Pedestrian Wind Comfort Study

Adamstown Development – Blocks A, C & D

Project No. Q067

06th April 2022

OCSC
O'CONNOR | SUTTON | CRONIN
Multidisciplinary Consulting Engineers

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DOCUMENT CONTROL & HISTORY

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EXECUTIVE SUMMARY

This report outlines the predicted climatic wind conditions experienced within and surrounding the proposed Adamstown Development – Blocks A, C & D, located in Adamstown, County Dublin.

A conscious effort has been made by the design team during the design stages to mitigate the risk of localised increased wind speed conditions due to the proposed development. The introduction of mitigation measures, such as the courtyard locations, as well as the strategic location of extensive landscaping, all assist in reducing local increased wind speed and the negative impact on local climatic conditions.

Based on the CFD modelling results, the proposed development will be a comfortable environment for occupants. Some areas will present slightly higher wind speeds, however, they are in line with the activities that each area has been designed for. In addition, the incorporation of landscaping has been shown to mitigate excessive wind speeds in these areas.

Finally, the wind speed threshold for a certain pedestrian class is only meant to provide guidance on where to locate spaces where a certain type of activity is expected to be performed. In practice, the experience of the outdoor climate depends on more than just wind speed. Other factors such as clothing, air temperature, solar irradiation, age, and relative humidity must also be considered.

Overall, the proposed development will be a high-quality, comfortable environment for occupants and residents throughout the year.

PEDESTRIAN WIND COMFORT STUDY

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1. INTRODUCTION

The purpose of this report is to outline the predicted climatic wind conditions experienced within and surrounding the proposed Adamstown Development – Blocks A, C & D, located in Adamstown, County Dublin.

The proposed method for compliance validation is via the industry best practice standard for pedestrian comfort (Lawson Criteria). The Lawson Criteria sets acceptable levels of wind speed and velocities for various human activities.

Given the specific location of the building and recorded metrological data available for the area, and standard interpolation calculation procedures, it is possible to predict the expected wind speeds and their annual occurrence.

2. PROPOSED DEVELOPMENT

The proposed development consists of:

- A development to be constructed in 3no. blocks (known as Block A,C and D) ranging in height from 2 to 9 storeys including an ancillary residents Pavilion Amenity Building.
- 436no. apartments comprising 9no. studio units, 204no. 1-bedroom units, 213no. 2-bedroom units and 10no. 3-bedroom unit.
- Communal open space provided at podium and ground levels
- 220no. car parking spaces are to be provided in a mixture of on-street parking, podium and within the already permitted Block F multi-storey car park.
- The provision of 526no. bicycle parking spaces provided through stacked (416no. spaces) and Sheffield (110no. spaces) bicycle parking spaces.

The development also includes the provision of all ancillary site development and landscape works.

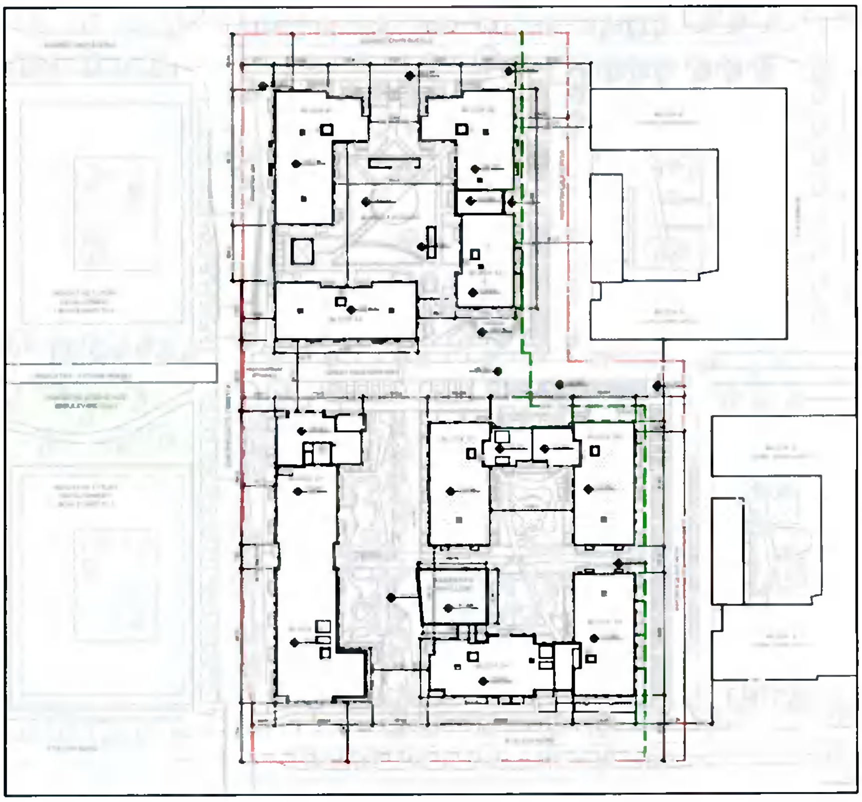

Figure 1: Proposed Site Plan

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3. PEDESTRIAN COMFORT COMPLIANCE

The Lawson criteria gives guidance to quantify the effect of wind velocity on pedestrian comfort and safety. The Lawson recommended guidance indicates that for the comfort and safety assessment of the wind environment, it is not only the velocity of wind that is considered, but also the frequency of occurrence of these velocities. The frequency of occurrences is used here as an indicator of the likely duration of certain wind speeds.

The Lawson criteria indicates that the threshold mean hourly wind speed for each pedestrian activity should not be exceeded for more than 5% of the time to maintain pedestrian comfort.

Pedestrian Activity	Threshold mean hourly wind speed not to be exceeded for more than 5% of the time [m/s]
Uncomfortable	> 10
Walking Fast	10
Walking Leisurely	8
Standing or Short-Term Sitting	6
Long-Term Sitting	4

Table 1: Lawson Criteria for Pedestrian Comfort

There are 2 no. additional classes to quantify the safety conditions for typical or sensitive (e.g. frail people or a cyclist) pedestrians which are summarised in Table 2.

Pedestrian Activity	Threshold mean hourly wind speed not to be exceeded for more than 0.023 % of the time [m/s]
Typical Pedestrian	20
Sensitive Pedestrian	15

Table 2: Lawson Criteria for Safety Assessment

4. ASSESSMENT METHODOLOGY

The methodology adopted for the study combines the use of Computational Fluid Dynamics (CFD) to predict air flow patterns and wind velocities around the proposed development. This is then combined with the use of wind data from the nearest suitable meteorological station as well as the recommended comfort and safety standards (The Lawson Criteria).

The study considered the following factors:

- The effect of the geometry, height and massing of the proposed development and existing surroundings on local wind speeds and directions;
- The wind speed as a function of the local environment - such as topography, ground roughness and nearby obstacles (buildings, bridges, etc.);
- The effects of site location (open field, inner city, etc.);
- Orientation of the buildings relative to the prevailing wind direction; and
- The pedestrian activity to be expected (long term sitting, standing or short term sitting, leisure and business walking).

The wind analysis focuses on the potential variation of the wind velocities from the reference wind data due at the proposed development.

4.1. EXTENT OF CFD STUDY AREA

The extent of the built area that is represented in the computational domain is dependent on the influence of the features on the region of interest which includes the site and its nearby surroundings.

The analytical CFD model of the development is assessed against the full Lawson Criteria to identify the pedestrian comfort and safety conditions surrounding the development.

The analytical CFD model has been constructed based on the information provided below:

- 3D model and AutoCAD plans, as received from Henry J Lyons Architects;
- Landscape plans as received by Camlins Landscape Architects;
- Topographical survey drawings of surrounding buildings;
- Available aerial photographic data via Google Maps;
- Meteorological wind data for Casement Aerodrome.

