10 Wind & Microclimate Modelling

10.1. Introduction

B-Fluid Limited has been commissioned by 'Oval Target Ltd.' to carry out a Wind Microclimate Study for Temple Hill, Monkstown, Blackrock, Co. Dublin's Project. The following Figure shows the proposed extent and location of the site.

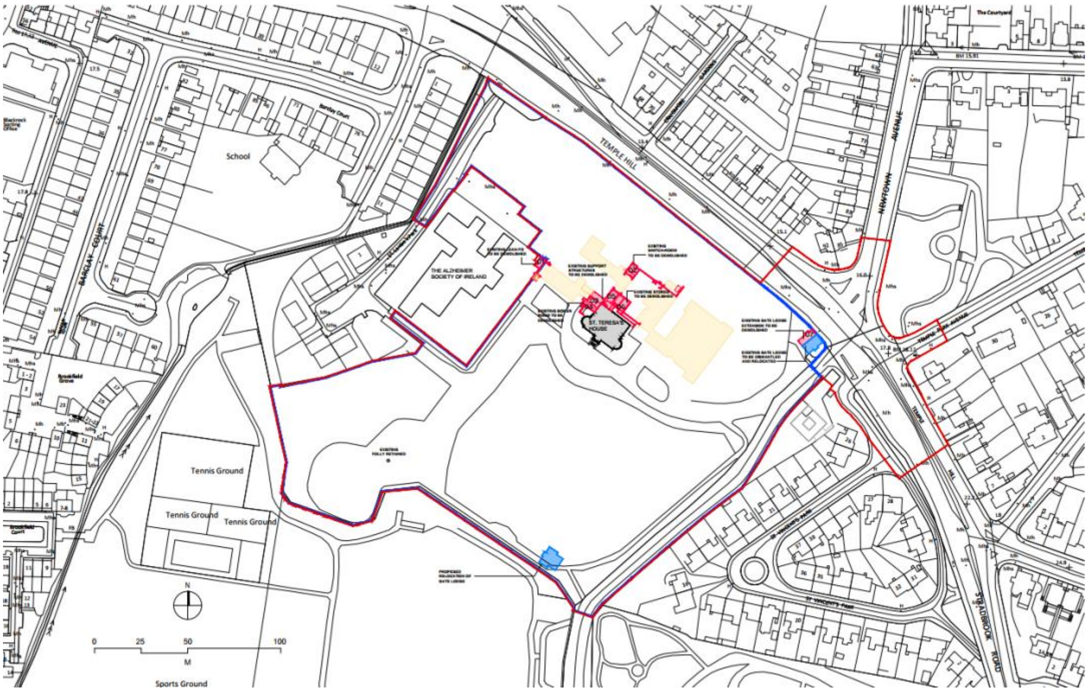


Figure 10.1: Extents and location of the site

The wind desktop study has identified the possible wind patterns around the area of the proposed development, under mean and peaks wind conditions typically occurring in Dublin.

The assessment has identified areas of potential downwash/funneling/downdraft/critical flow accelerations that may occur around the proposed development.

The results of the wind desktop study have been utilized by Oval Target Ltd. design team to configure the optimal layout for the proposed St. Teresa's SHD, with the aim of achieving a high quality environment for the scope of use intended of each areas/building and not to introduce any critical wind impact on the surrounding areas and on the existing buildings.

This chapter of the EIAR describes the wind desktop study performed and the rational of the methodology and assumptions that B-Fluid Ltd. has adopted for this analysis. In summary, as set out below, the wind desktop study carried out demonstrates that the proposed development has been designed as a high-quality environment for the scope of use intended of each areas/building (i.e. comfortable and pleasant for potential pedestrian) and does not introduce any critical impact on the surrounding areas and on the existing buildings. In particular:

- The wind profile was built using the annual average of meteorology data collected at Dublin Airport Weather Station. In particular, the local wind climate was determined from historical meteorological data recorded 10 m above ground level at Dublin Airport.

- The site is well surrounded by landscaping. This has a beneficial effect in mitigating the impact of the incoming wind. The prevailing wind directions for the site are identified in the West, West South-West and South-East with magnitude of approximately 6m/s. In all of these directions the development presents a good shielding through landscaping. The trees are beneficial in calming the incoming wind and deviating it.

- The buildings of the development also are all designed to have a larger base in relation to the top roof area. This type of design is well capable of mitigating potential funnelling effect.

- Given the position of the development, the major wind directions and the landscaping implemented, issues on the Temple Hill existing footpath (on the Northeast side of the development) are not expected.

Wind microclimate studies identify the possible wind patterns around the existing environment and proposed development under mean and peak wind conditions typically occurring in Dublin.

This assessment is performed through advanced Computational Fluid Dynamics (CFD) which is a numerical method used to simulate wind conditions and its impact on the development and to identify areas of concern in terms of downwash/funnelling/downdraft/critical flow accelerations that may likely occur. The Advanced CFD numerical algorithms applied here are solved using high performance computing cluster.

These results are utilized by the design team to configure the optimal layout for the proposed development, with the aim of achieving a high-quality environment for the scope of use intended of each areas/building and not to introduce any critical wind impact on the surrounding areas and on the existing buildings.

The next sections describe in details the wind and microclimate modelling performed, it's methodology and assumptions which B-Fluid Ltd. has adopted for this study, together with impacts of the proposed development on the existing environment.

Objective of Wind and Microclimate Modelling

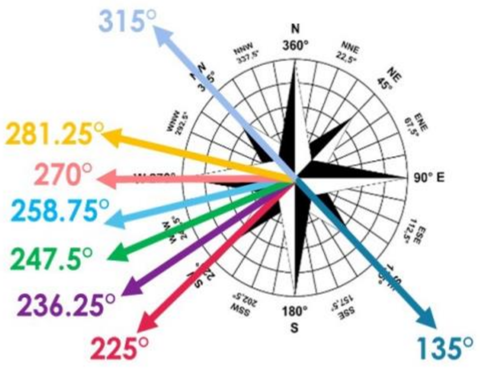
CFD wind modelling is adopted to identify critical flows and areas where pedestrian safety and comfort could potentially be compromised. Pedestrian Wind Comfort and Safety Studies are conducted to predict, assess and, where necessary, mitigate the impact of the residential development on pedestrian level wind conditions. The objective is to maintain comfortable and safe pedestrian level wind conditions that are appropriate for the season and the intended use of pedestrian areas. Pedestrian areas include side-walks, street frontages, pathways, building entrance areas, open spaces, amenity areas, outdoor sitting areas, and accessible roof top areas among others.

For this purpose, 18 different wind scenarios and directions have been studied as shown in Table 10.1 in order to take into consideration all the different relevant wind directions. In particular, a total of 18 compass directions on the wind rose are selected. For each direction, the reference wind speed is set to the 5% exceedance wind speed for that direction, i.e. the wind speed that is exceeded for over 5% of the time whenever that wind direction occurs.

Dublin Wind Scenarios And Directions		
Velocity (*m/s*)	**Direction ($_{deg}$)**	**Frequency**
5.601	225	11.233
4.626	135	6.849
5.847	236.25	6.792
6.049	258.75	6.747
6.034	247.5	6.689
5.888	270	5.662
4.994	315	4.338
5.503	281.25	3.904
4.974	292.5	3.436
5.357	213.75	3.288
4.736	123.75	3.105
4.406	146.25	2.751
5.101	303.75	2.648
5.246	112.5	2.500
4.121	157.5	2.386
4.581	101.25	2.340
4.169	45	2.180
3.558	90	2.135

Table 10.1: Summary of The most critical wind speeds in Dublin

This modelling study focuses on reporting 8 no. worst cases and most relevant wind speeds frequently occurring in Dublin, which are the speeds and directions showing the most critical wind speeds relevant to the development. The 8 no. modelled scenarios reported in this study are presented in Figure 10.2.



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5.888	270	5.662
4.994	315	4.338
5.503	281.25	3.904

Figure 10.2: Summary of 8 Wind Scenarios Reported

National Policies

Good wind microclimate conditions are necessary for creating outstanding public spaces. Adverse wind effects can reduce the quality and usability of outdoor areas, and lead to safety concerns in extreme cases.

According to the 'Urban Development and Building Heights, Guidelines for Planning Authorities (Government of Ireland, December 2020)' specific impact assessment of the micro-climatic effects should be performed for 'buildings taller than prevailing building heights in urban areas', (In the same guidance, standard buildings height is considered 6-8 storeys. Above this height, buildings are considered 'taller' for Dublin standards).

Usually, the recommended approach to wind microclimate studies is based on the building height, as presented for example in Figure 10.3.

Building Height	Recommended Approach to Wind Microclimate Studies
Similar or lower than the average height of surrounding buildings **Up to 25m**	Wind studies are not required, unless sensitive pedestrian activities are intended (e.g. around hospitals, transport hubs, etc.) or the project is located on an exposed location
Up to double the average height of surrounding buildings **25m to 50m**	Computational (CFD) Simulations **OR** Wind Tunnel Testing
Up to 4 times the average height of surrounding buildings **50m to 100m**	Computational (CFD) Simulations **AND** Wind Tunnel Testing
High Rise **Above 100m**	**Early Stage Massing Optimization:** Wind Tunnel Testing OR Computational (CFD) Simulations **Detailed Design:** Wind Tunnel Testing **AND** Computational (CFD) Simulations to demonstrate the performance of the final building design

Figure 10.3.: Recommended Approach to Wind Microclimate Studies based on Building Height, as prescribed by the Wind Microclimate Guidelines for Developments in the City of London (August 2019)

Computational fluid dynamics (CFD) tools can create high quality output that provide a good understanding of fundamental flow features. The CFD models must include a detailed three-dimensional representation of the proposed development.

Maximum cell sizes near critical locations (e.g. entrances, corners, etc.) must be 0.3m or smaller. Sufficient cells should be also used between buildings with a minimum of 10 across a street canyon. However, the cell size of buildings away from the target can be larger to allow for modelling efficiency. The CFD models should represent all surrounding buildings that are within 400m from the centre of the site. Other taller buildings outside of this zone that could have an influence on wind conditions within the project site should be included for wind directions where they are upwind of the project site. The models must contain at least 3 prism layers below 1.5m height, to capture near-ground effects.

CFD analysis also reports conditions in areas away from the site where cumulative effects of a cluster of tall buildings could lead to adverse wind conditions.

10.2. Study Methodology

Acceptance Criteria

Pedestrian Comfort Pedestrian Wind Comfort is measured in function of the frequency of wind speed threshold exceeded based on the pedestrian activity. The assessment of pedestrian level wind conditions requires a standard against which measured or expected wind velocities can be compared.

Only gust winds are considered in the safety criterion. These are usually rare events but deserve special attention in city planning and building design due to their potential impact on pedestrian safety. Gusts cause the majority of cases of annoyance and distress and are assessed in addition to average wind speeds. Gust speeds should be divided by 1.85 and these "gust equivalent mean" (GEM) speeds are compared to the same criteria as for the mean hourly wind speeds. This avoids the need for different criteria for mean and gust wind speeds.

The following criteria are widely accepted by local authorities as well as the international building design and city planning community:

- Discomfort Criteria: Relates to the activity of the individual.
  Onset of discomfort:
  - Depends on the activity in which the individual is engaged and is defined in terms of a mean hourly wind speed (or GEM) which is exceeded for 5% of the time.

- Distress Criteria: Relates to the physical well-being of the individual.
  Onset of distress:
  - 'Frail Person Or Cyclist': equivalent to an hourly mean speed of 15 m/s and a gust speed of 28 m/s (62 mph) to be exceeded less often than once a year. This is intended to identify wind conditions which less able individuals or cyclists may find physically difficult. Conditions in excess of this limit may be acceptable for optional routes and routes which less physically able individuals are unlikely to use.

  - 'General Public': A mean speed of 20 m/s and a gust speed of 37 m/s (83 mph) to be exceeded less often than once a year. Beyond this gust speed, aerodynamic forces approach body weight and it rapidly becomes impossible for anyone to remain standing. Where wind speeds exceed these values, pedestrian access should be discouraged.

The above criteria set out six pedestrian activities and reflect the fact that calm activity requires calm wind conditions, which are summarised by the Lawson scale, shown in Figure 10.4. Lawson scale assesses pedestrian wind comfort in absolute terms and defines the reaction of an average person to the wind. Each wind type is associated to a number, corresponding to the Beaufort scale, which is represented in Figure 10.5. Beaufort scale is an empirical measure that relates wind speed to observed conditions at sea or on land. A 20% exceedance is used in these criteria to determine the comfort category, which suggests that wind speeds would be comfortable for the corresponding activity at least 80% of the time or four out of five days.

These criteria for wind forces represent average wind tolerances. They are subjective and variable depending on thermal conditions, age, health, clothing, etc. which can all affect a person's perception of a local microclimate. Moreover, pedestrian activity alters between winter and summer months. The criteria assume that people will be suitably dressed for the time of year and individual activity. It is reasonable to assume, for instance, that areas designated for outdoor seating will not be used on the windiest days of the year.

Weather data measured are used to calculate how often a given wind speed will occur each year over a specified area. Pedestrian comfort criteria are assessed at 1.5m above ground level. Unless in extremely unusual circumstances, velocities at pedestrian level increase as you go higher from ground level.

A breach of the distress criteria requires a consideration of:

- whether the location is on a major route through the complex,
- whether there are suitable alternate routes which are not distressful.

If the predicted wind conditions exceed the threshold, then conditions are unacceptable for the type of pedestrian activity and mitigation measure should be implemented into the design.

Beaufort Scale	Wind Type	Mean Hourly Wind Speed (m/s)		Acceptance Level Based on Activity–Lawson Criteria			
				Sitting	Standing/ Entrances	Leisure Walking	Business Walking
0-1	Light Air	0 – 1.55	COMFORT				
2	Light Breeze	1.55 - 3.35					
3	Gentle Breeze	3.35 - 5.45					
4	Moderate	5.45 - 7.95					
5	Fresh Breeze	7.95 - 10.75					
6	Strong Breeze	10.75 - 13.85					
7	Near Gale	13.85 - 17.15					
8	Gale	17.15 - 20.75	DISTRESS				
9	Strong Gale	20.75 - 24.45					
Legend	Acceptable / Tolerable	Not acceptable / Dangerous					

Figure 10.4.: Lawson Scale

Wind	Symbol	Speed	Force	Effect	Wind	Symbol	Speed	Force	Effect
Calm		>1 mph	0	Smoke rises vertically	Moderate Gale		32-38 mph	7	Whole trees in motion
Light Air		1-3 mph	1	Smoke drifts slightly	Fresh Gale		39-46 mph	8	Twigs broken off trees: Difficult to drive a car
Light Breeze		4-7 mph	2	Leaves rustle: Wind vane moves	Strong Gale		47-54 mph	9	Slight structural damage occures
Gentle Breeze		8-12 mph	3	Leaves in constant motion: Light flag extended	Whole Gale		55-63 mph	10	Trees uprooted: Severe structural damage
Moderate Breeze		13-18 mph	4	Raises dust and papers: Small branches stir	Storm		64-73 mph	11	Widespread damage
Fresh Breeze		19-24 mph	5	Small trees sway	Hurricane		Above 75 mph	12	Devastation
Strong Breeze		25-31 mph	6	Large branches move: Use of umbrella difficult	The Beaufort scale has unofficially been extended to force 17 to describe tropical storms exceeding 126 miles per hour				

Figure 10.5.: Beaufort Scale

Modelling Method

Computational Fluid Dynamics (CFD) is a numerical technique to simulate fluid flow, heat and mass transfer, chemical reaction and combustion, multiphase flow, and other phenomena related to fluid flows. CFD modelling includes three main stages: pre-processing, simulation and post-processing as described in Figure 10.6. The Navier-Stokes equations, used within CFD analysis, are based entirely on the application of fundamental laws of physics and therefore produce extremely accurate results providing that the scenario modelled is a good representation of reality.

