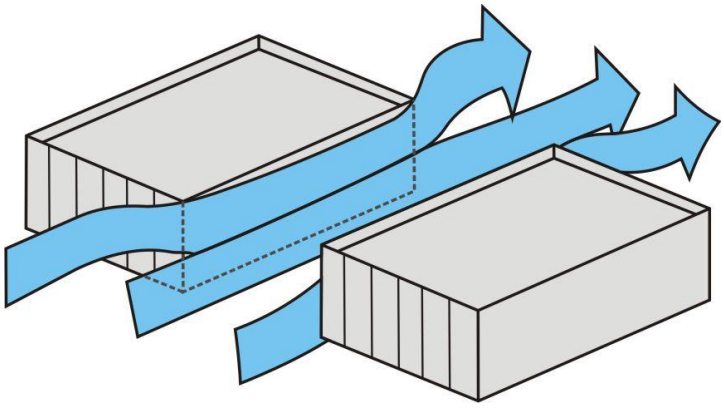

Figure A2: Funnelling/Venturi wind effect

7.3 Gap effect

The gap effect occurs in small openings in the façade that are open to wind on opposite faces, as seen in Figure A3. 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.

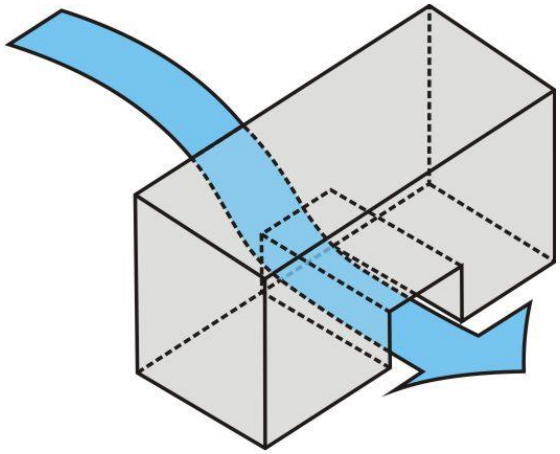

Figure A3: Gap wind effect

7.4 Sidestream and corner effects

The sidestream effect is due to a gradual accumulation of winds 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 A4

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.

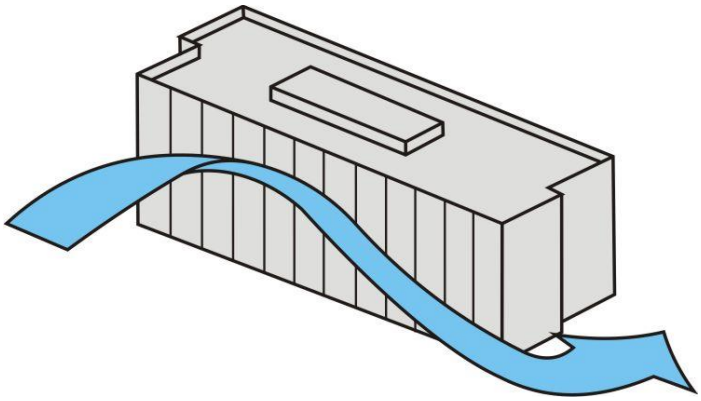

Figure A4: Sidestream and corner wind effect

7.5 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.