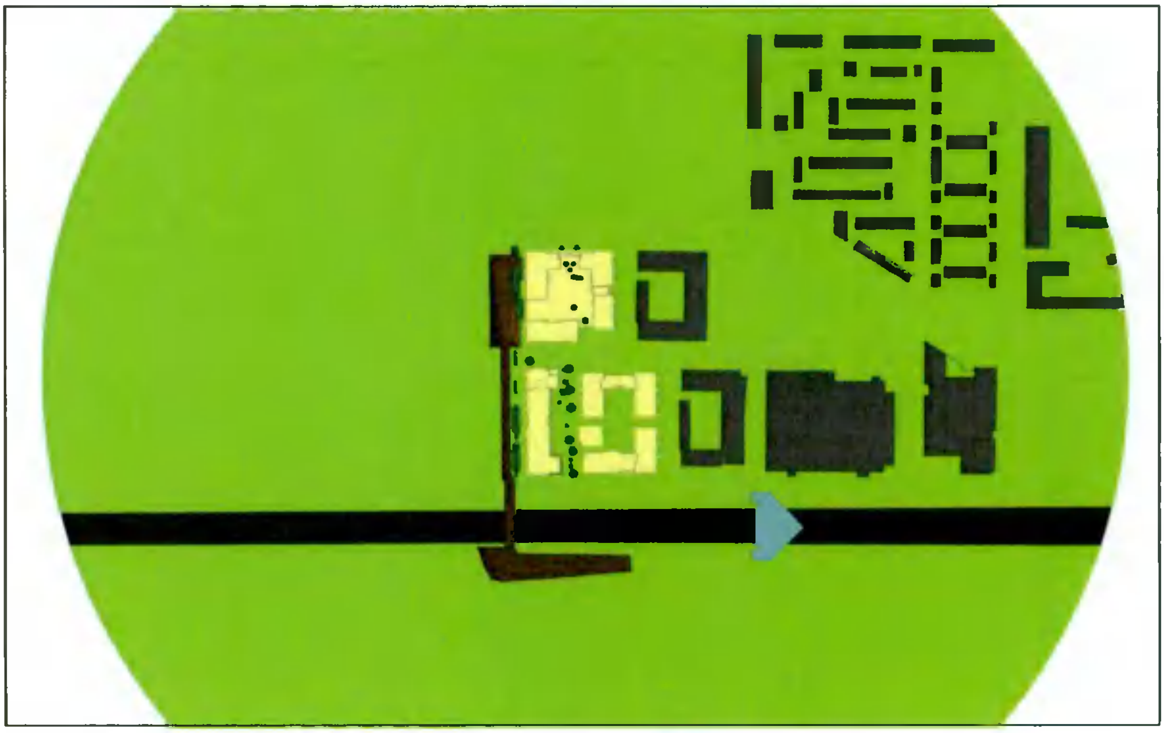


Figure 2: Extent of CFD Study Area

4.2. WIND CLIMATE

The wind climate analysis is based on the wind data obtained from the Casement Aerodrome weather station which incorporates hourly wind data over a 30-year period (1990 to 2020) outlined on the data in Table 3.

Wind dir.	N	NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW	Total	Total
	0	30	60	90	120	150	180	210	240	270	300	330		
Speed [m/s]	[hrs]	[hrs]	[hrs]	[hrs]	[hrs]	[hrs]	[hrs]	[hrs]	[hrs]	[hrs]	[hrs]	[hrs]	[hrs]	(%)
0-1	19	16	20	21	17	17	18	20	23	26	18	14	229	2.61
1-2	51	63	108	109	65	59	76	90	100	107	63	48	939	10.72
2-3	46	51	125	139	63	56	85	136	169	130	59	50	1109	12.66
3-4	40	41	108	138	53	47	75	177	224	145	65	44	1157	13.21
4-5	25	30	91	109	41	38	68	221	263	142	59	32	1119	12.77
5-6	16	21	62	84	40	30	65	255	275	131	45	21	1045	11.93
6-7	8	14	34	48	27	23	54	247	230	98	25	12	820	9.36
7-8	4	8	19	30	18	18	48	228	203	77	15	5	673	7.68
8-9	1	5	10	17	11	13	37	202	176	60	7	2	541	6.18
9-10	0	2	4	10	6	9	31	150	118	41	3	1	375	4.28
10-11	0	1	2	4	4	6	27	107	80	28	2	0	261	2.98
11-12	0	1	1	2	2	4	22	73	53	19	1	0	178	2.03
12-13	0	0	0	1	2	3	16	52	34	12	0	0	120	1.37
13-14	0	0	0	0	1	2	9	31	18	6	0	0	67	0.76
14-15	0	0	0	0	0	1	7	18	11	4	0	0	41	0.47
15-16	0	0	0	0	0	1	5	12	6	2	0	0	26	0.30
16-17	0	0	0	0	0	1	2	7	2	1	0	0	13	0.15
17-18	0	0	0	0	0	0	1	2	1	0	0	0	4	0.05
18-19	0	0	0	0	0	0	2	2	1	0	0	0	5	0.06
19-20	0	0	0	0	0	0	0	1	0	0	0	0	1	0.01
Total (hrs)	210	253	584	712	350	328	648	2031	1987	1029	362	229	8760	100%
Total (%)	2.40	2.89	6.67	8.13	4.00	3.74	7.40	23.18	22.68	11.75	4.13	2.61	100%	

Table 3: Frequency of Wind Velocity Occurrence per Wind Direction

Figure 3 graphically illustrates the data in Table 3 above and illustrates the percentage of hours per wind direction over the 30 year period (1990 – 2020) for the 12 no. wind directions. It is evident from the figure below the predominant wind directions are SSW, WSW and W.

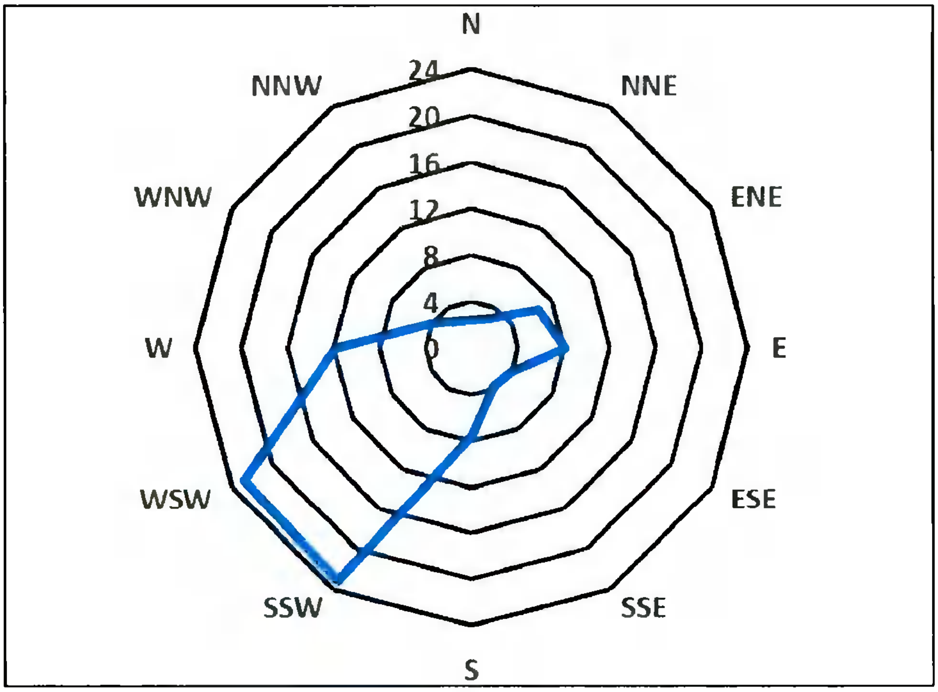


Figure 3: Percentage of Hours per Wind Direction over 30 years

The hourly wind data is the basis for the wind climate analysis. The number of hours that wind occurs from a given wind direction and velocity influences the local wind climate. The CFD simulation is used to calculate the wind-factor (local wind velocity relative to reference wind velocity). The wind-factor is a measure to calculate the number of hours that a given threshold wind velocity is exceeded based on statistical wind data.

4.3. WIND PROFILE

A rectangular computational domain was created to simulate the effect of the atmospheric boundary layer surrounding the region of interest. The extents of the computational domain are illustrated in Figure 4, where H is the height of the highest block within the proposed development.