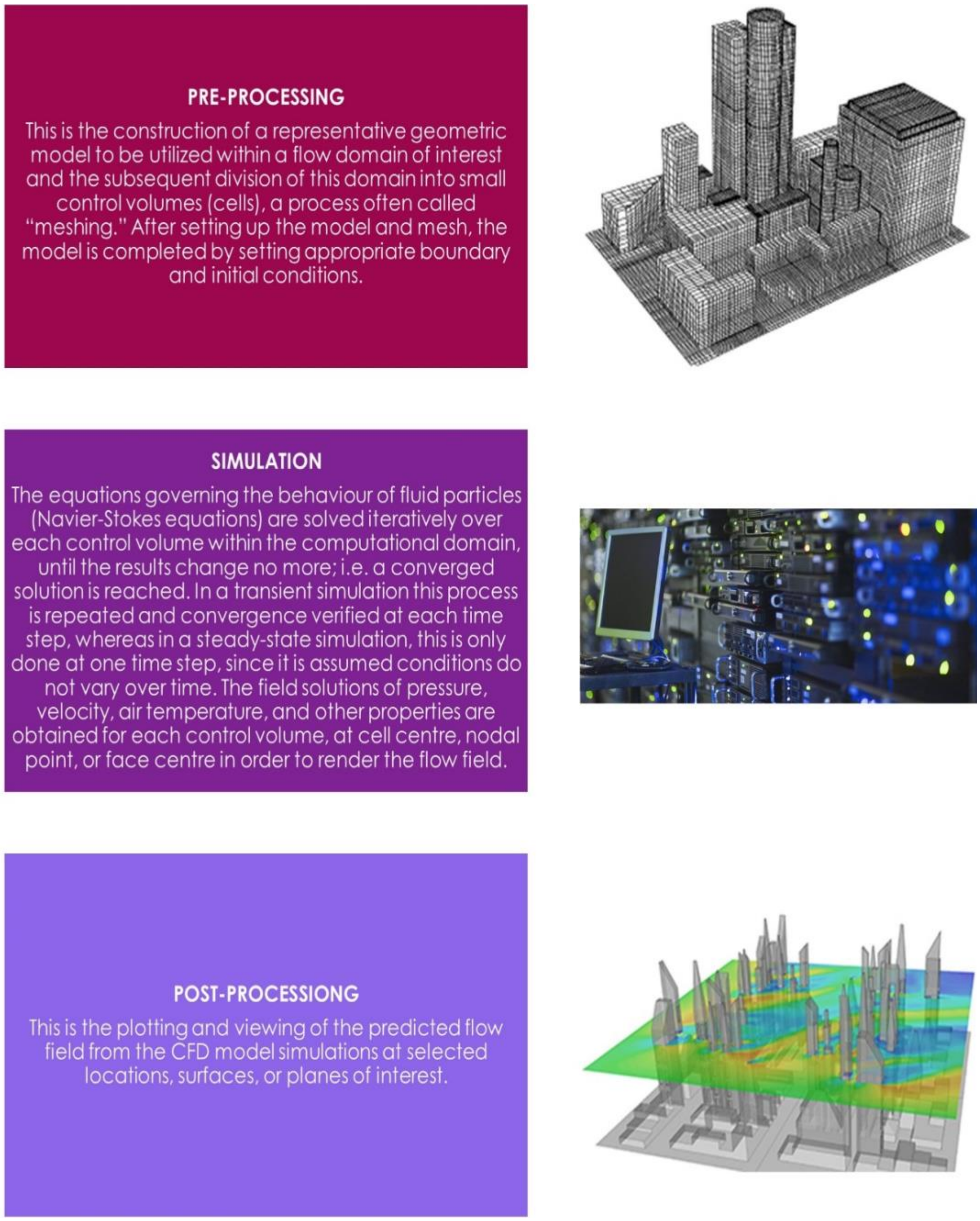


Figure 10.6.: CFD Modelling Process Explanation

<u>OpenFOAM Numerical Solver Details</u>

This report employs OpenFoam Code, which is based on a volume averaging method of discretization and uses the post-processing visualisation toolkit Paraview version 5.5. OpenFoam is a CFD software code released and developed primarily by OpenCFD Ltd, since 2004. It has a large user base across most areas of engineering and science, from both commercial and academic organisations.

OpenFOAM CFD code has capabilities of utilizing a Reynolds Averaged Navier-Stokes (RANS) approach, Unsteady Reynolds Averaged Navier-Stokes (URANS) approach, Detached Eddy

Simulation (DES) approach, Large Eddy Simulation (LES) approach or the Direct Numerical Simulation (DNS) approach, which are all used to solve anything from complex fluid flows involving chemical reactions, turbulence and heat transfer, to acoustics, solid mechanics and electromagnetics. Quality assurance is based on rigorous testing. The process of code evaluation, verification and validation includes several hundred daily unit tests, a medium-sized test battery run on a weekly basis, and large industry-based test battery run prior to new version releases. Tests are designed to assess regression behaviour, memory usage, code performance and scalability.

The OpenFOAM solver algorithm directly solves the mass and momentum equations for the large eddies that comprise most of the fluid's energy. By solving the large eddies directly no error is introduced into the calculation.

To reduce computational time and associated costs the small eddies within the flow have been solved using the widely used and recognised Smagorinsky Sub-Grid Scale (SGS) model. The small eddies only comprise a small proportion of the fluids energy therefore the errors introduced through the modelling of this component are minimal.

The error introduced by modelling the small eddies can be considered of an acceptable level. Computational time will be reduced by modelling the small eddies (compared to directly solving).

10.3. The Existing Receiving Environment (Baseline)

In this chapter, wind impact has been assessed on the existing receiving environment considered as the existing buildings and the topography of the site prior to construction of the proposed development. A statistical analysis of 30 years historical weather wind data has been carried out to assess the most critical wind speeds, directions and frequency of occurrence of the same. The aim of this assessment has been to identify the wind microclimate of the area that may cause critical conditions for pedestrian's comfort criteria.

Figure 10.7.: Built-in Environment around Construction Site at Lands at St. Teresa's Project-Google Map Image May 2020

Site Location and Surrounding Area

The proposed development site is located on zoned lands within the boundary of the Blackrock LAP 2015, approximately 1.5 Km of Blackrock Village Centre, within the functional area of Dun Laoghaire Rathdown County Council. The site is delimited from the south side by Rockfield Public Park. Access to the site is via the N31 directly in front to a gate lodge, a protected structure.

The area surrounding the site can be characterised as urban environment. Some shelter effect can be expected for wind approaching from directions within this sector. All for the study considered main wind directions of west to south-west and Southeast are in this connection "urban winds" and no distinction will be made between them. The site is located near a coastal area however, between the sea and the site, there is an urban environment, so the effect of the sea is expected to be mitigated. Figure 10.8 shows the model of the Proposed Development and View of the Built-in Environment. The highest block is above 30m.

Figure 10.8: Model of the Proposed Development and View of the Built-in Environment

Figure 10.9: Model of the Proposed Development and View of the Built-in Environment.

<u>Topography and Built-in Environment</u>

Figure 10.10 shows the model of the Proposed Development and View of the Built-in Environment. The highest block is above 30m.

Figure 10.10.: Site and Proposed development

Wind and Microclimate Conditions

This analysis considers the whole development being exposed to the typical wind condition of the site. The building is oriented as shown in the previous sections. The wind profile is built using the annual average of meteorology data collected at Dublin Airport Weather Station. Figure 10.11. shows on the map the position of Proposed development and the position of Dublin Airport.

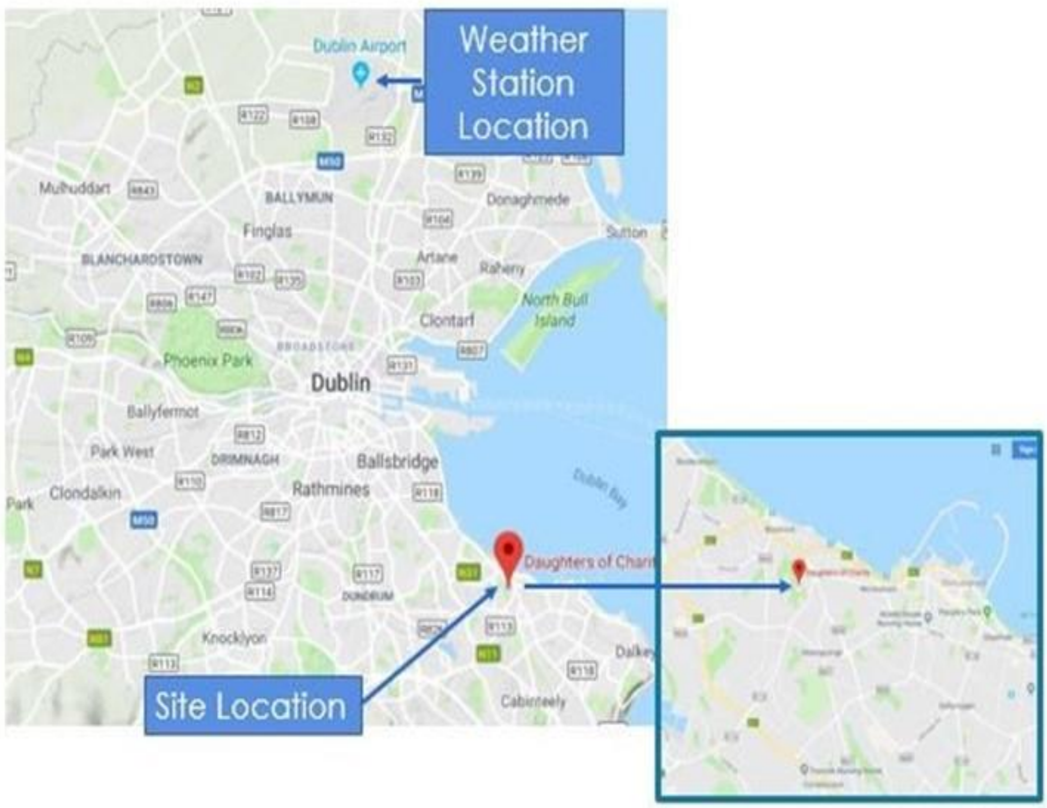


Figure 10.11.: Map showing the position of Proposed development and Dublin Airport

Regarding the transferability of the available wind climate data following considerations have been made:

- Terrain: The meteorological station is located in the flat open terrain of the airport, whereas the development site is located in urban area with dense built-in structure with buildings of at least 15m height and above.

- Mean Wind Speeds: Due to the different terrain environment, the ground-near wind speeds (at pedestrian level) will be lower at the construction site compared to the meteorological station at the airport.

- Wind Directions: The landscape around the development site can in principle be characterized as flat terrain. Isolated elevations in the near area of the development should have no influence on the wind speed and wind directions. With respect to the general wind climate no significant influence is expected. Based on the above considerations it can be concluded that the data from the meteorological station at Dublin Airport are applicable for the desktop assessment of the wind comfort at the development site.

Wind Conditions

The assessment of the wind comfort conditions at the proposed development will be based on the dominating wind directions throughout a year (annual wind statistic).

As stated above, the local wind climate is determined from historical meteorological data recorded at Dublin Airport. Two different data sets are analysed for this assessment as follows:

- The meteorological data associated with the maximum daily wind speeds recorded over a 30 year period between 1990 and 2020 and,
- The mean hourly wind speeds recorded over a 10 year period between 1990 and 2020. The data is recorded at a weather station at the airport, which is located 10m above ground or 71mOD.

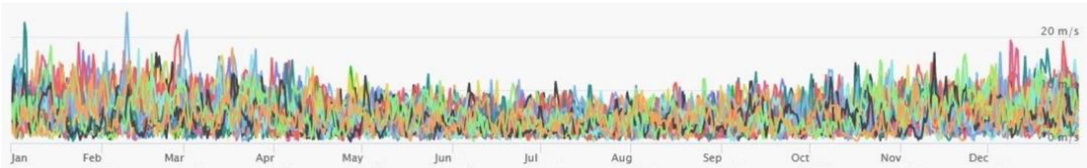


Figure 10.12.: Local Wind Conditions - Wind Speed - 1990-2020

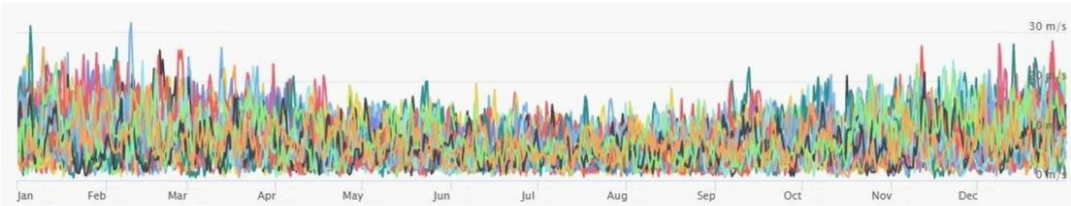


Figure 10.13.: Local Wind Conditions - Wind Gust - 1990-2020

Figure 10.14., presenting the wind speed diagram for Dublin, shows the days per month, during which the wind reaches a certain speed. In Figure 10.15., the wind rose for Dublin shows how many hours per year the wind blows from the indicated direction, confirming how the predominant directions are WSW, W, and SW.

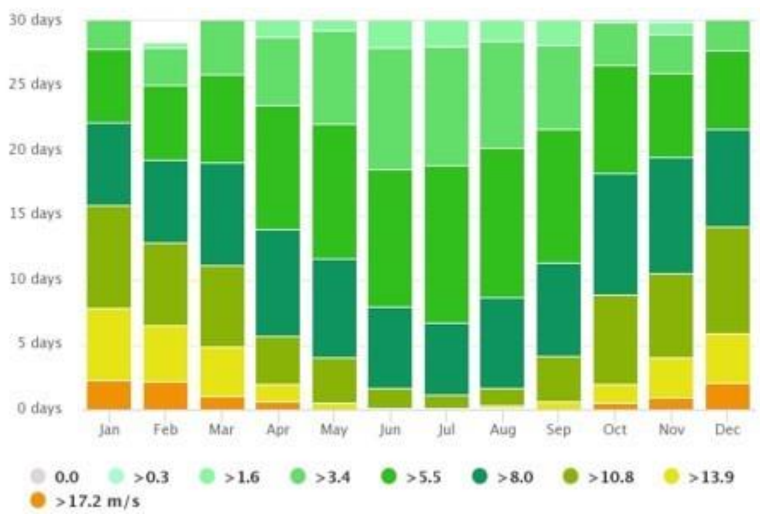


Figure 10.14.: Dublin Wind Speed Diagram

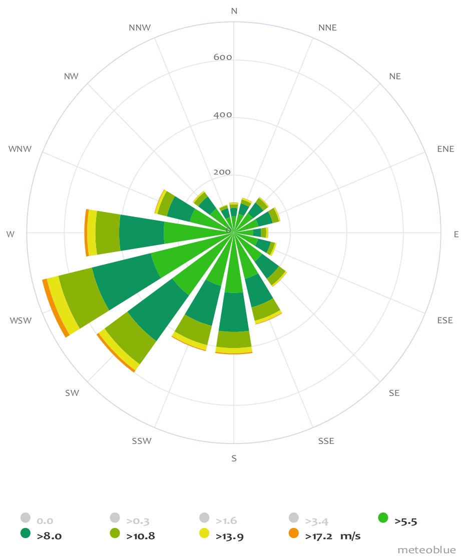


Figure 10.15.: Dublin Wind Rose

Based on the criterion of occurrence frequency, the main wind directions to be considered in pedestrian wind comfort assessment are presented in Figure 10.16. and listed below in descending order of dominance:

1. South-West with most frequent wind speeds around 6m/s (all year).
2. South-East
3. West-South-West.

The analysis will mainly focus on the large sector of prevailing wind directions of winds from above. Other wind directions will be discussed if deemed necessary for the study.

Velocity (m/s)	Direction (°)	Frequency
5.601	225	11.233
4.626	135	6.849
5.847	236.25	6.792
6.049	258.75	6.747
6.034	247.5	6.689
5.888	270	5.662
4.994	315	4.338
5.503	281.25	3.904
4.974	292.5	3.436
5.357	213.75	3.288
4.736	123.75	3.105
4.406	146.25	2.751
5.101	303.75	2.648
5.246	112.5	2.500
4.121	157.5	2.386
4.581	101.25	2.340
4.169	45	2.180
3.558	90	2.135
4.801	202.5	2.021
3.689	78.75	1.963
3.627	168.75	1.495
4.285	67.5	1.370
4.863	56.25	1.279
4.042	191.25	1.199
4.630	326.25	1.164
3.844	11.25	1.142
4.418	337.5	1.062
4.787	348.75	0.982
4.006	22.5	0.959
3.555	180	0.879
4.059	33.75	0.845
0.700	0	0.011
Selected Conditions : **32**	Total Coverage : **95.35 %**	

Figure 10.16.: Main Wind Directions Occurrence Frequency

<u>Mean and Maximum Wind Conditions</u>

Examination of the daily wind data reveals that the wind predominantly blows from West and Southwest directions, however, there is a secondary wind from the Southeast. It is apparent that winds from other directions are rare. Maximum daily wind speeds of nearly 30 m/s were recorded in the past 30 years, however, the maximum daily winds are commonly found between 6 m/s and 15 m/s. the strongest winds arise from the West and Southwest.