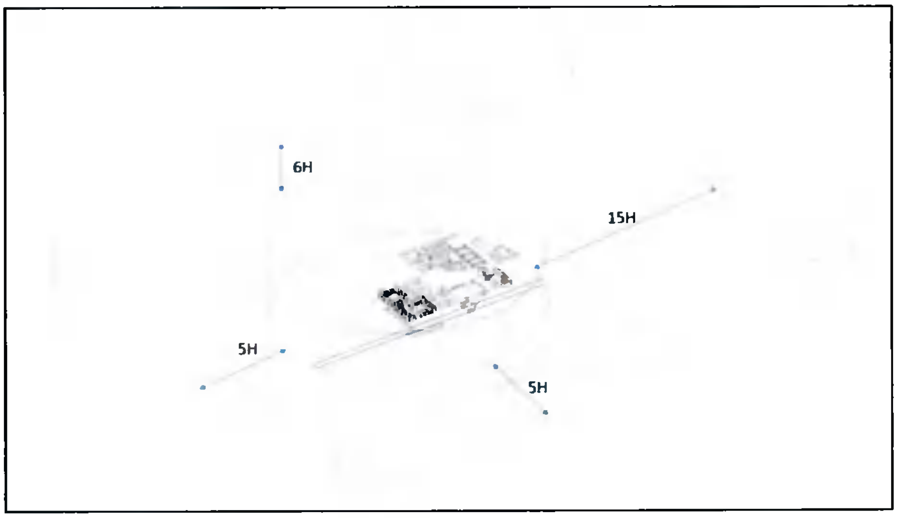


Figure 4: Computational Domain Surrounding the Region of Interest

An atmospheric boundary layer wind profile (v_{wind}) is applied to the boundaries of the computational model. To incorporate the effect of small height differences and small objects at street level, which are not explicitly included in the model, a roughness has been applied to the ground surface of the detailed CFD model. For the wind profile a roughness length (z_0) of 0.4 m has been estimated.

Based on the reference velocity, reference height, and roughness length, a wind profile can therefore be defined. The wind profile v_{wind} is defined as follows:

$$v_{wind} = v_{ref} \cdot \left(\frac{\ln\left(\frac{z}{z_0}\right)}{\ln\left(\frac{z_{ref}}{z_0}\right)} \right)$$

Where

v_{wind}	Wind velocity	[m/s]
v_{ref}	Reference velocity	[m/s]
z	Height above the ground	[m]
z_0	Roughness length	[m]
z_{ref}	Reference height	[m]

4.4. WIND FACTOR

The CFD simulations are used to calculate the wind factor. The wind factor is a factor which indicates if the wind speed is locally increased (wind factor > 1.0) or decreased (wind factor < 1.0) due to buildings (or other geometry), relative to the applied reference wind speed at 10m height. The wind factor is independent of the magnitude of the reference wind speed at 10m height, making the obtained wind factor valid for all wind speeds in a specific wind direction range. Hence, one simulation can be applied per wind direction covering all wind speeds in this direction.

To explain the wind factor in more detail, the wind factor results for the 0 - degree wind direction (i.e. North) are illustrated in Figure 5. The wind factor arrows that are coloured green, cyan or dark blue indicate that the local wind speed has been reduced (wind factor < 1.0), while wind factor arrows which are coloured light green/yellow indicate the local wind speed has increased (wind factor > 1.0). Using the wind factors, the quantity of hours that a wind speed is exceeded can be calculated (per wind direction) which is then used to assess compliance against the Lawson Criteria.
The wind factor results for all 12 no. wind directions are included in Appendix A.

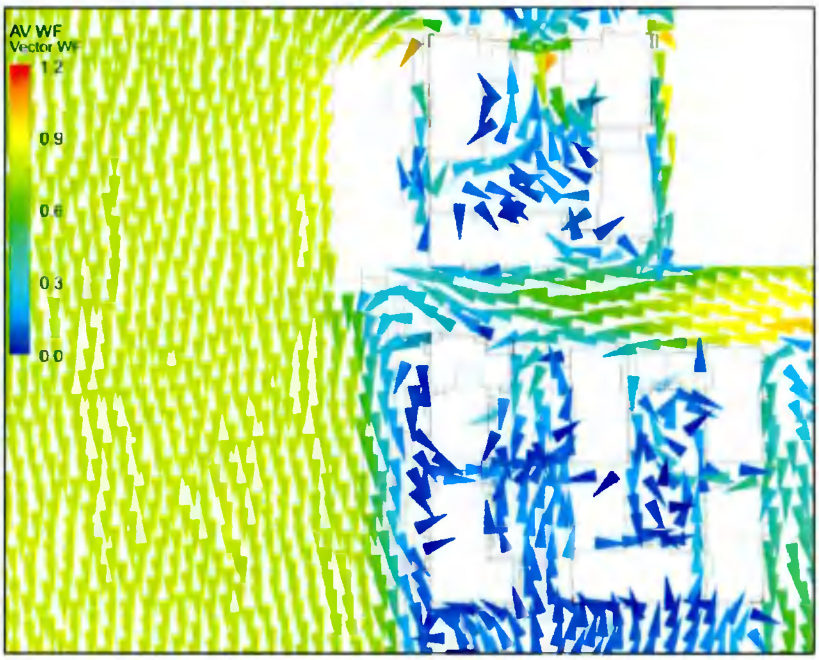


Figure 5: Wind Factor – 0 Degree (N) Wind Orientation

4.5. CFD MODELLING

The CFD simulation has been performed using the software package ANSYS CFX version 2021 version R1. This software package can be used for a large range of applications and has been extensively validated.

A full 3D CFD model of the proposed development and surrounding buildings was created and split into a large number of control volumes or cells. The standard equations for fluid motion and energy transport are applied to each cell. The equations are then solved using numerical techniques. The CFD settings used for the analysis are summarised in Table 4.

CFD settings	Description
Grid type	Hybrid, mixture of tetrahedrons, pyramids and prisms
Cell size	Dynamic, ranging from 0.025 up to 2 m at the building surfaces and streets, growing with a factor of 1.05 to a maximum of 10 m in the volume
Number of cells	50 million
Simulation type	Steady state
Convergence	RMS maximum $1 \cdot 10^{-4}$
Simulation time	2.5 s
No. iterations	1000
Fluid	Air fixed properties
Turbulence model	RANS, RNG Kappa-Epsilon model
Walls	Smooth, no slip
Wind volume	Profile for velocity and turbulence
Roughness	Volumetric sources for momentum and turbulence
Vegetation	Volumetric loss coefficient

Table 4: Summary of CFD Model Settings

5. ASSUMPTIONS AND LIMITATIONS

Computational Fluid Dynamic (CFD) is a widely recognised method for modelling airflow problems and as computer power develops, it increasingly improves its applicability. However, there are some limitations with CFD in relation to the modelling of wind environments. The method uses mean hourly wind values and presents a limitation to capture gusts.

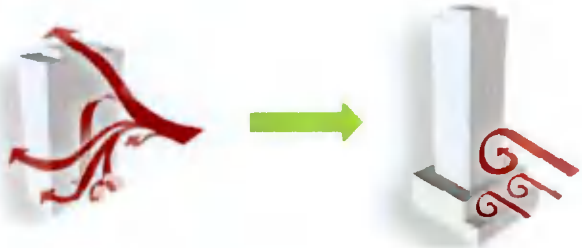
The Lawson criteria for pedestrian comfort focus on the effect of wind and do not factor in other environmental variables such as air temperature, solar radiation and relative humidity. However, overlaying all these factors would be a complex process and Lawson's simplified method presents the best available methodology for anticipating wind effects in the built environment.

The buildings were modelled as blocks, i.e. with smooth surfaces and sharp corners, which is generally sufficient detail to represent buildings in airflow modelling. This assumption is industry accepted as further detail to the model such as the window reveals and façade texture would add an impractical and unnecessary complexity to the model without adding greater quality results. Landscaping features such as small trees or hedges were not modelled within the simulation as they would provide an extra level of complexity to an otherwise large CFD model. Furthermore, a limited number of trees and hedges were modelled locally to prove their impact on mitigating wind speeds. Incorporating all trees and hedges would be impractical on a model this size.

6. WIND MITIGATION MEASURES

The following are common strategies to mitigate excessive wind speeds associated with building developments[1].

- When wind hits the windward face of a building, the building deflects the wind downwards (downwashing), causing accelerated wind speeds at pedestrian level and around the corners of the building. By introducing a base building or podium, the downward wind flow can be deflected, resulting in a reduction of wind speed at pedestrian level.



- When the leeward face of a low building faces the windward face of a tall building, it causes an increase in the downward wind flow. By landscaping the base building roof, wind speeds can be further reduced.

- Wind speed is accelerated when wind is funneled between two buildings. A horizontal canopy on the windward face of a base building can improve pedestrian comfort conditions.

[1] *Pedestrian Wind Comfort and Safety Studies,* (City of Mississauga, 2014).

The following specific mitigation measures have been incorporated into the proposed design to prevent excessive wind speeds.

6.1. LANDSCAPING

The landscaping has been strategically designed to mitigate increased wind speeds and to provide shelter for pedestrians at street level and in the central courtyard areas. The landscaping design incorporates covered and sheltered seating, hedge and raised planters as wind breakers and sheltered seating pockets to act as wind mitigation measures.

The proposed landscaping design is illustrated in Figure 6. Trees are to be planted close to primary entrance ways and along the streetscape, aiding to mitigate excessive wind speeds and also providing shelter for pedestrians at street level. The use of trees and low-level shrubs all assist in the localised reduction of wind speed.

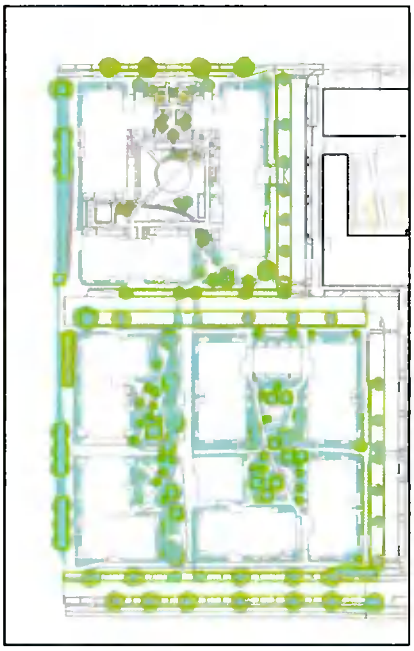


Figure 6: Wind Mitigation Measure – Landscaping Design

7. PEDESTRIAN COMFORT RESULTS

The number of hours for all wind directions are summed to calculate the total number of hours that a given pedestrian activity class exceeds the 5% yearly threshold. The results are shown below in Figure 7. The classification of the classes stated in this report are based on a hierarchy of wind speed. The principle is that the "long term" sitting represents minimum wind speeds and all classes above that represent higher expected wind speeds. It must be noted that when a space is classified under an activity class, the space will also achieve all activity classes above it in the hierarchy scale. As an example, if a space is classified as "sitting short" class, the space by default will also achieve the standard of "walking leisurely" and "walking fast". Also, it must be noted that a pedestrian activity class is only a statistical assessment of the local wind climate. When a region is classified as a certain class (e.g. short sitting), this does not mean that one can never sit there for a long time. It only means that for more than 5% of the time (per year), the wind speed for this activity could result in an uncomfortable surrounding. However, during the remaining times of a given year, this activity will be classified as comfortable. Though a small area within one of the central areas is classified as uncomfortable, additional landscaping has been included i.e. trees to the Southwest of the courtyard in Block A in order to further reduce the higher wind speeds observed in this area.

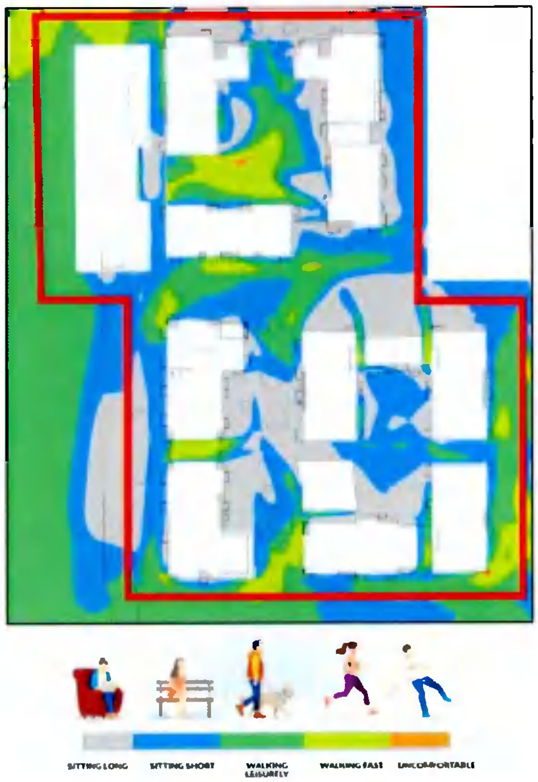


Figure 7: Pedestrian Wind Comfort Results
(Approximate extent of site outlined in red)

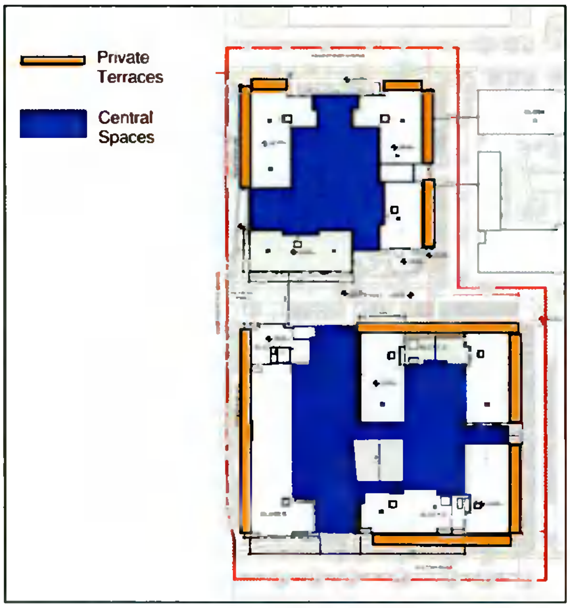


Figure 8: Main Pedestrian Wind Comfort Activity Areas

The results of the simulations are explained as follows:

- **Central Spaces:** The landscape design of the central 'breakout' spaces have been designed as short term sitting, in line with wind classes. The results have shown that the majority of the courtyard spaces can be classified as "short-term sitting". In areas that demonstrated higher wind speeds than required to be classified as "short term sitting", further mitigation measures were incorporated at key locations in order to further reduce the wind speeds observed. These additional measures include further incorporation of evergreen trees to the southwest corner of the courtyard of Block A as well as along the southern areas of Blocks C & D. Therefore, as previously stated, these spaces will be comfortable for short-term sitting and also for all activity classes above it in the hierarchy scale.

Following on from the above summary, it should also be noted that a pedestrian activity class is only a statistical assessment of the local wind climate. When a region does not meet a certain criterion (e.g. sitting), this does not mean that one can never do this activity in this region. It only means that for more than 5% of the time per year, the wind speed for this activity has been exceeded. For the remainder of time in the year, this activity is considered possible. For this reason, the percentage of time that "Standing or Short Term Sitting" is comfortable is illustrated in Figure 9 below.

It is evident from this image that "Standing or Short Term Sitting" is comfortable for more than 90% of the year on the vast majority of the central areas. However, as also outlined above, landscaping features such as small trees and hedging were not modelled due to the complexity they would add to the CFD model. The landscaping design will aid in ensuring that the areas which exceed the pedestrian classes will be comfortable spaces and will mitigate excessive wind speeds.

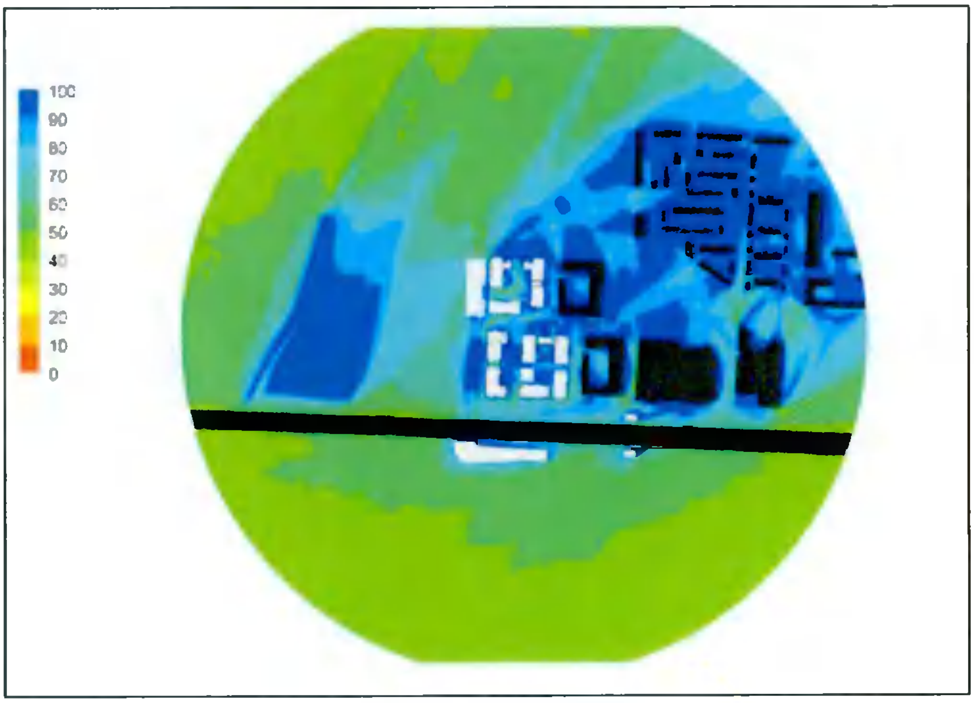


Figure 9: Percentage of Time per Year that Standing or Short-Term Sitting is Comfortable

Finally, the wind speed threshold for a certain pedestrian class is only meant to provide guidance on where to locate areas where a certain type of activity is expected to be performed. In practice, the experience of the outdoor climate depends on more than just wind speed. Other factors such as clothing, air temperature, solar irradiation, age and relative humidity must also be considered.