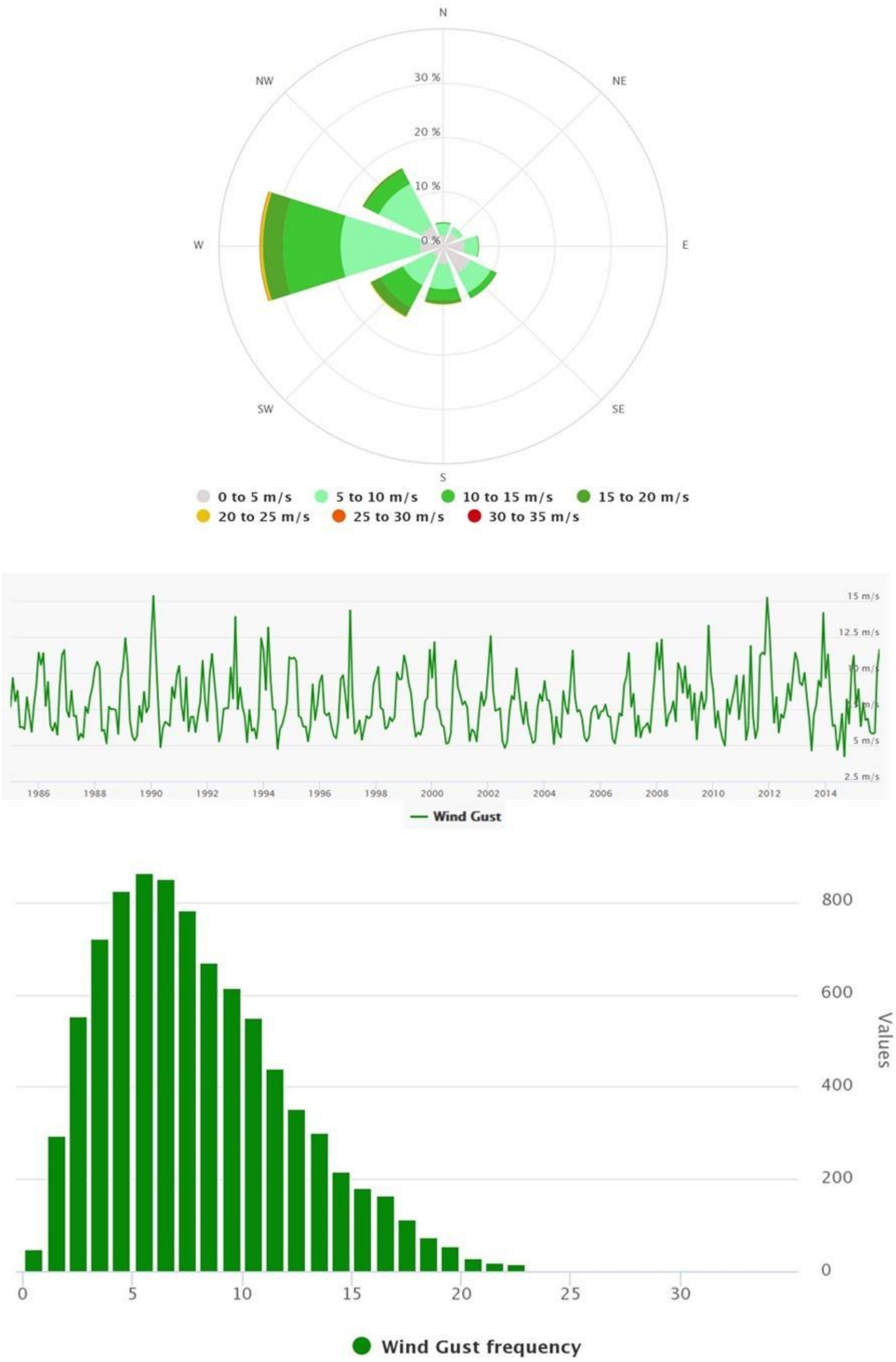


Figure 10.17.: Maximum Wind Conditions

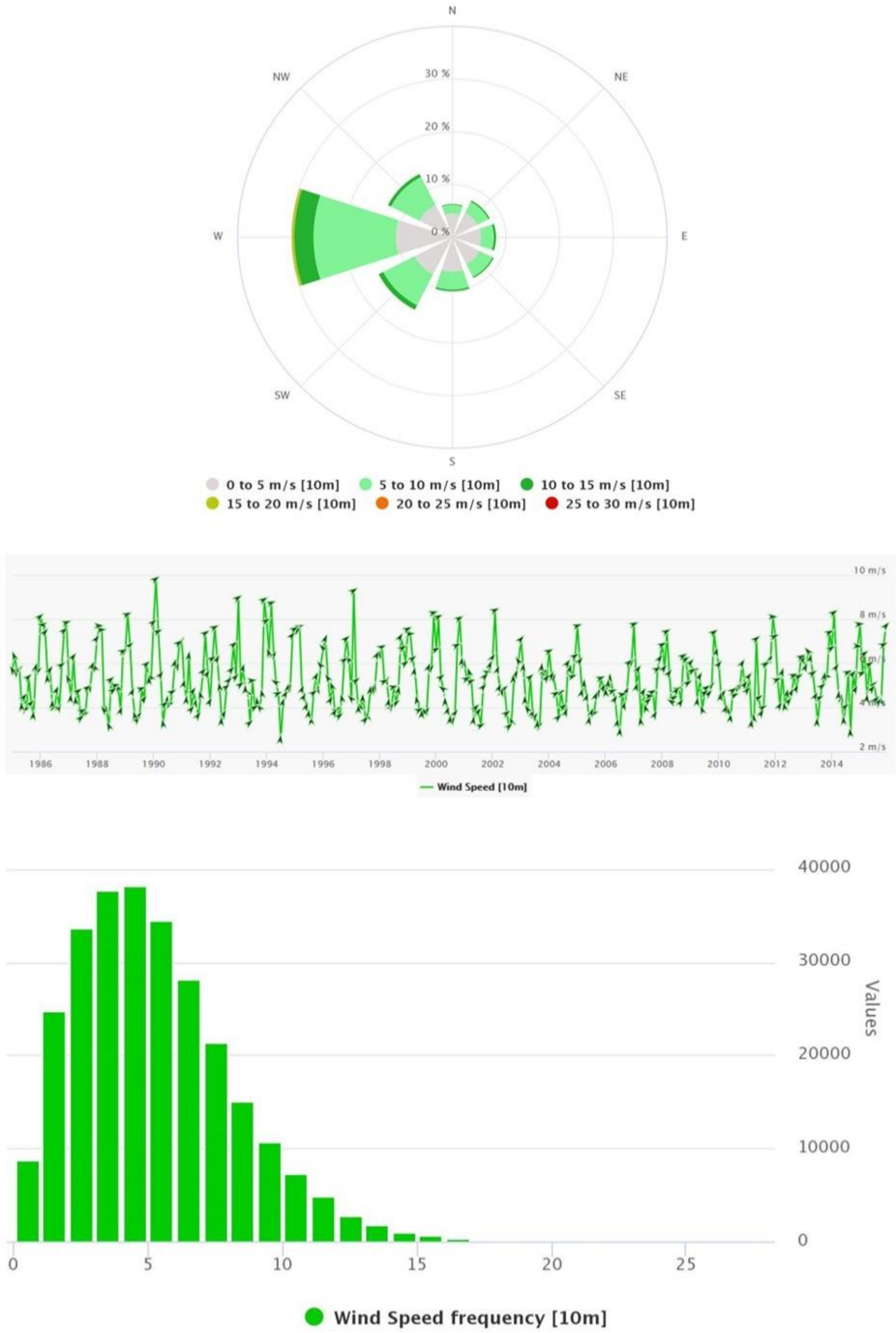


Figure 10.18.: Mean Wind Conditions

Open Area Functions

The assessment of pedestrian wind comfort in urban areas focuses on activities people are likely to perform in the open space between buildings, which are in turn related to a specific function. For example, the activity sitting for a long period of time is typically associated with the location of a street café or similar. Such combinations of activity and area can be grouped into four main categories:

A	Sitting for a long period of time; laying steady position; pedestrian sitting; Terrace; street cafe or restaurant; open field theatre; pool
B	Pedestrian standing; standing/sitting over a short period of time; short steady positions; Public Park; playing field; shopping street; mall
C	Pedestrian walking; leisurely walking; normal walking; ramble; stroll Walkway; shopping street; mall
D	Objective business walking; brisk or fast walking; Car Park; avenue; sidewalk; belvedere

Table 10.2: Main Categories for Pedestrian Activities

Existing Receiving Environment Summary

The wind desktop study of the existing receiving environment showed that:

- The wind profile was built using the annual average of meteorology data collected at Dublin Airport Weather Station. In particular, the local wind climate was determined from historical meteorological data recorded 10 m above ground level at Dublin Airport.

- Different scenarios were selected in order to take into consideration all the different relevant wind directions. In particular, a total of 18 compass directions on the wind rose are selected. For each direction, the reference wind speed is set to the 5% exceedance wind speed for that direction, i.e. the wind speed that is exceeded for over 5% of the time whenever that wind direction occurs.

- The prevailing wind directions for the site are identified in the West, West South-West and South-East with magnitude of approximately 6m/s.

10.4. Characteristics of the Proposed Development

Description of the Proposed Development

This technical report presents a wind desktop study carried out for the site of the proposed St. Teresa's strategic housing development [SHD]. The image in Figure 10.19 shows a 3D View of Lands at the proposed St. Teresa's SHD.

Figure 10.19: 3D View of Lands at proposed St. Teresa's SHD

The following paragraphs detail all the project information used throughout the study, together with results of the assessment carried out.

The proposed development comprises 493 residential units delivered in a combination of new apartment buildings (ranging in height from 3- 10 storeys overall in height) and a relocated St. Teresa's Lodge.

St. Teresa's House provides for 6 apartments, comprising 5 no. 2-bed units and 1 no. 3-bed unit. The new build element of 487 units is set out in 11 no. residential development blocks (Blocks A1-C2 and D1 – E2) ranging in height from 3-10 storeys over basement comprising:

- Block A1 (5 storeys) comprising 37 no. apartments (33 no. 1 bed units and 4 no. 2 bed units)
- Block B1 (10 storeys) comprising 55 no. apartments (37 no. 1 bed units, 10 no. 2 bed units and 8no. 3 bed units)
- Block B2 (8 storeys) comprising 42 no. apartments (28 no. 1 beds, 9 no. 2 beds and 5 no. 3 beds)
- Block B3 (8 storeys) comprising 42 no. apartments (28 no. 1 beds, 9 no. 2 beds and 5 no. 3 beds)
- Block B4 (5 storeys) comprising 41 no. apartments (4 no. studio units, 4 no. 1 bed units, 27 no. 2 bed units and 6 no. 3 bed units).
- Block C1 (3 storeys) comprising 10 no. apartments (1 no. studio unit, 3 no. 1 bed units and 6 no. 2 bed units).
- Block C2 (3 storeys) comprising 6 no. apartments (2 no. 1 bed units, 4 no. 2 bed units,) together with a creche facility of 392 sq. m at ground floor level and outdoor play area space of 302sq.m
- Block C3 (1 storey plus basement level) comprising residential amenity space of 451 sq. m.
- Block D1 (6 storeys) comprising 134 no. apartments (12 no. studio units, 22 no. 1 bed units, 90 no. 2 bed units and 10 no. 3 bed units).
- Block E1 (6 storeys) comprising 70 apartment units (34 no. 1 bed units, 26 no. 2 bed units and 10 no. 3 bed units).
- Block E2 (6 storeys) comprising 50 units (1 no. studio unit, 29 no. 1 bed units, 18 no. 2 bed units and 2 no. 3 bed units).

Each residential unit has associated private open space in the form of a terrace/balcony.

Resident amenity space c. 451 sq. m. accommodating a gym and studio space at basement level; residents' lounge/café, work booths/meeting room and reception/foyer/parcel store at ground floor.

Crèche facility of 392. sq. m.

252 no. residential car parking spaces (161 no. at basement level and 91 no. at surface level) and 20 motorcycle spaces at basement level are proposed. 8 no. car parking spaces for creche use are proposed at surface level.

1056 no. bicycle parking spaces (656 no. at basement level and 400 no. at surface level).

15,099.7 sq. m. public open space in the form of a central parkland, garden link, woodland parkland (incorporating an existing folly), a tree belt, entrance gardens, plazas, terraces, gardens, and roof terraces for Blocks B2 and B3.

10.5. Potential Impact of the Proposed Development

Construction Phase

The effects on wind microclimate at the site during the construction phase have been assessed using professional judgement. As construction of the proposed development progresses, the wind conditions at the site will gradually adjust to those of the completed development, and mitigation measures will need to be implemented before completion and operation.

Operational Phase

The construction of the development can potentially calm the existing wind condition in the area by providing further "urban context" to the existing topography, however, some areas can become more critical from a wind acceleration and re-circulation point of view and phenomena such as downwash, funnelling and downdraft can be experienced as well. The development, in principle, offers more drag to the incoming wind profile as detailed in the sections that follow (see "Planetary boundary layer and terrain roughness"). Consequently, the wind at lower level can reduce and modify its flow path directions. However, zones of re-circulations caused by the re-direction of the wind can also be expected, especially in the West Southwest direction where some funnelling can potentially occur. The potential impact of the development on the local wind microclimate has been assessed through the modelling of different wind scenarios and where areas of critical wind conditions have been detected, appropriate mitigation has been implemented and modelled to verify the reduction of the critical wind conditions and the suitability of the specific area to the designated pedestrian activity.

Planetary Boundary Layer and Terrain roughness

Due to aerodynamic drag, there is a wind gradient in the wind flow just a few hundred meters above the Earth's surface – "the surface layer of the planetary boundary layer".

Wind speed increases with increasing height above the ground, starting from zero, due to the no-slip condition. In particular, the wind velocity profile is parabolic. Flow near the surface encounters obstacles that reduce the wind speed and introduce random vertical and horizontal velocity components. This turbulence causes vertical mixing between the air moving horizontally at one level, and the air at those levels immediately above and below it. For this reason, the velocity profile is given by a fluctuating velocity along a mean velocity value. Figure 10.21. shows the wind velocity profile, as described above.

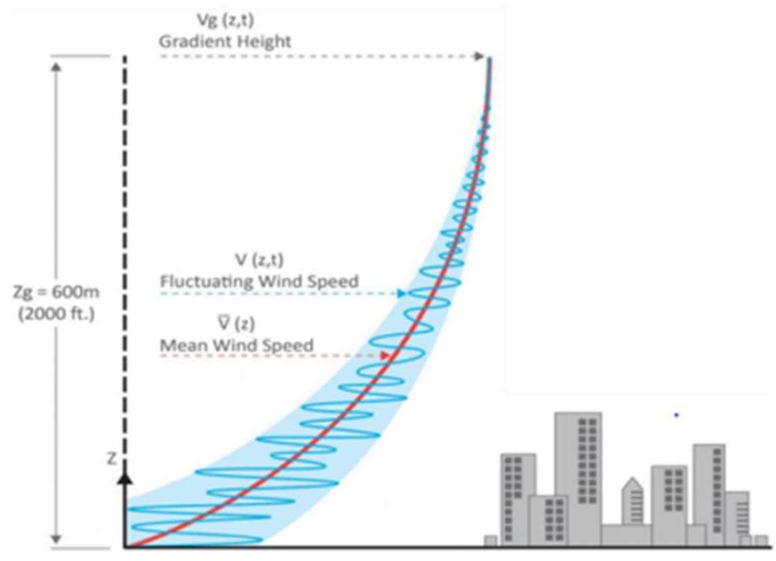


Figure 10.20.: Wind Velocity Profile

Two effects influence the shape of the wind speed profile:

- Contours of the terrain: a rising terrain such as an escarpment will produce a fuller profile at the top of the slope compared with the profile of the wind approaching the slope.

- Aerodynamic 'roughness' of the upstream terrain: natural roughness in the form of woods or man-made roughness in the form of buildings. Obstructions near the ground create turbulence and friction, lowering the average wind speed. The higher the obstructions, the greater the turbulence and the lower the windspeed. As a general rule, windspeed increases with height.

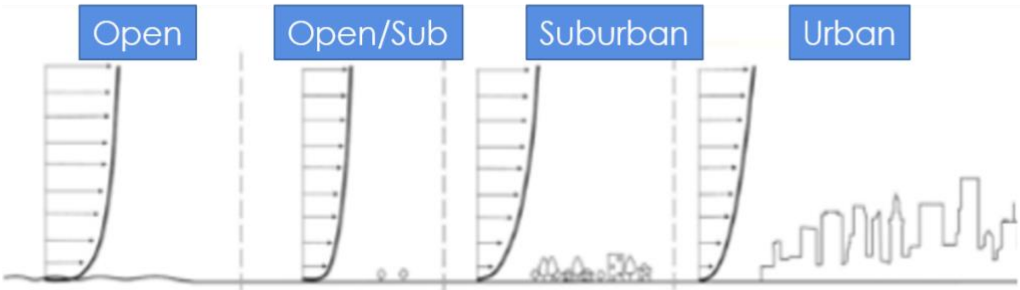


Figure 10.21: Wind Velocity Profile for different terrains

In order to assess the wind conditions in a particular area, it is important to know (Figure 10.23.):

- Weather conditions in the area
- Location and orientation of the site
- Buildings distribution in the area
- Flow patterns at the building

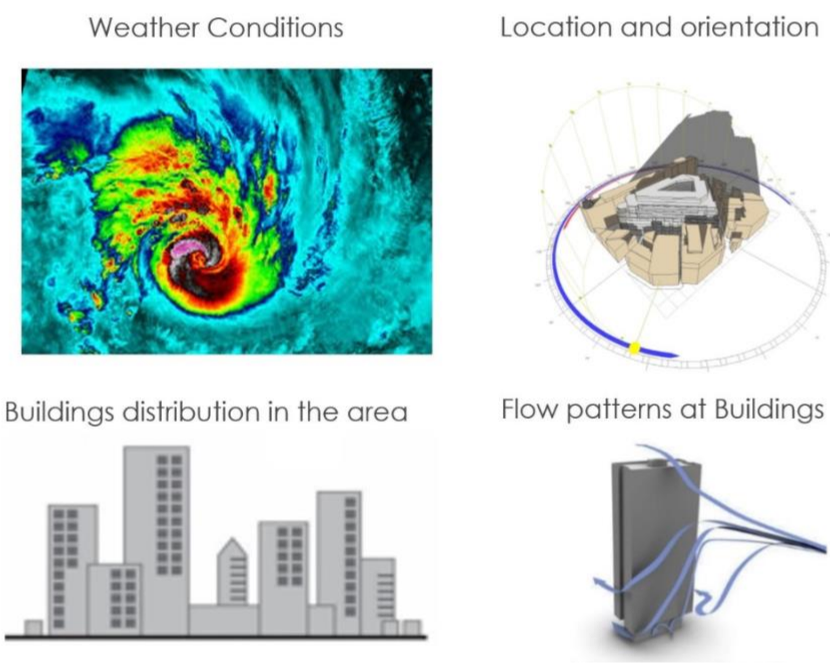


Figure 10.22: Parameters to know for Wind Conditions Assessment

Moreover, it is important to understand key flow features (Figure 10.24.):

- Broad Building Face creates "DOWNWASH"
- Low Building Upwind Increases Wind Effects
- Gaps Between Buildings Increases Wind Velocity
- Low Building Upwind Increases Wind Effects

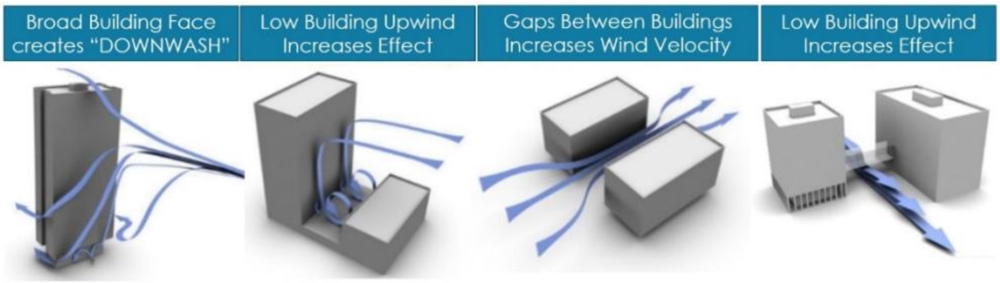


Figure 10.23.: Parameters to know for Wind Conditions Assessment

10.6. Mitigation Measures

Construction Phase

The effects on wind microclimate at the Site during the construction phase have been assessed using professional judgement.

As construction of the proposed development progresses, the wind conditions at the site will gradually adjust to those of the completed development, and mitigation measures will need to be implemented before completion of the construction phase.

Operational Phase

As stated above, if the wind conditions exceed the threshold, these conditions become unacceptable for favourable pedestrian activities and mitigation measure should be accounted for.

Mitigation measures include:

- Landscaping: the use of vegetation to protect buildings from wind
- Sculptural screening (solid or porous): to either deflect the wind or bleed the wind by removing its energy.
- Canopies and Wind gutters: horizontal canopies are used to deflect the wind and redirect the wind around the building and above the canopy.

In particular, it is possible to summarise the different flow features and the corresponding mitigation option as follows (Figures 10.24 and 10.25):

- **Downwash Effects:** when wind hits the windward face of a tall building, the building tends to deflect the wind downwards, causing accelerated wind speeds at pedestrian level and around the windward corners of the building. This can occur when Tall and wide building facades face the prevailing winds.

- **Downdraft Effects**: When the leeward face of a low building faces the windward face of a tall building, it causes an increase in the downward flow of wind on the windward face of the tall building. This results in accelerated winds at pedestrian level in the space between the two buildings and around the windward corners of the tall building.

Mitigation Measures**:**

- To mitigate unwanted wind effects, it is recommended to introduce a base building or podium with a step back and setting back a tower relative to the base building, the downward wind flow can be deflected, resulting in reduced wind speed at pedestrian level.
- Landscaping the base building roof and tower step back, wind speeds at grade can be further reduced, and wind conditions on the base building roof can improve.

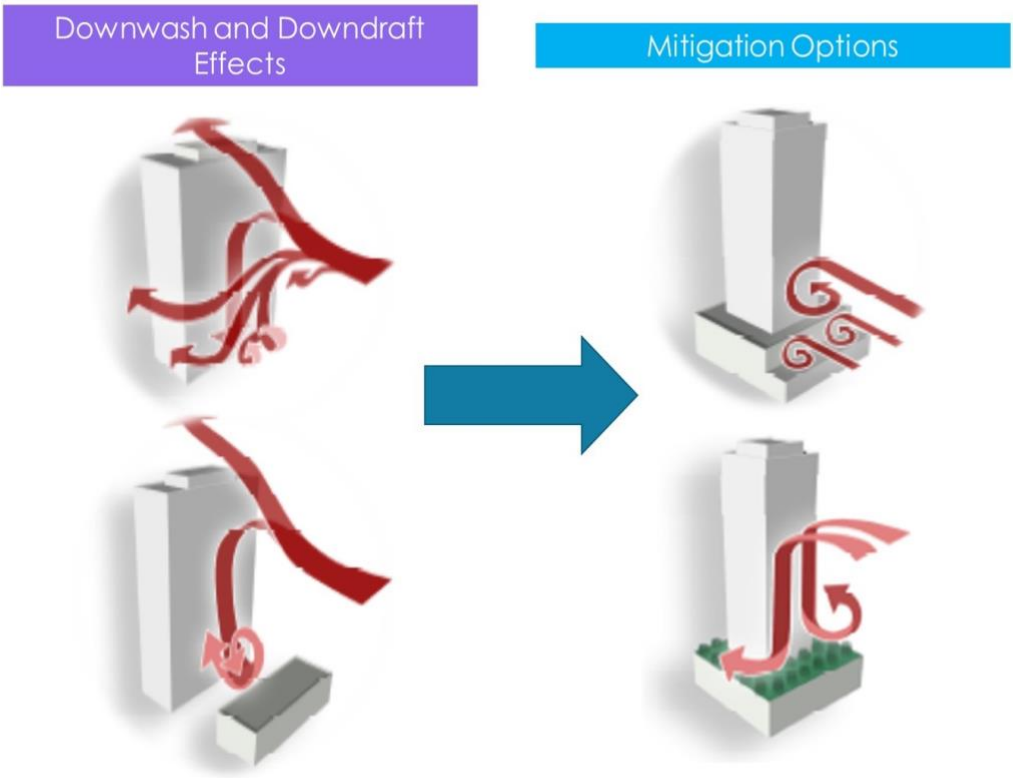


Figure 10.24.: Mitigation Measures for Downwash and Downdraft Effects

- **Funnelling Effects**: Wind speed is accelerated when wind is funnelled between two buildings. This is referred to as the "wind canyon effect". The intensity of the acceleration is influenced by the building heights, size of the facades, building separation distance and building orientation. Similar effect can be noticed when a bridge is connecting two buildings, the wind passing below the bridge is accelerated, therefore pedestrians can experience high uncomfortable velocities of wind.

  Mitigation Measures:

  - A horizontal canopy on the windward face of a base building can improve pedestrian level wind conditions. Parapet walls around a canopy can make the canopy more effective.
  - Sloped canopies only provide partial deflection of downward wind flow.

- A colonnade on the windward face of the base building provides the pedestrian with a calm area where to walk while being protected or a breeze walking space outside the colonnade zone.

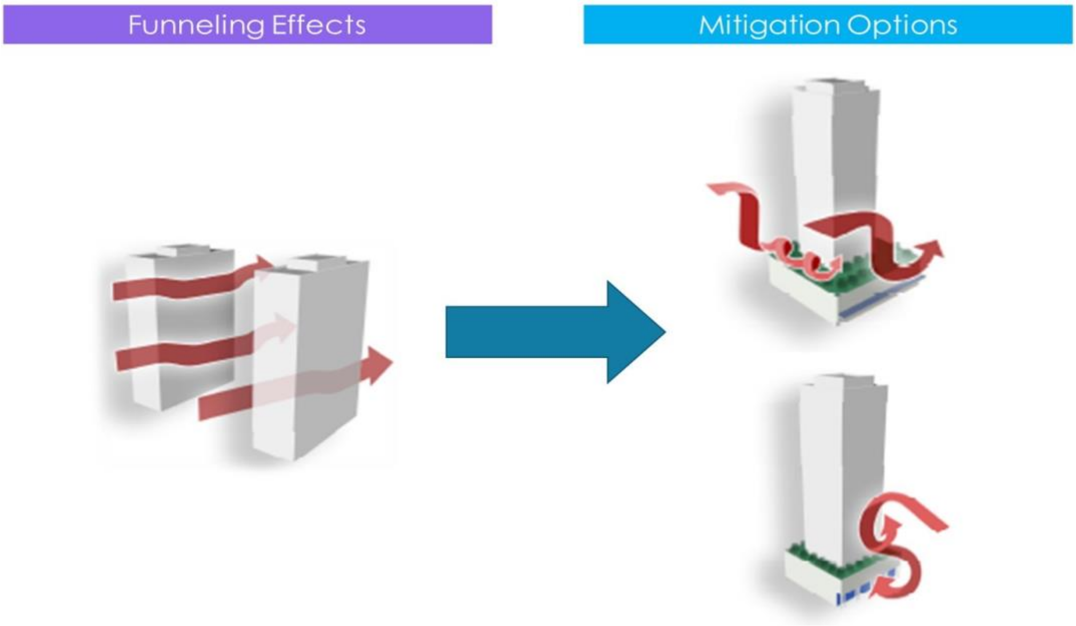


Figure 10.25: Mitigation Measures for Funnelling Effects

Landscape Trees Modelling (Using Porous Media)

Through CFD Modelling, it is possible to implement the effects of landscaping trees on the wind flowing through an urban environment. Urban landscape managers, local authorities and architects can now observe and assess the effects of landscaping trees in their urban landscape models. The landscape trees are simulated as comprising effects of porous zones within the urban environments. This is an essential tool for accurately assessing the actual wind speed and pattern at a pedestrian level when landscape is available. Figure 10.27. shows the modelling approach of utilizing porous media within the CFD numeric code to implement the effect of landscape within the Proposed development.

Figure 10.26: Orientation of Lands at St. Teresa's Project

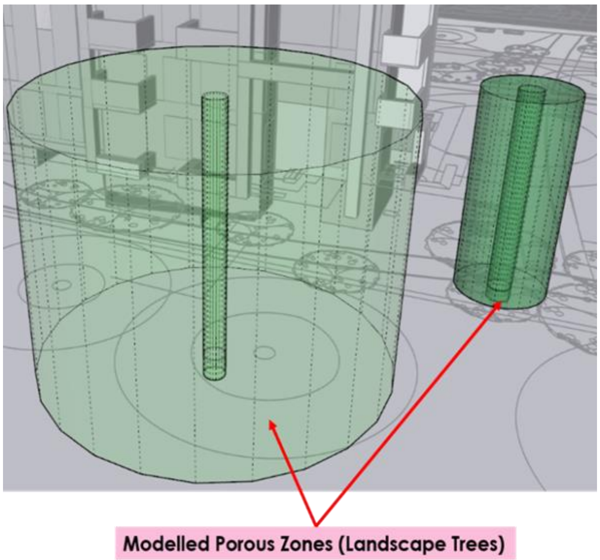


Figure 10.27.: Modelling Landscape Trees as Porous Zones

10.7. Potential Impacts of the Proposed Development

This section sets out the assessment of the potential impact of the proposed development on the already existing environment, and the suitability of the proposed development to create and maintain a suitable and comfortable environment for different pedestrian activities.

In order to conduct the wind comfort assessment, Figure 10.28 and Figure 10.29 shows the orientation of the development.

Figure 10.28: Orientation of Lands at St. Teresa's Project

Figure 10.29: Orientation of Lands at St. Teresa's Project

<u>Wind From South-West</u>

The different flow features are indicated in Figure 10.30 by letters and discussed in the following text. It should be kept in mind that the presented flow pattern is only indicative and based on experience and fundamental fluid mechanical principles and does not reflect the real flow vector in magnitude and direction.

The wind will flow through the West buildings, that provide a good shielding for the entire development and the central park land. The landscape implemented seem to guarantee a good shielding of the areas around the units. No issues are found to be critical in terms of safety.

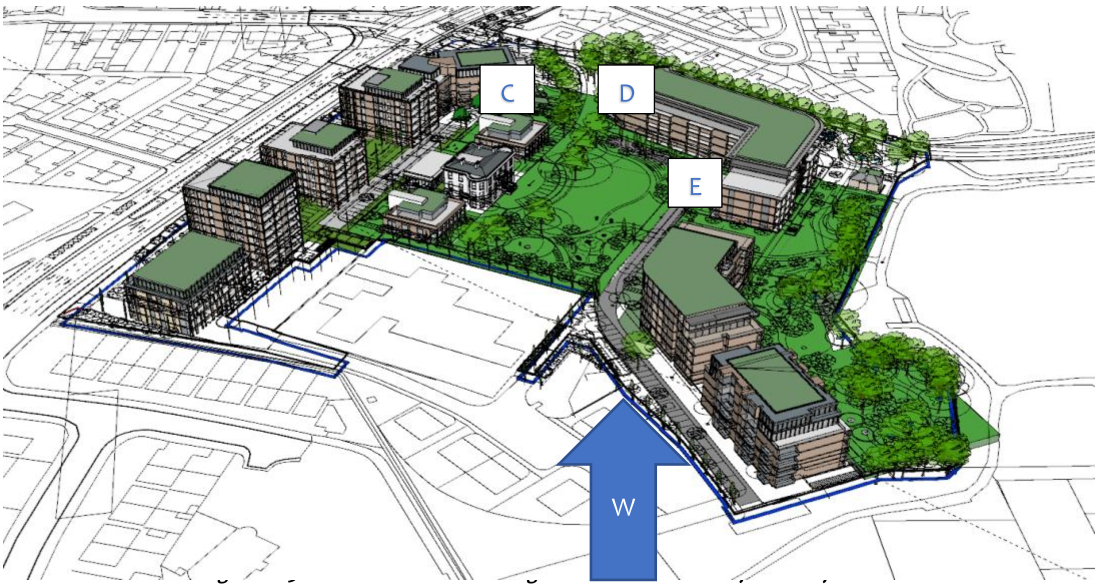
Higher velocities and funnelling effects could be experienced in areas A and B. However, possible solutions for this could be horizontal canopies on the windward face of a base building, which improve pedestrian level wind conditions. Parapet walls around a canopy can make the canopy more effective. Sloped canopies only provide partial deflection of downward wind flow. The use of rows of trees on either sides of the roads corresponding to these three areas have been implemented to contrast the above effects. It must be considered also that the Southwest wind will be mitigated at the entrance by flowing through the large courtyard, this area is provided with trees, and it is enveloped by buildings of similar heights. The flow will lose speed once entering the courtyard from the South-West direction.

Figure 10.30: Flow around the Buildings at St. Teresa's House for Wind from Southwest

Wind From West

The wind will flow through the avenue, which is well shielded by the vegetation. The landscape implemented seem to guarantee a good shielding of the areas around the units. There are no critical issues arising.

The existing St Teresa's House, a Protected Structure, in the main central parkland will deviate the airflow along its west and east façades towards the buildings that are at the back (C and D). An air circulation zone is expected in E that can cause downwash effect. However, this seems to be mitigated by the presence of the trees.



Wind From South-East

The wind will flow through the avenue, which is well shielded by the vegetation. The landscape implemented seem to guarantee a good shielding of the areas around the units. There are no critical issues arising. An air circulation zone is expected in F. In this area as it can be seen there is different height between Buildings number B3 and B4 which can cause Downdraft effect in this area. However, this seems to be mitigated by the presence of the trees.

Figure 10.32: Flow around the Buildings at St. Teresa's development for Wind from South-East

CFD Model Details of The Proposed Development

This subsection describes all features included in the geometrical and physical representation of Proposed development CFD model. Any object which may have significant impact on wind movement and circulation are represented within the model. To be accurate, the structural layout of the building being modelled should include only the obstacles, blockages, openings and closures which can impact the wind around the building. It is important to remember that a CFD simulation approximates reality, so providing more details of the geometry within the model will not necessarily increase the understanding of the bulk flows in the real environment.

Modelled Geometry

The modelled layout and dimensions of the surrounding environment are outlined in the table below (Table 10.3.).

In order to represent reality and consider the actual wind impacting on the site, the modelled area for the wind modelling study comprises a wider urban area of 2km² around the Proposed development.

	Modelled CFD Environment Dimensions		
	Width	Length	Height
CFD Mesh Domain	1500m approx.	1500m approx.	60m approx.

Table 10.3: Modelled Environment Dimensions

Boundary Conditions

A rectangular computational domain was used for the analysis. The wind directions were altered without changing the computational mesh. For each simulation scenario, an initial wind velocity was set according to the statistical weather data collected in order to consider the worst-case scenario. Building surfaces within the model are specified as 'no slip' boundary conditions. This condition ensures that flow moving parallel to a surface is brought to rest at the point where it meets the surface. Air flow inlet boundaries possess the 'Inlet' wind profile velocity patch boundary condition with its appropriate inflow turbulence intensity and dissipation rates. Air exits the domain at the 'pressure outlet' boundary condition.