Private Balconies:

All balconies with the exception of some minor areas in a number of balconies have been classified for "sitting short". Therefore, all balconies are comfortable with the wind speeds for typical pedestrian comfort. In addition, they have been assessed based on the safety criteria with the most stringent condition being considered, i.e. "sensitive" (please refer to Table 2). Based on the sensitive class, all private balconies are considered safe as illustrated in Figure 10. Additionally, as part of the balcony assessment for wind speeds obtained, a glass balustrade solution will incorporated at key balcony locations in order to achieve a safe level of wind speeds.

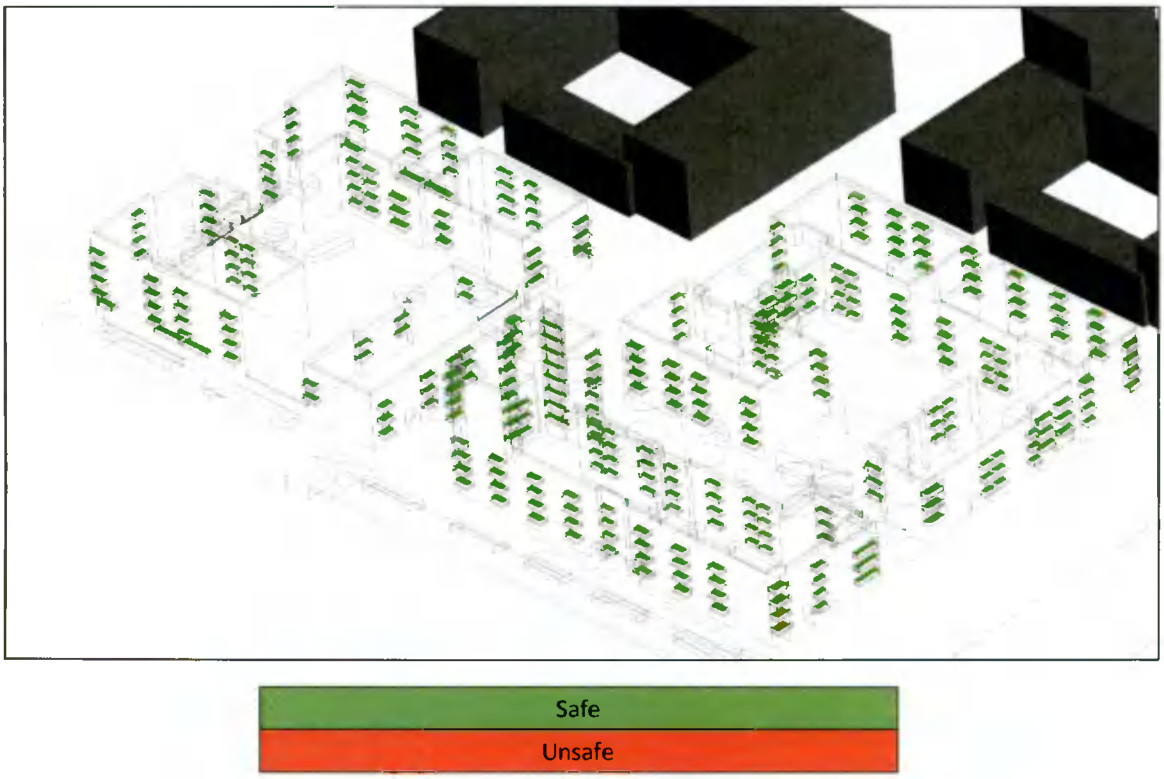


Figure 10: Pedestrian Wind Comfort Results - Frail Pedestrian (Private Balconies)

8. CONCLUSION

This report outlines the predicted climatic wind conditions experienced within and surrounding the proposed Adamstown Development – Blocks A, C & D, located in Adamstown, County Dublin.

As part of this assessment, the industry accepted standard of the Lawson Criteria was utilised. The Lawson Criteria gives guidance to quantify the effect of wind velocity on pedestrian comfort and safety. The wind climate analysis is based on the wind data obtained from the Casement Aerodrome weather station, which incorporates hourly wind data over a 30-year period (1990 until 2020).

A conscious effort was made by the design team during the design stages to mitigate the risk of localised increased wind speed conditions due to the proposed development. The introduction of mitigation measures such as the centralised courtyard location, as well as the strategic location of extensive landscaping, all assist in reducing the potential development of local increased wind speed and the negative impact on local climatic conditions.

Based on the CFD modelling results, the proposed development will be a comfortable environment for occupants. Some areas will present slightly higher wind speeds, however, they are in line with the activities that the area has been designed for. In addition, the incorporation of landscaping which will mitigate excessive wind speeds in these areas will further assist in reducing the wind speed values.

Overall, the proposed development is considered to be a high-quality, comfortable environment for occupants throughout the year.

APPENDIX A – CFD SIMULATION RESULTS

The CFD wind factor results included in this section are for all 12 No. wind directions as referenced within the body of the report. The wind directions referenced in the wind rose below correspond to the wind directions referenced in the CFD results.

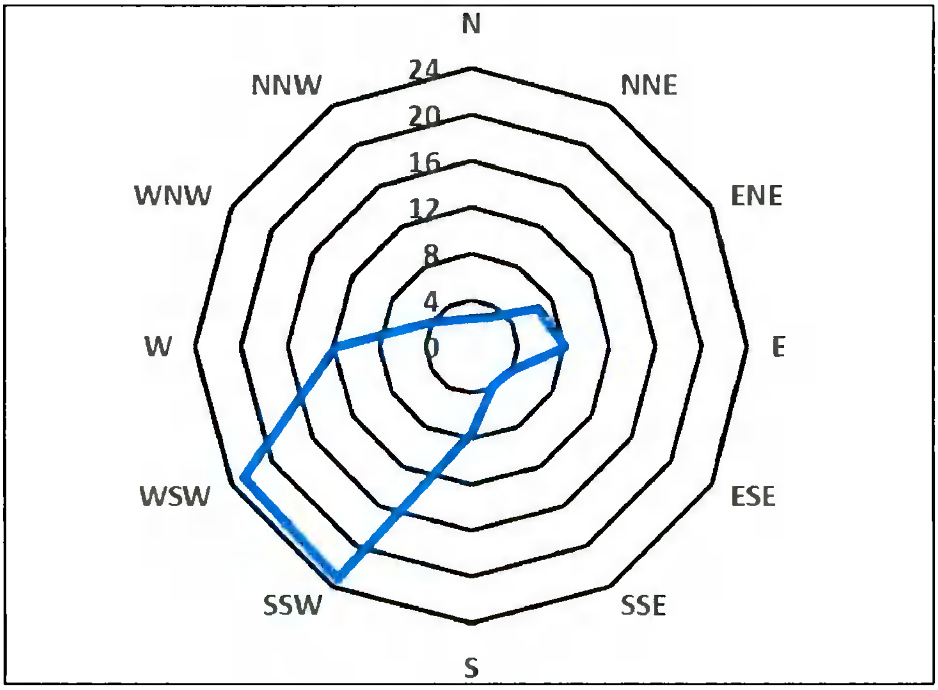


Figure A.1: Casement Aerodrome Airport Wind Rose Data (1990 – 2020)

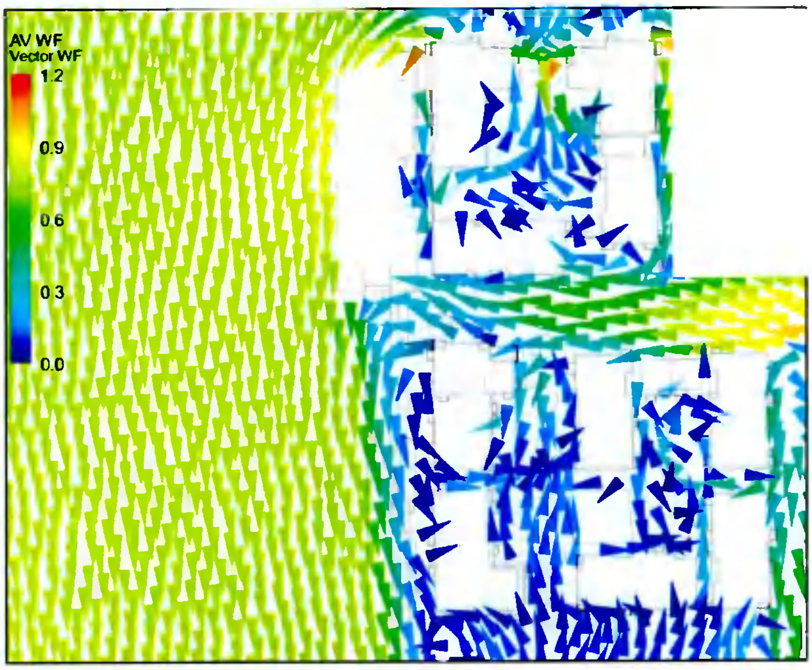


Figure A.2: Wind Factor – 0 Degree (N) Wind Direction

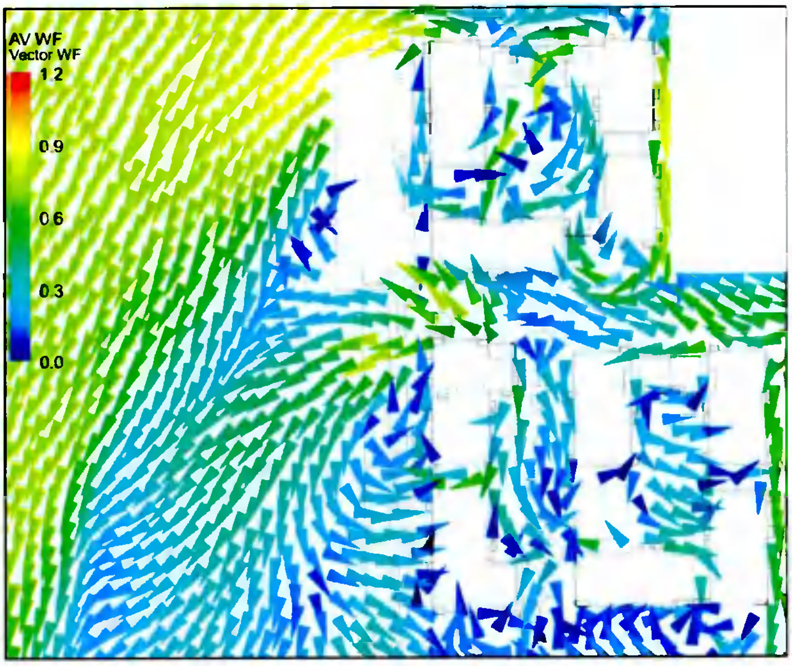


Figure A.3: Wind Factor – 30 Degree (NNE) Wind Direction

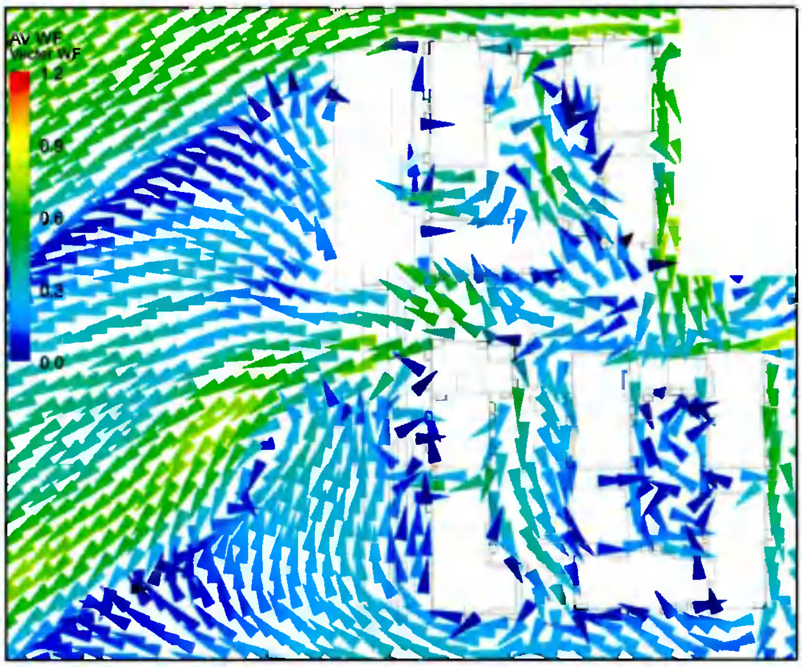


Figure A.4: Wind Factor – 60 Degree (ENE) Wind Direction

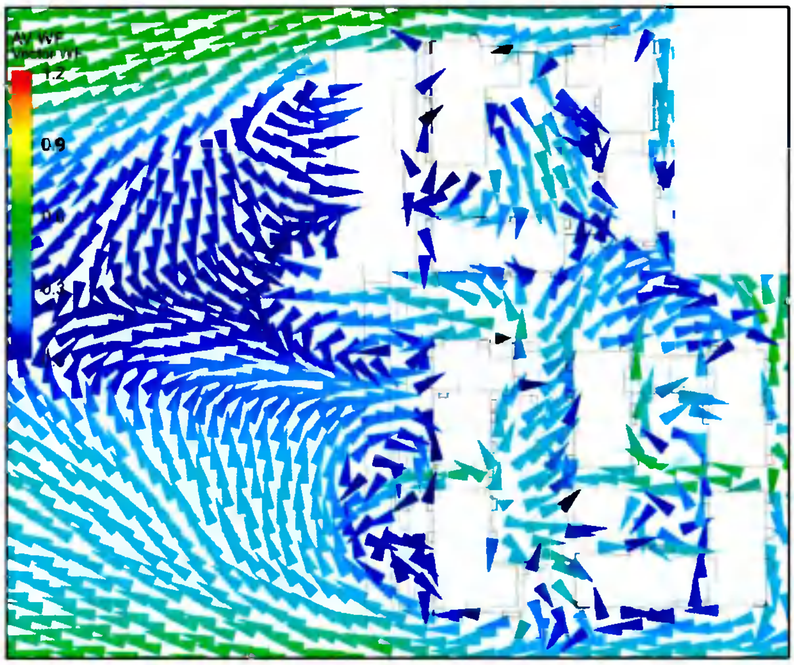


Figure A.5: Wind Factor – 90 Degree (E) Wind Direction

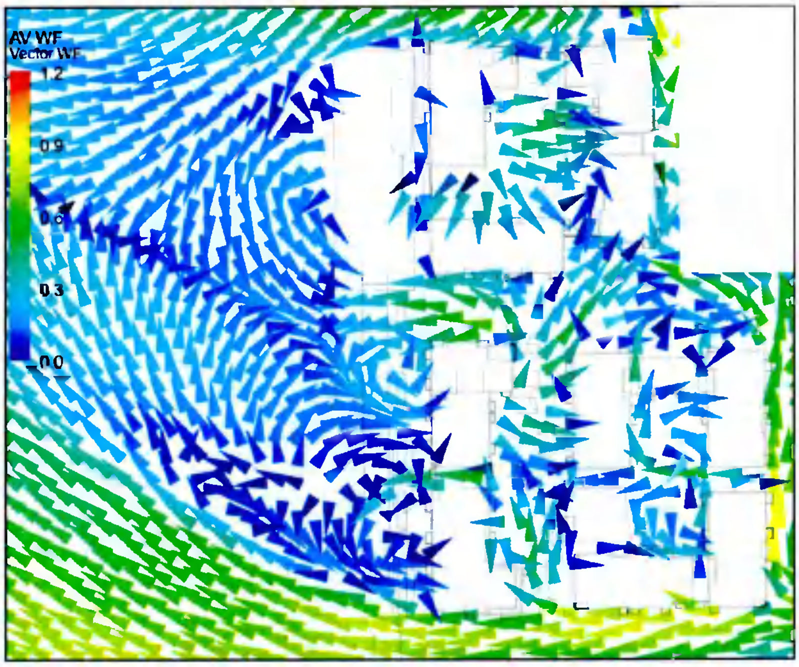