The wind velocity data provided by the historical data collection and by the local data measuring are used in the formula below for the logarithmic wind profile to specify the wind velocity profile (wind velocity at different heights) to be applied within the CFD model:

$$v_2 = v_1 \cdot \frac{ln\frac{h_2}{z_0}}{ln\frac{h_1}{z_0}}$$

Figure 10.33.: Equation of logarithmic wind profile

where:

- v_1 = wind speed measured at the reference height h_1
- h_1 = reference height to measure v_1
- h_2 = height of the wind speed v_2 calculated for the wind profile
- z_0 = 0.4 [m] roughness length selected (see table in Figure 10.32. below)

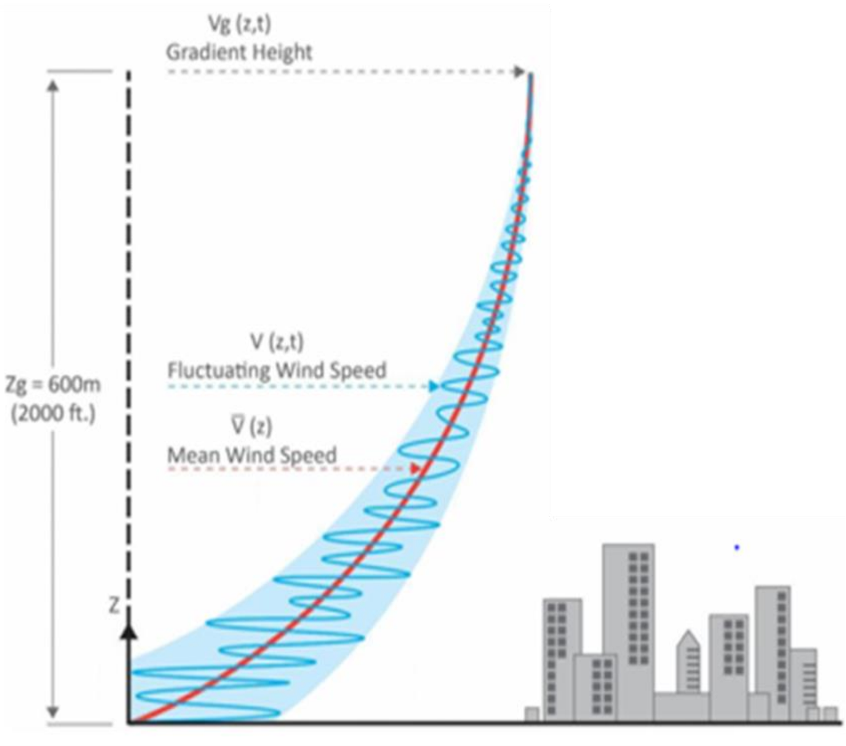


Figure 10.34.: Roughness length and class to be used for the logarithmic wind profile

Computational Mesh

The level of accuracy of the CFD results are determined by the level of refinement of the computational mesh. Details of parameters used to calculate the computational mesh are presented in Table 10.4. Figure 10.35. shows the mesh utilised in the simulations.

The grid follows the principles of the 'Finite Volume Method', which implies that the solution of the model equations is calculated at discrete points (nodes) on a three-dimensional grid, which includes all the flow volume of interest. The mathematical solution for the flow is calculated at the centre of each of these cells and then an interpolation function is used by the software to provide the results in the entire domain.

Parameters To Calculate Computational Mesh	
Air Density	1.2 kg/m^3
Ambient Temperature (T)	288 K (approx.15°C)
Gravity Acceleration (g)	9.8m/s^2
dx	0.5 m at the building 1 m in the surroundings 2 m elsewhere
Mesh Cells Size	0.1 m (ratio 1:1)
Total Mesh Size	Approx. cells number = 26 million

Table 10.4: Parameters to Calculate Computational Mesh

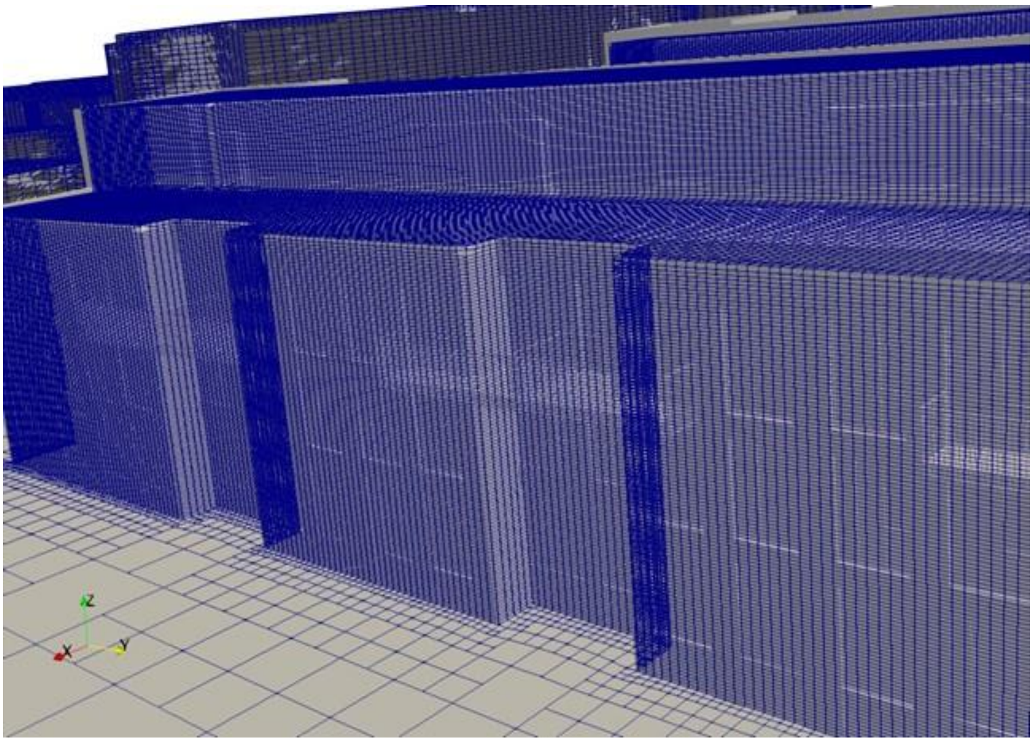


Figure 10.35.: Computational Mesh Utilized

Construction Phase

The possible effects on wind micro-climate at the site during the construction phase of Proposed development has not been directly assessed but was evaluated based on professional judgement. Statistical Dublin historical wind data have been used to carry out this analysis based on the fact that the dominant wind direction is from South-West.

As the finalization of the development proceeds, the wind setting at the site would progressively conform to those of the completed development. It is possible that in the final stages of construction, implementation of the mitigation measures would be needed in areas that are expected to be windier than others should in case some areas of the site are expected to be functional before the construction is finalized.

Due to the fact that windier conditions are acceptable within a construction area (not accessible to the public), and the proposed development would not be the reason for critical wind conditions on-Site (and are slightly calmer when the development is in site), the impacts evaluated on-Site are considered to be insignificant. Thus, the predicted impacts during construction phase are identified as not significant or negligible.

In summary, as construction of the Proposed development progresses, the wind conditions at the site would gradually adjust to those of the completed development. During the construction phase, predicted impacts are classified as negligible.

Operational Phase

This section shows CFD results of wind and microclimate assessment carried out considering the" Operational Phase" of Proposed development. In this case the assessment has considered the impact of wind on the existing area including the Proposed development. For this scenario, Proposed development has been simulated. Wind simulations have been carried out on all the various directions for which the development could show critical areas in terms of pedestrian comfort and safety. For this, the Lawson and Distress Maps have been presented to identify the suitability of each area to its prescribed level of usage and activity. The results present parameters outlined within the acceptance criteria previously described.

It is also of interest at this point to underline once more the objectives of simulations performed. In particular:

- Pedestrian Wind Comfort and Safety Studies are conducted to predict, assess and, where necessary, mitigate the impact of the development on pedestrian level wind conditions.

- To assess comfortable and safe pedestrian level wind conditions that are appropriate for the intended use of pedestrian areas. Pedestrian areas include sidewalks and street frontages, pathways, building entrance areas, open spaces, public spaces, amenity areas, outdoor sitting areas, etc.

Results of simulations carried out are detailed in the following sections. These results present parameters as outlined in the acceptance criteria section described previously for Proposed development. Results of wind flow speeds are collected throughout the simulation and analysed based on the Lawson Discomfort Criteria.

Figure 10.37. shows an example of wind data mapped on surface, located at 1.5m above the ground. The scale used for all flow velocity results is set out in Figure 10.36. Red colours indicate critical values while blue colours indicate tenable conditions.

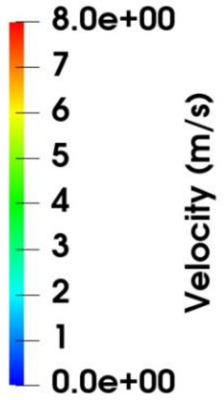


Figure 10.36.: Velocity Colour Map

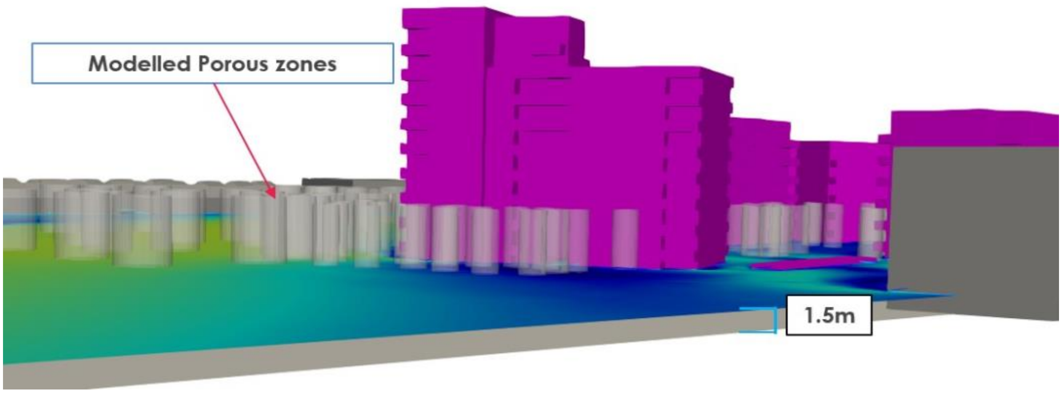


Figure 10.37.: An example of wind data mapped on surface at 1.5m above the ground

Flow Velocity Results - Ground Floor Level

Results of wind speeds and their circulations at pedestrian level of 1.5m above the development ground are presented in Figures 10.38. to 10.51. in order to assess wind flows at ground floor level of the Proposed development.

Wind flow speeds are shown to be within tenable conditions. Some higher velocity indicating minor funnelling effects are found near the South-West side of the development. However, as it can be seen, both areas were mitigated with landscaping and the flow velocities shown in the Lawson map indicate that the areas can be utilised for the intended use (such as entrances and pedestrian walking area).

Therefore, it can be concluded that the wind speeds do not attain critical levels around the development. The courtyard area between the blocks is well protected. According to the Lawson Criteria (described in the next sections), this area is suitable for all different pedestrian activities.

Wind 135° Direction

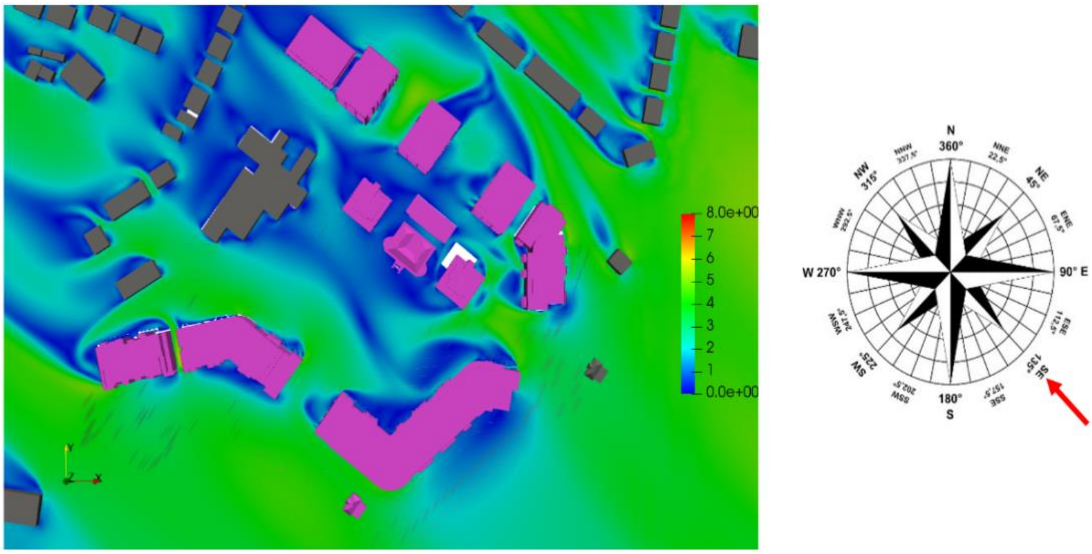


Figure 10.38: Ground Floor Level - Flow Velocity Results at Z=1.5m above the ground - Wind Direction: 135°

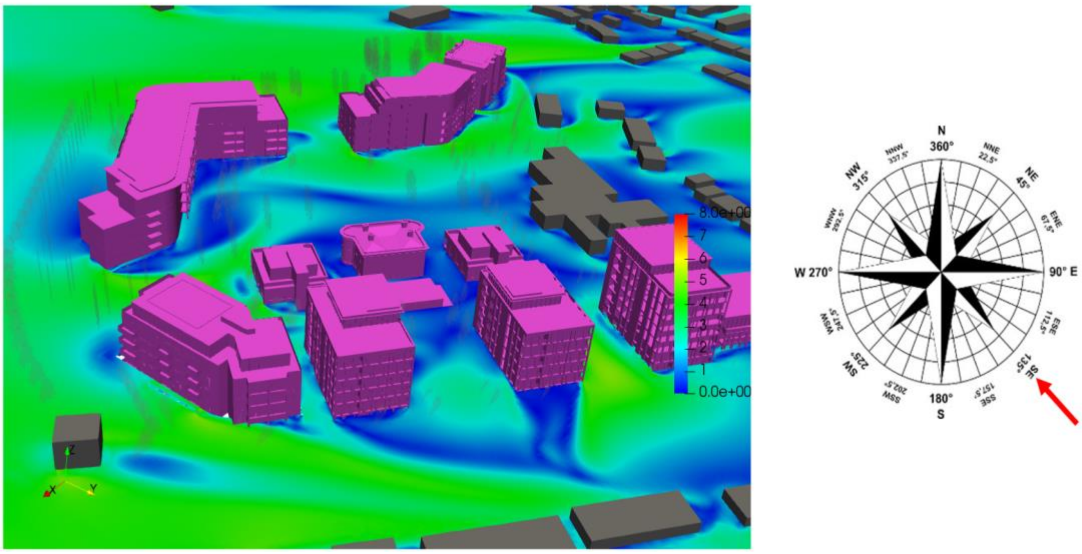


Figure 10.39: Isometric View- Flow Velocity Results at Z=1.5m above the ground - Wind Direction: 135°

Wind 225° Direction

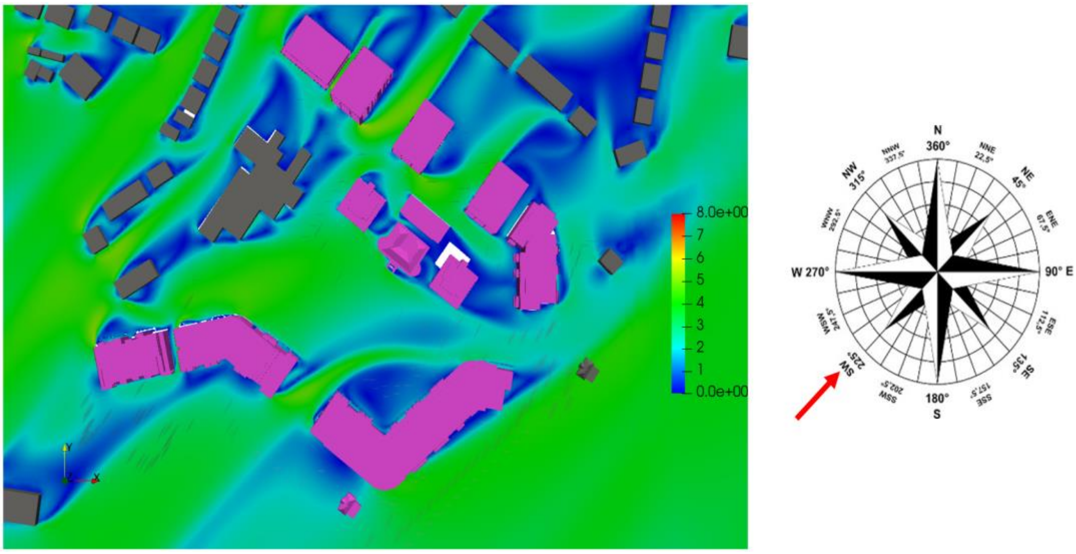


Figure 10.40: Ground Floor Level - Flow Velocity Results at Z=1.5m above the ground - Wind Direction: 225°