Figure A.6: Wind Factor – 120 Degree (ESE) Wind Direction

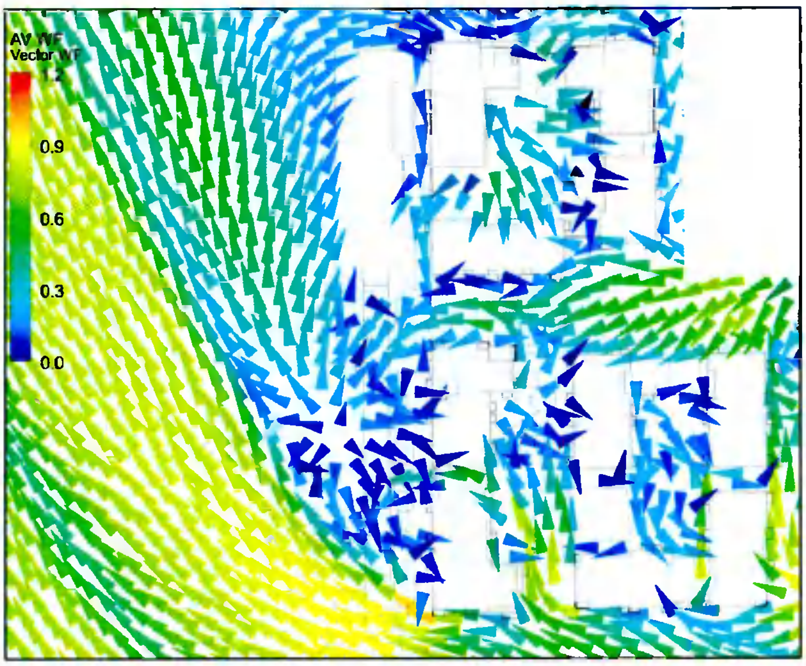


Figure A.7: Wind Factor – 150 Degree (SSE) Wind Direction

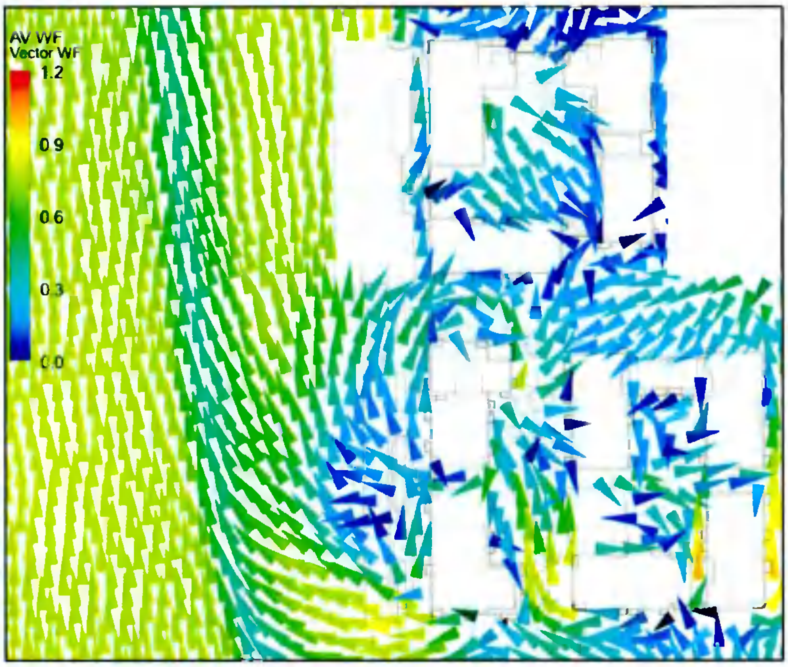


Figure A.8: Wind Factor – 180 Degree (S) Wind Direction

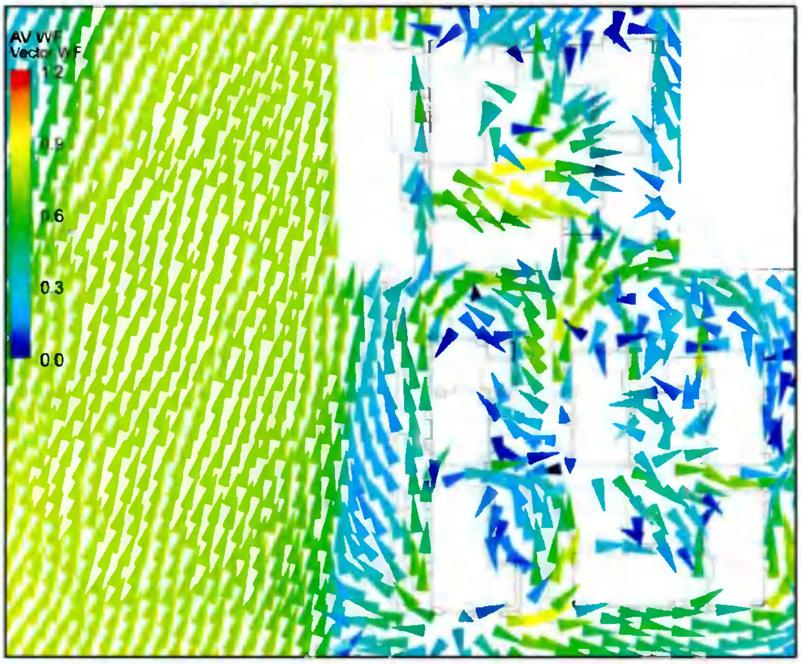


Figure A.9: Wind Factor – 210 Degree (SSW) Wind Direction

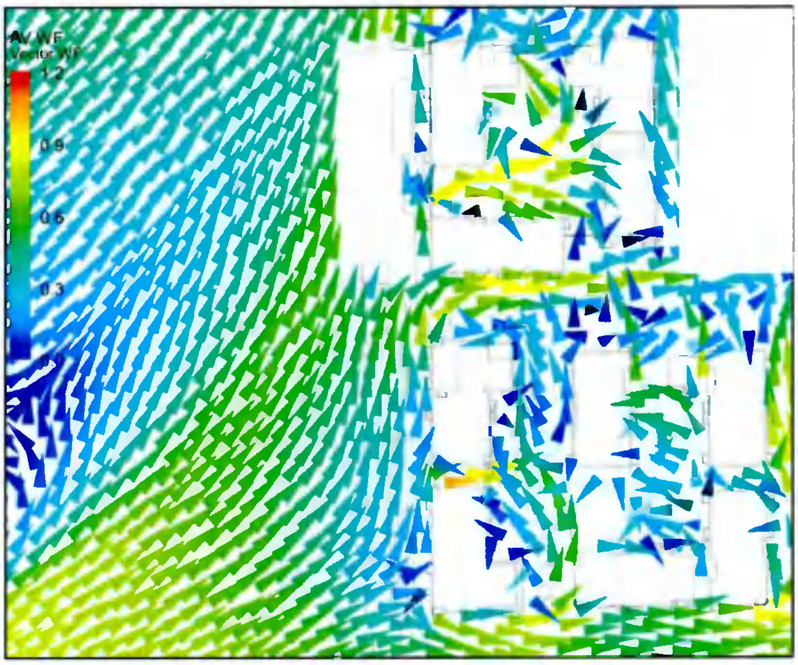


Figure A.10: Wind Factor – 240 Degree (WSW) Wind Direction

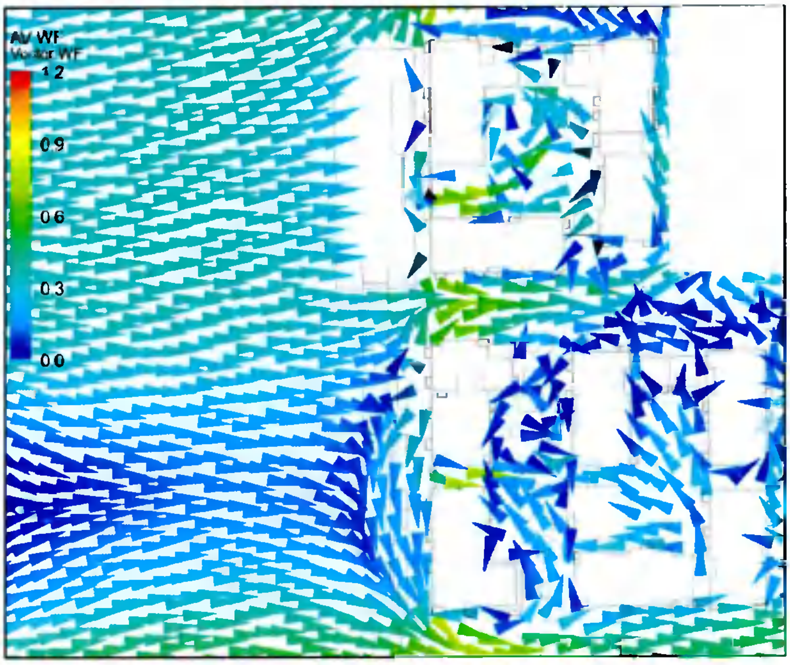


Figure A.11: Wind Factor – 270 Degree (W) Wind Direction

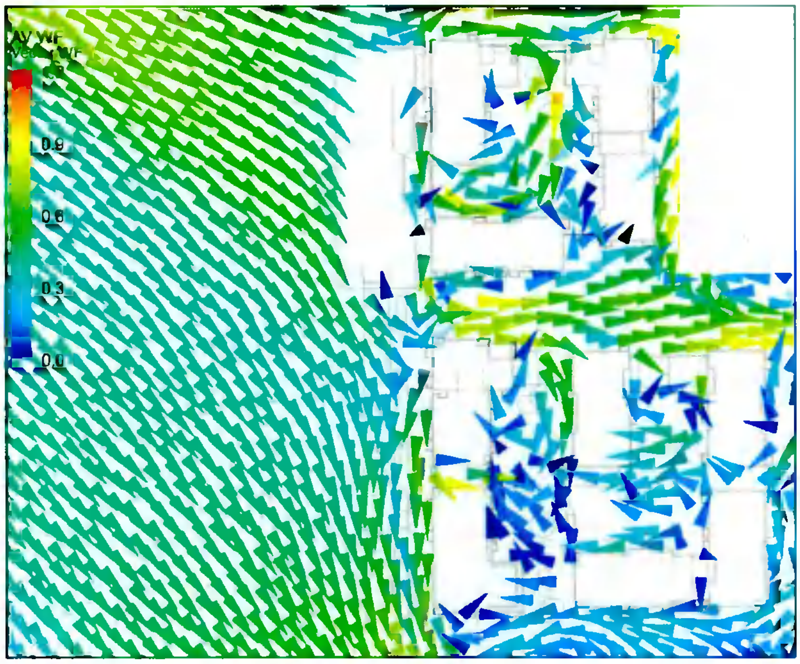


Figure A.12: Wind Factor – 300 Degree (WNW) Wind Direction

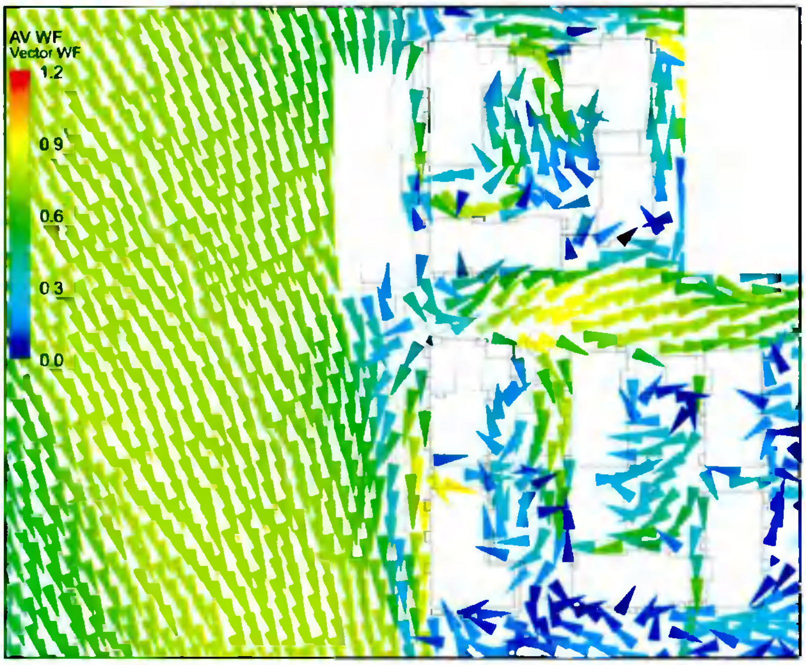
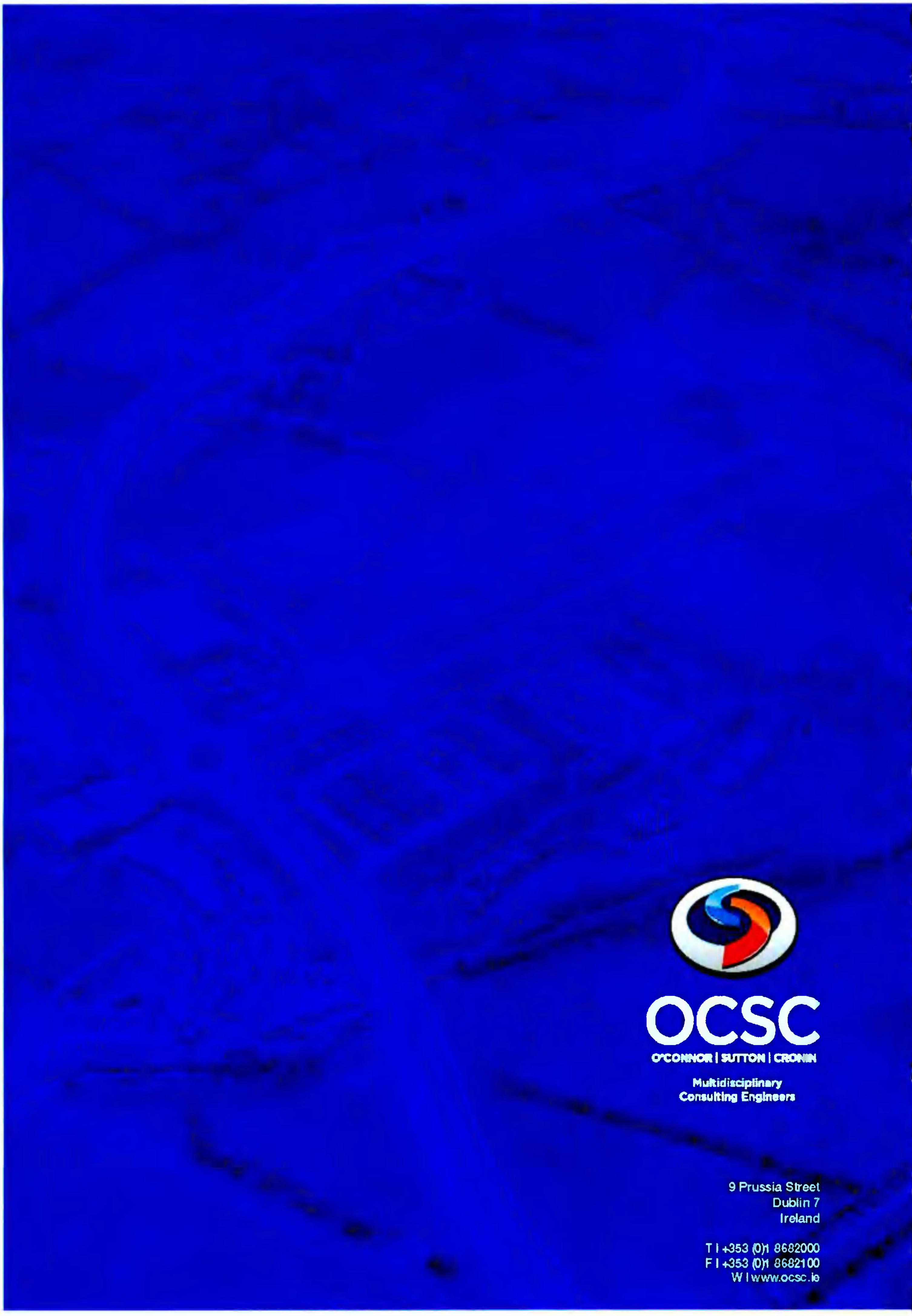


Figure A.13: Wind Factor – 330 Degree (NNW) Wind Direction



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