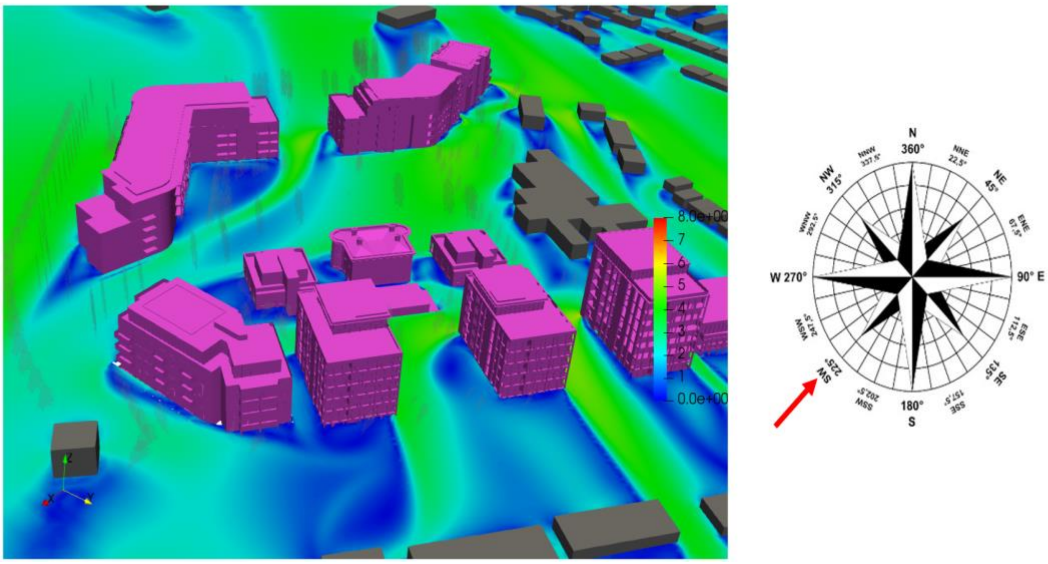


Figure 10.41: Isometric View- Flow Velocity Results at Z=1.5m above the ground - Wind Direction: 225°

Wind 236° Direction

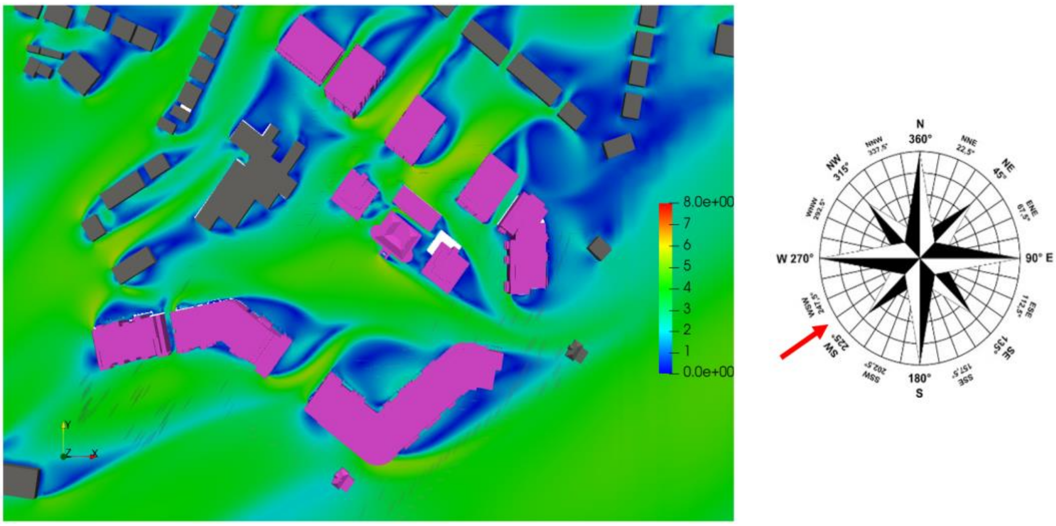


Figure 10.42: Ground Floor Level - Flow Velocity Results at Z=1.5m above the ground - Wind Direction: 236°

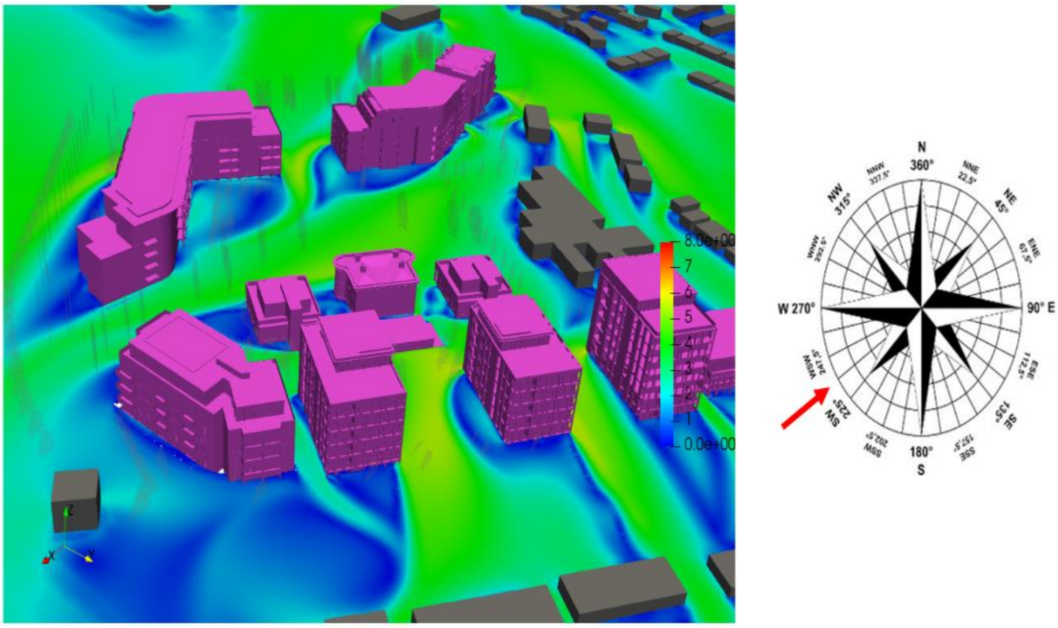


Figure 10.43: Isometric View- Flow Velocity Results at Z=1.5m above the ground - Wind Direction: 236°

Wind 247° Direction

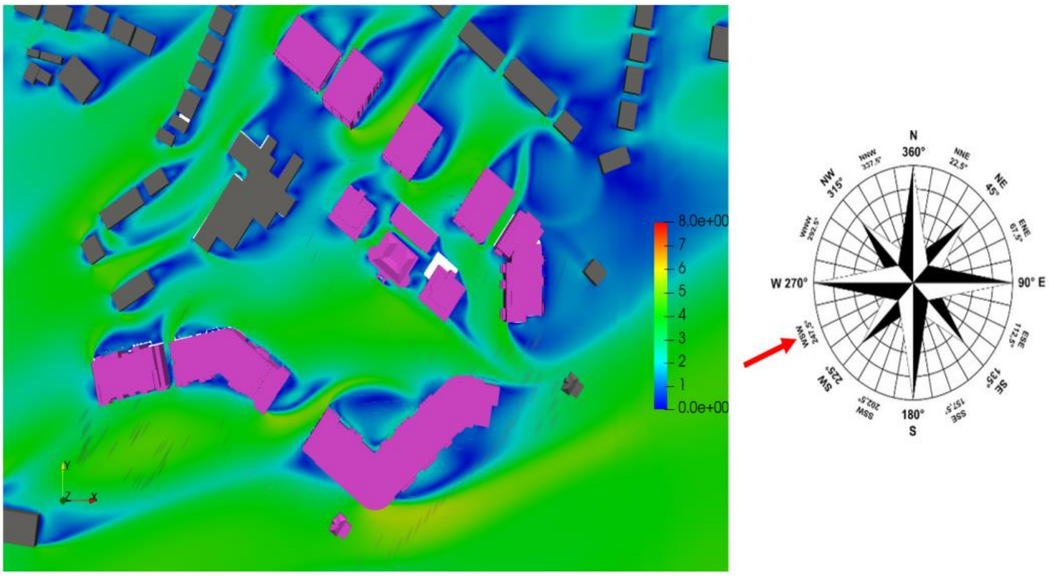


Figure 10.44: Ground Floor Level - Flow Velocity Results at Z=1.5m above the ground - Wind Direction: 247°

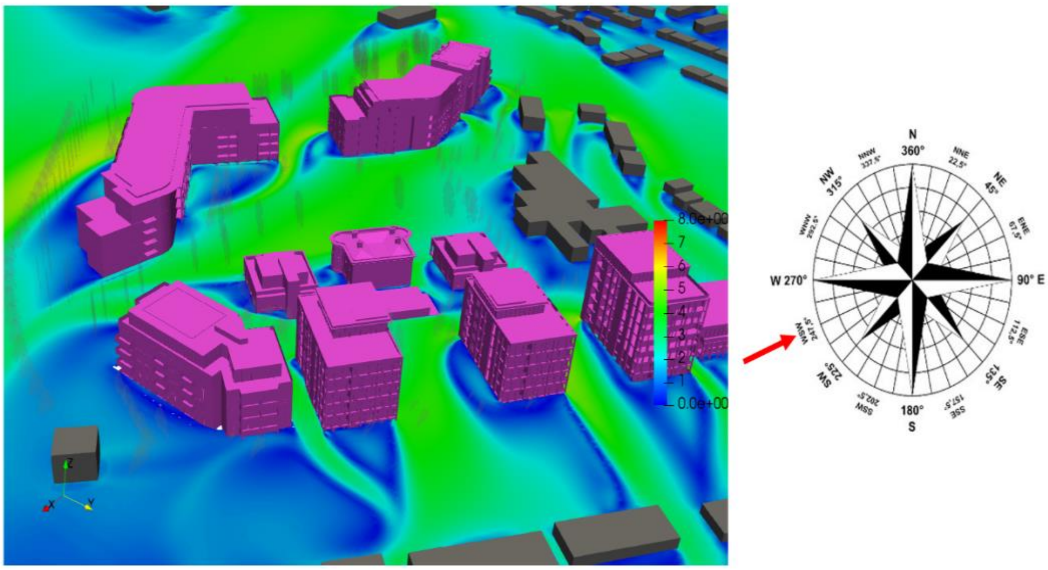


Figure 10.45: Isometric View- Flow Velocity Results at Z=1.5m above the ground - Wind Direction: 247°

Wind 258° Direction

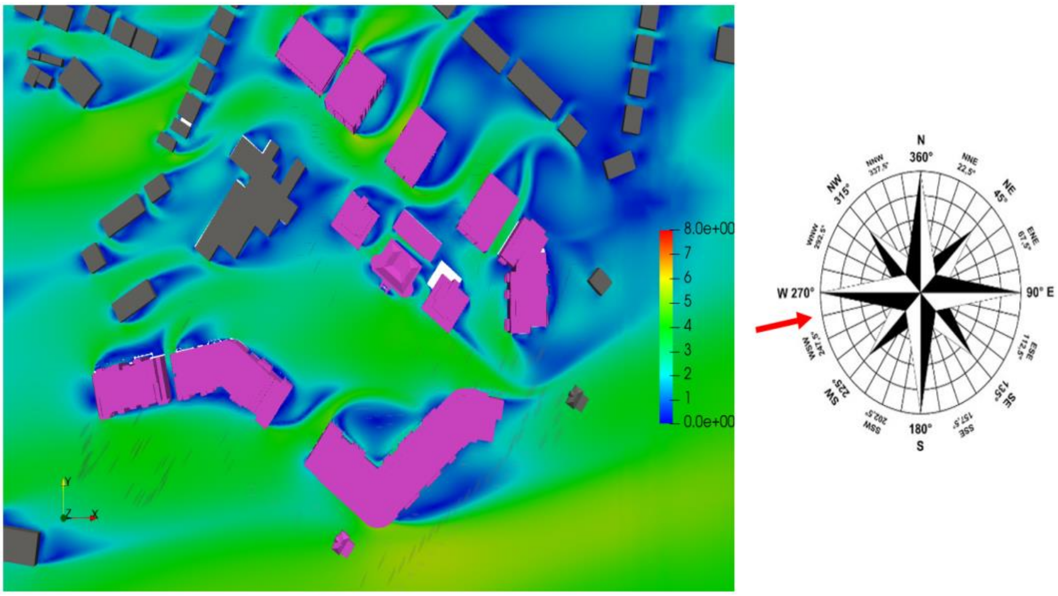


Figure 10.46: Ground Floor Level - Flow Velocity Results at Z=1.5m above the ground - Wind Direction: 258°

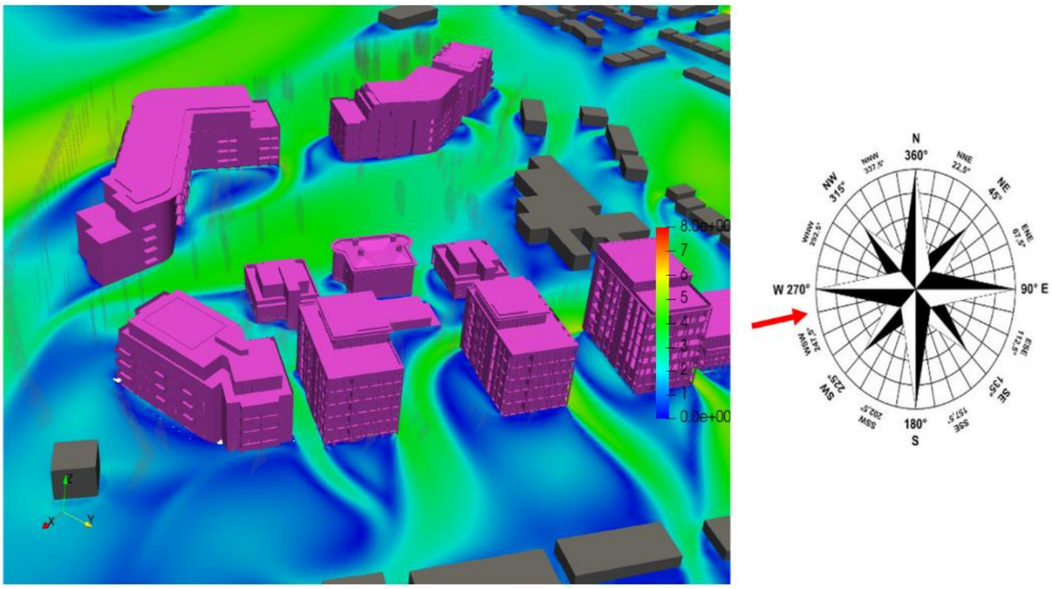


Figure 10.47: Isometric View- Flow Velocity Results at Z=1.5m above the ground - Wind Direction: 258°

Wind 270° Direction

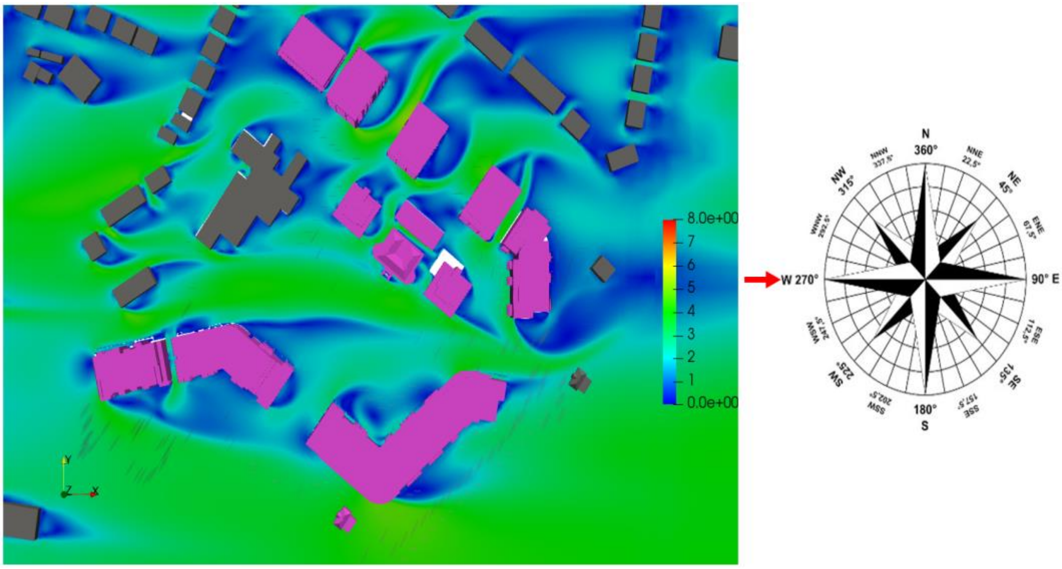


Figure 10.48: Ground Floor Level - Flow Velocity Results at Z=1.5m above the ground - Wind Direction: 270°

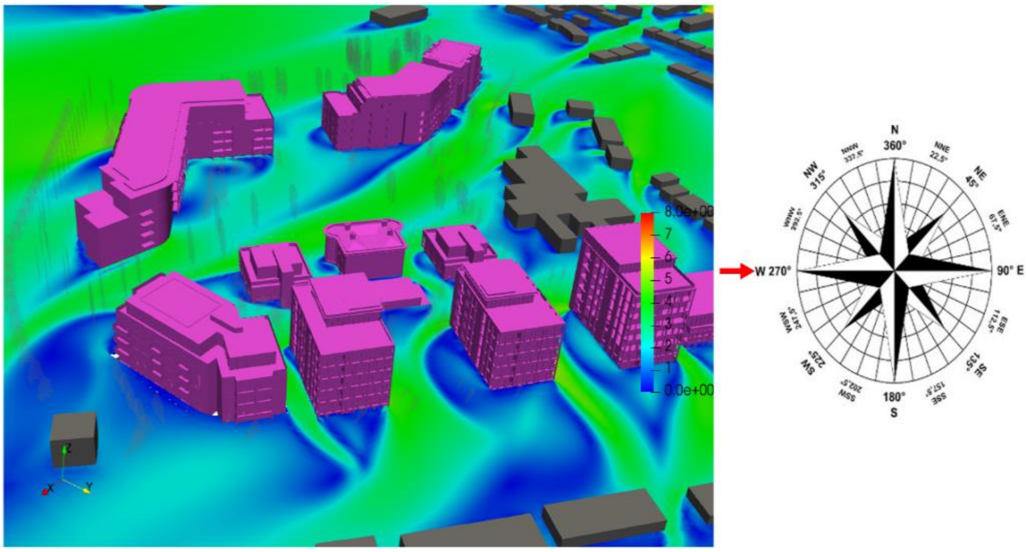


Figure 10.49: Isometric View- Flow Velocity Results at Z=1.5m above the ground - Wind Direction: 270°

Wind 315° Direction

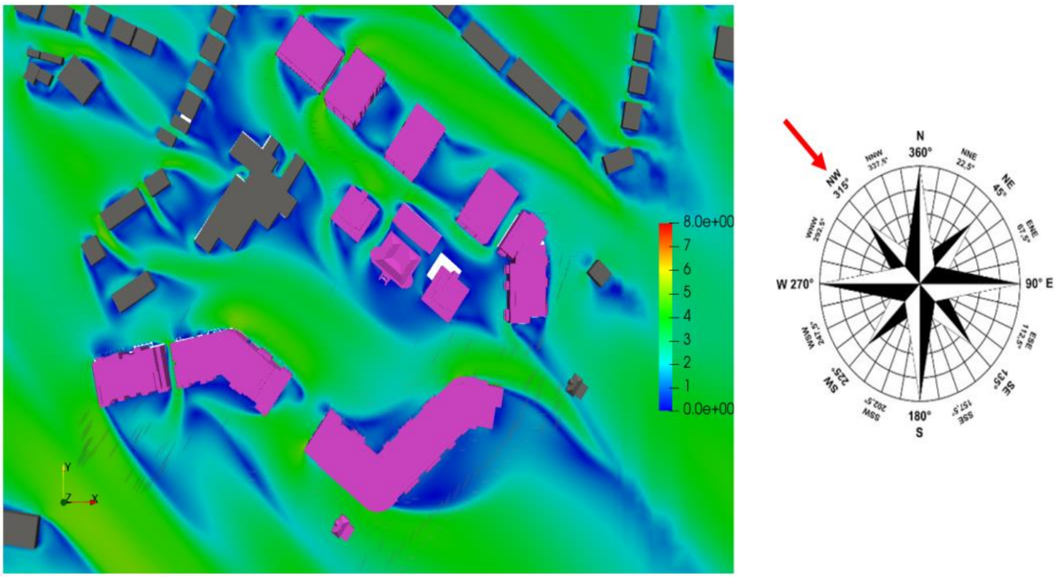


Figure 10.50: Ground Floor Level - Flow Velocity Results at Z=1.5m above the ground -Wind Direction: 315°

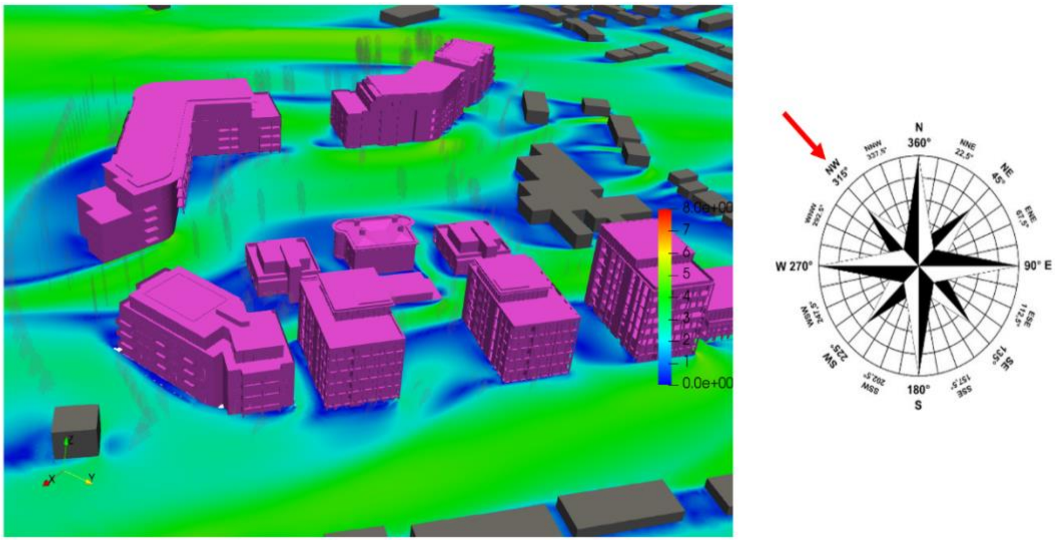


Figure 10.51: Isometric View- Flow Velocity Results at Z=1.5m above the ground - Wind Direction: 315°

Flow Velocity Results - Terraces

Velocity at 1.5m above the terraces for development are presented in Figures 10.52. to 10.72, for wind assessment of the Terraces of the Proposed development (Block B3 and Block B4).

The analysis show that the areas are well protected. The terraces on Block B3 and B4 are suitable for every activity, including long-term sitting. Some small area that is suitable for short-term sitting instead of long-term sitting are noticeable. However, this analysis has been performed considering the worst-case scenario conditions, considering the whole year. Terraces are not areas that are used all year around and long-term sitting is an activity performed during spring/summer months, when the frequency of such high wind is below 5%.

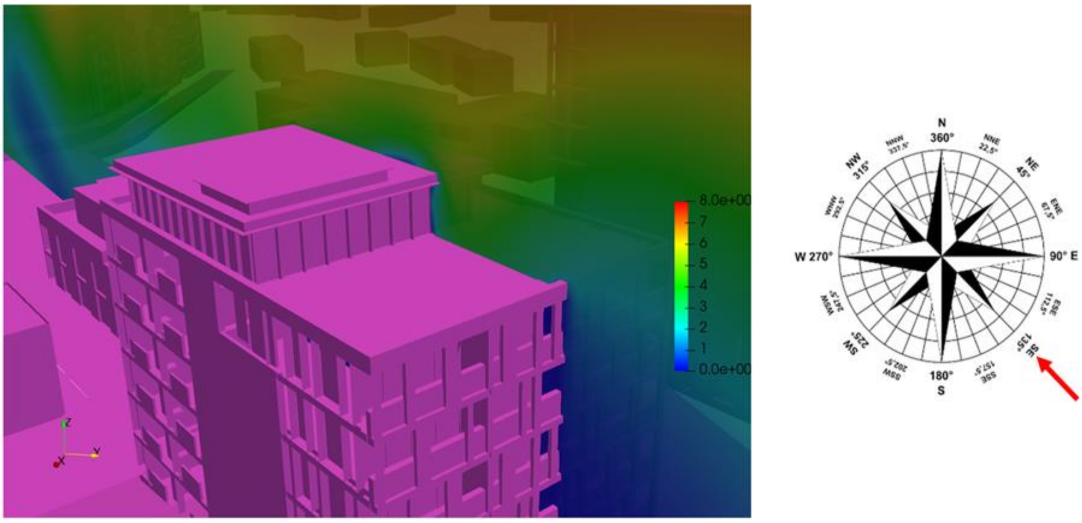


Figure 10.52.: Roof Terraces - Velocity Results across the terrace Wind Direction: 135°

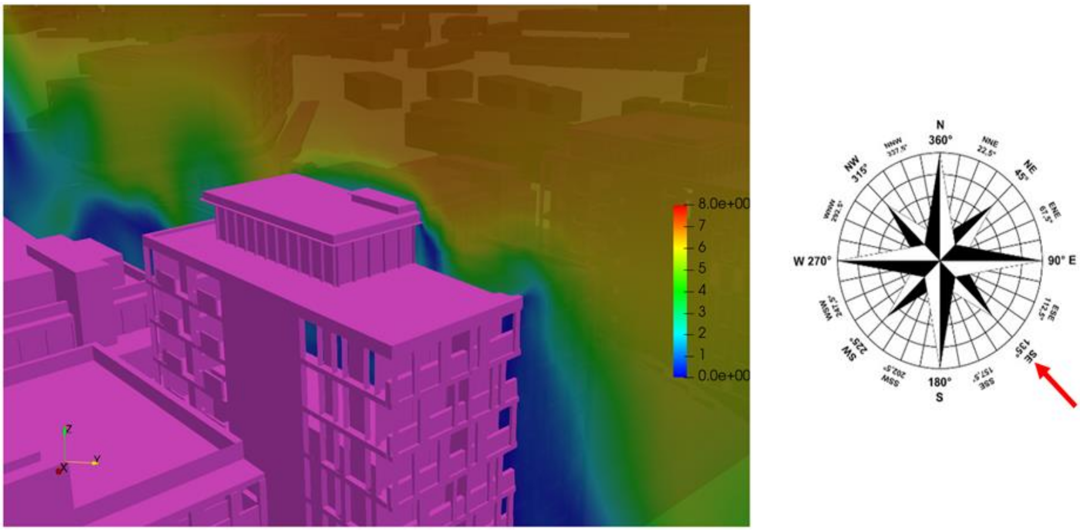


Figure 10.53.: Roof Terraces - Velocity Results across the terrace Wind Direction: 135°

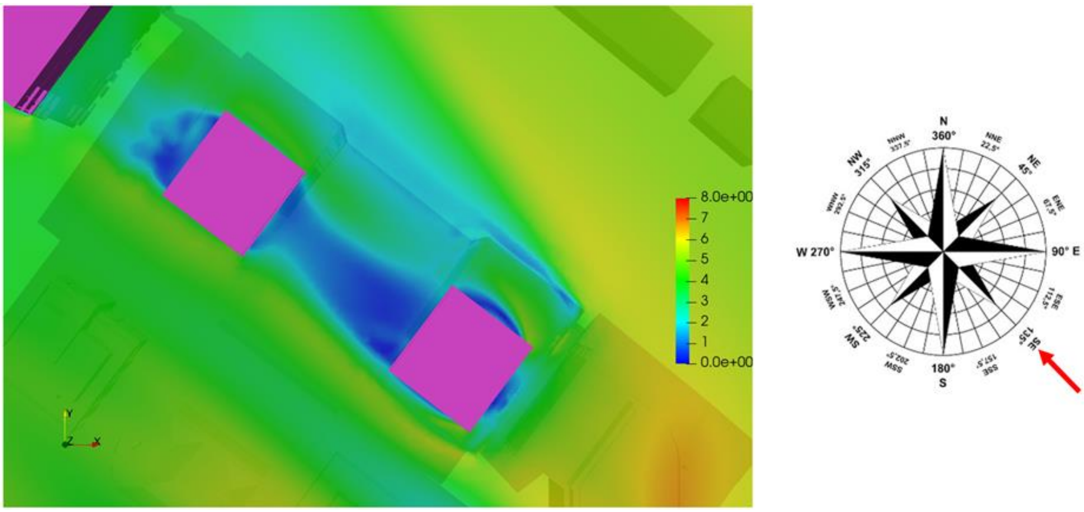


Figure 10.54.: Roof Terraces - Velocity Results at Z=1.5m above the terrace Wind Direction: 135°

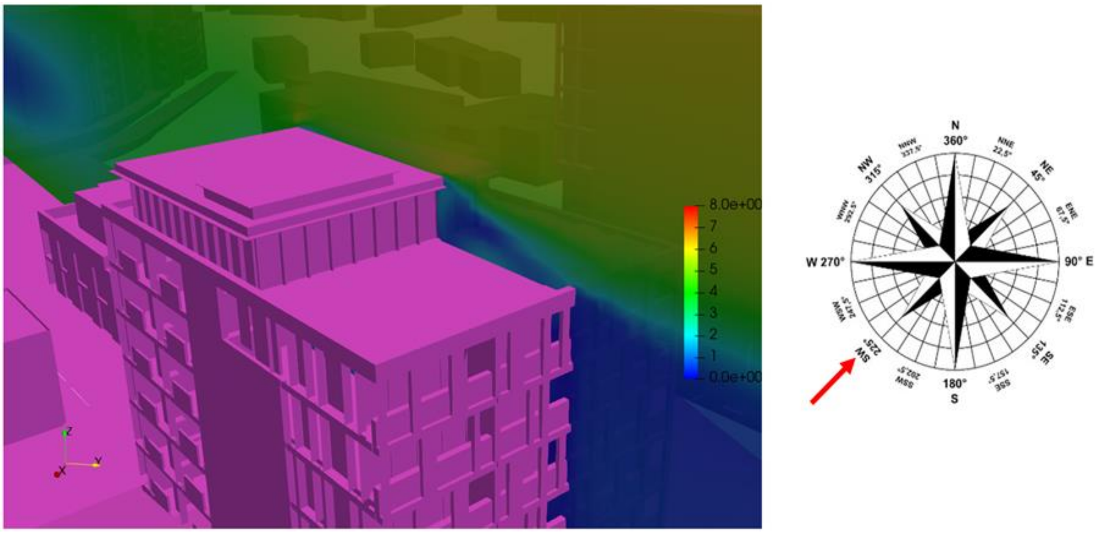


Figure 10.55.: Roof Terraces - Velocity Results across the terrace Wind Direction: 225°

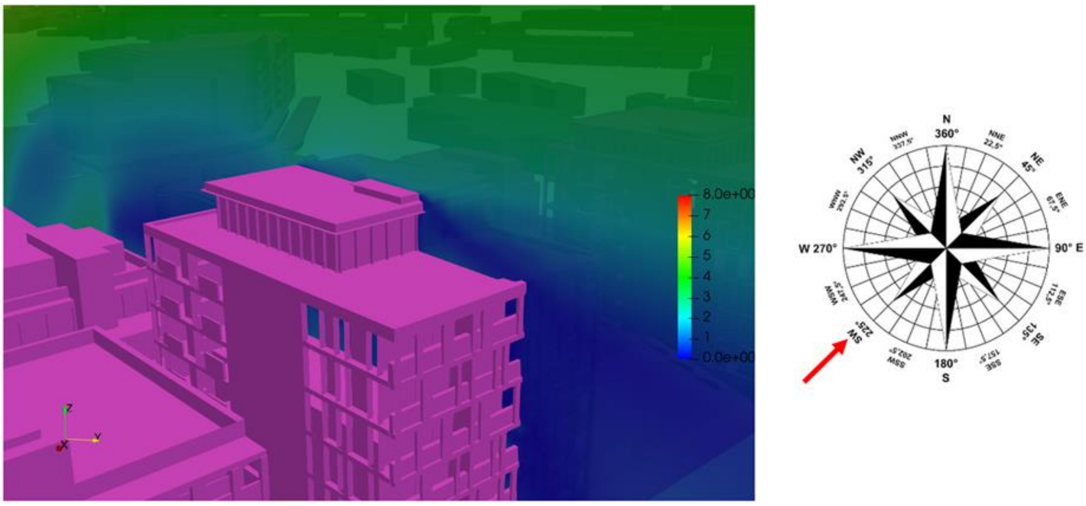


Figure 10.56.: Roof Terraces - Velocity Results across the terrace Wind Direction: 225°

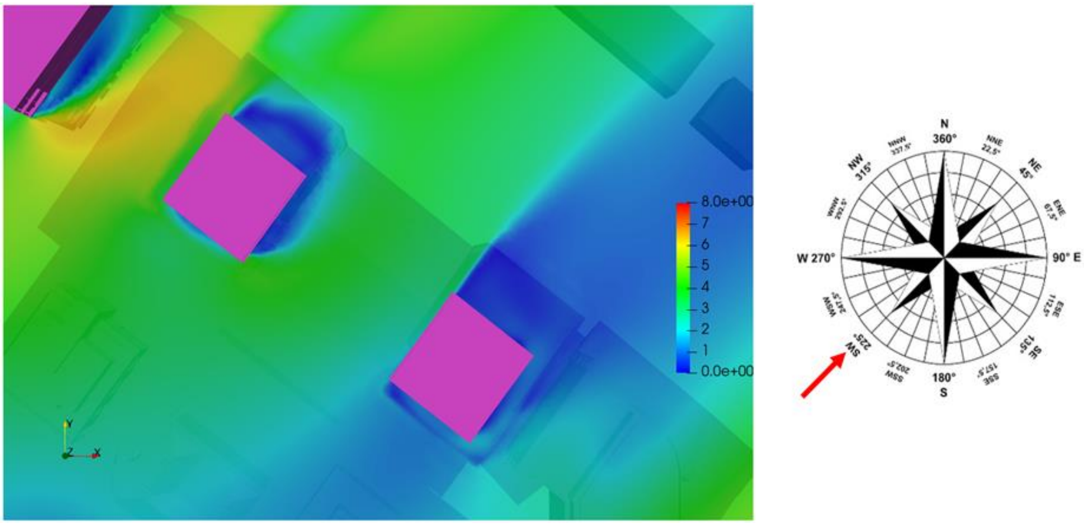


Figure 10.57.: Roof Terraces - Velocity Results at Z=1.5m above the terrace Wind Direction: 225°

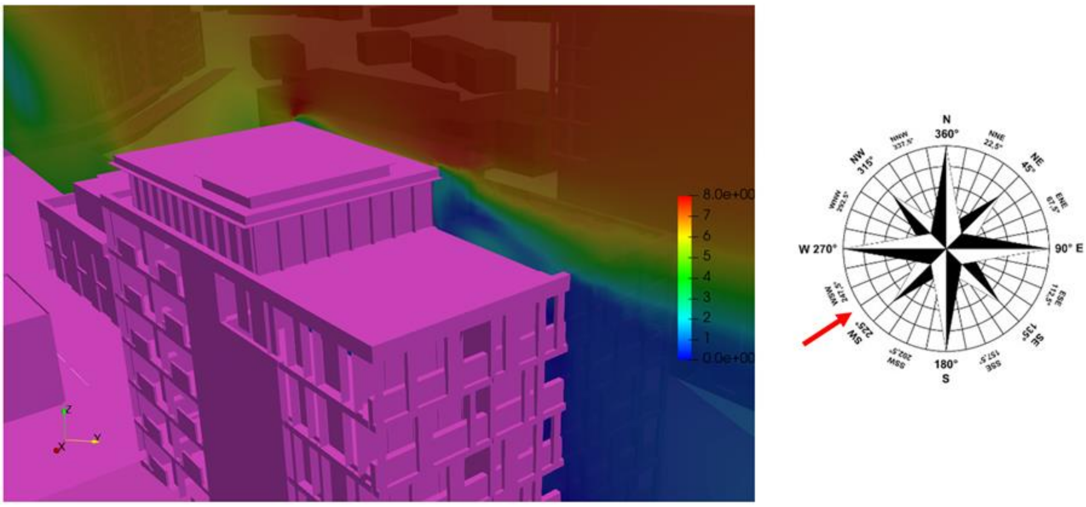


Figure 10.58.: Roof Terraces - Velocity Results across the terrace Wind Direction: 236°

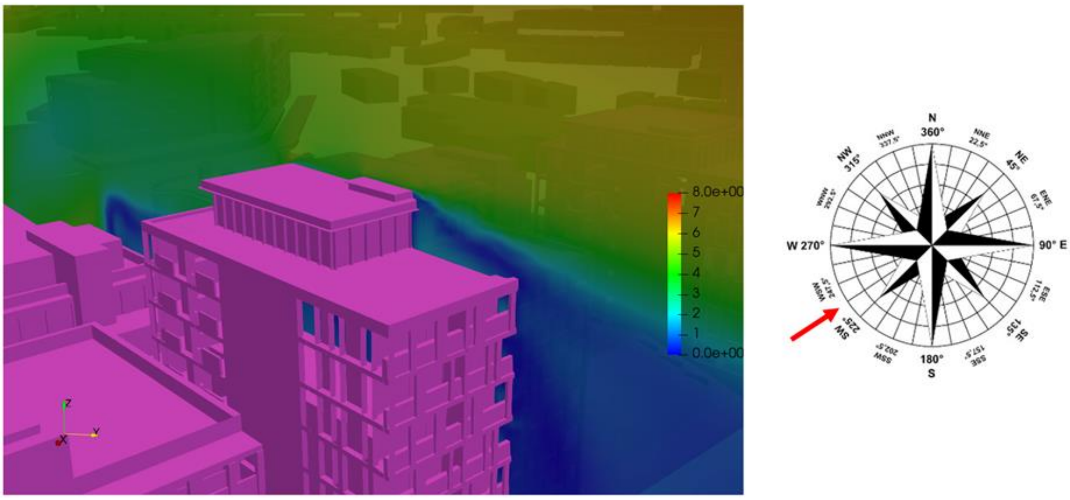


Figure 10.59.: Roof Terraces - Velocity Results across the terrace Wind Direction: 236°

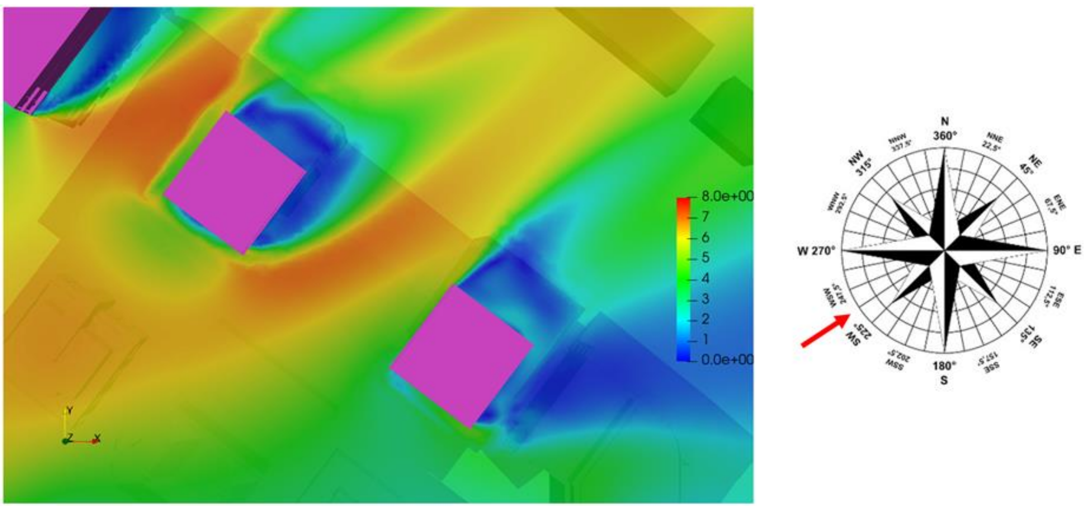


Figure 10.60.: Roof Terraces - Velocity Results at Z=1.5m above the terrace Wind Direction: 236°

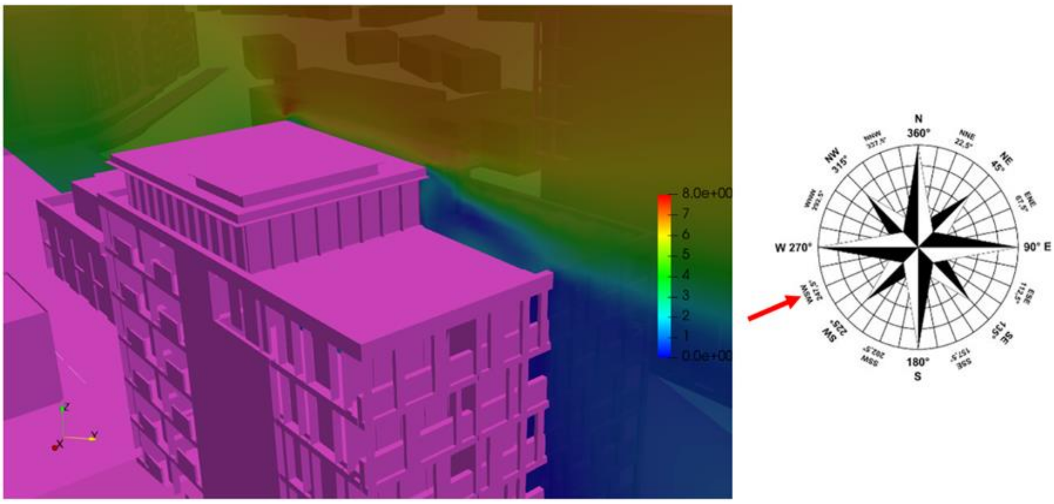


Figure 10.61.: Roof Terraces - Velocity Results across the terrace Wind Direction: 247°

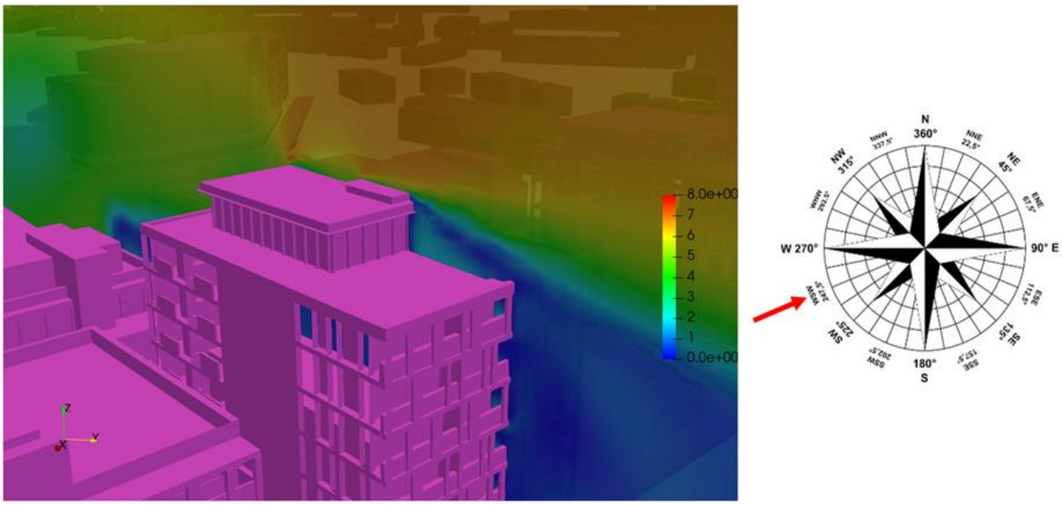


Figure 10.62.: Roof Terraces - Velocity Results across the terrace Wind Direction: 247°

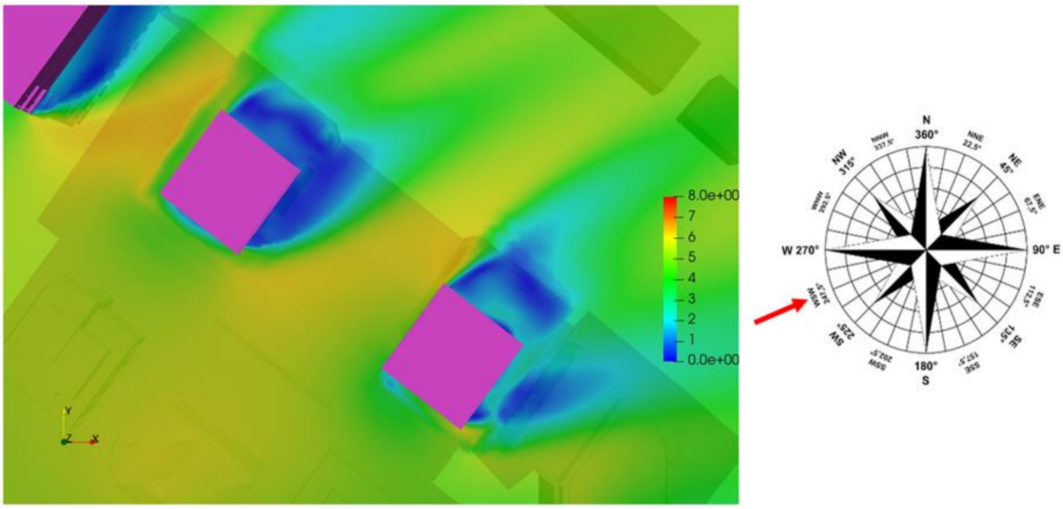


Figure 10.63.: Roof Terraces - Velocity Results at Z=1.5m above the terrace Wind Direction: 247°

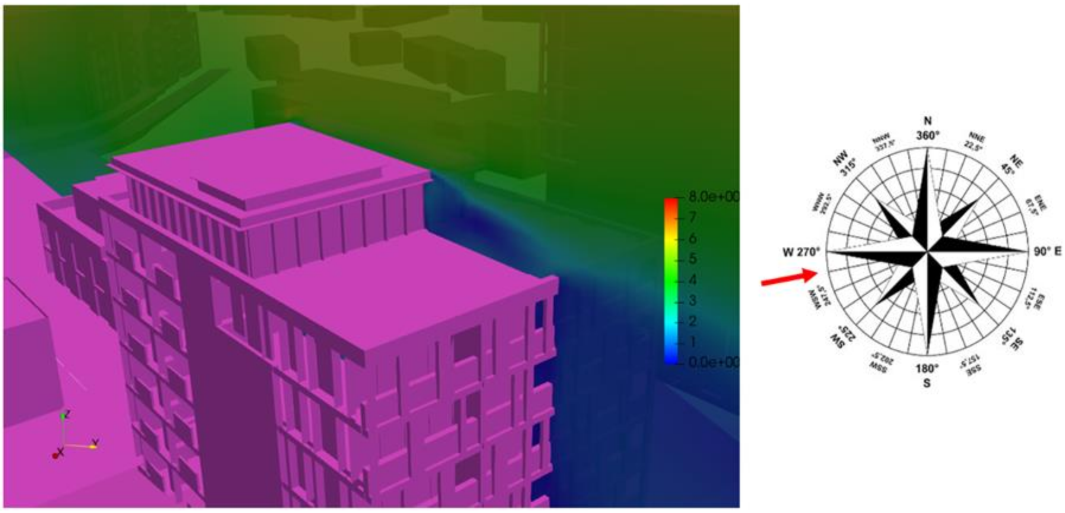


Figure 10.64.: Roof Terraces - Velocity Results across the terrace Wind Direction: 258°

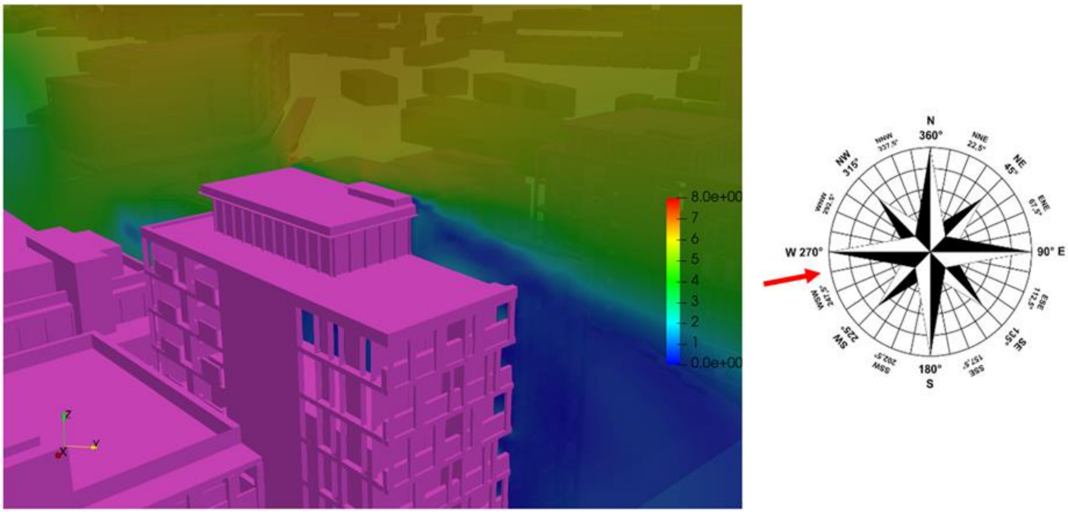


Figure 10.65.: Roof Terraces - Velocity Results across the terrace Wind Direction: 258°

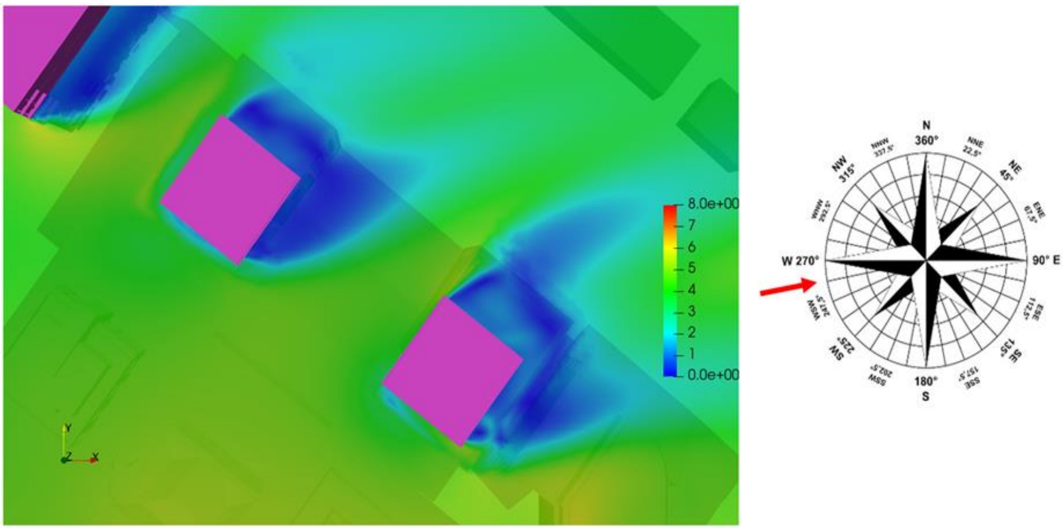


Figure 10.66.: Roof Terraces - Velocity Results at Z=1.5m above the terrace Wind Direction: 258°

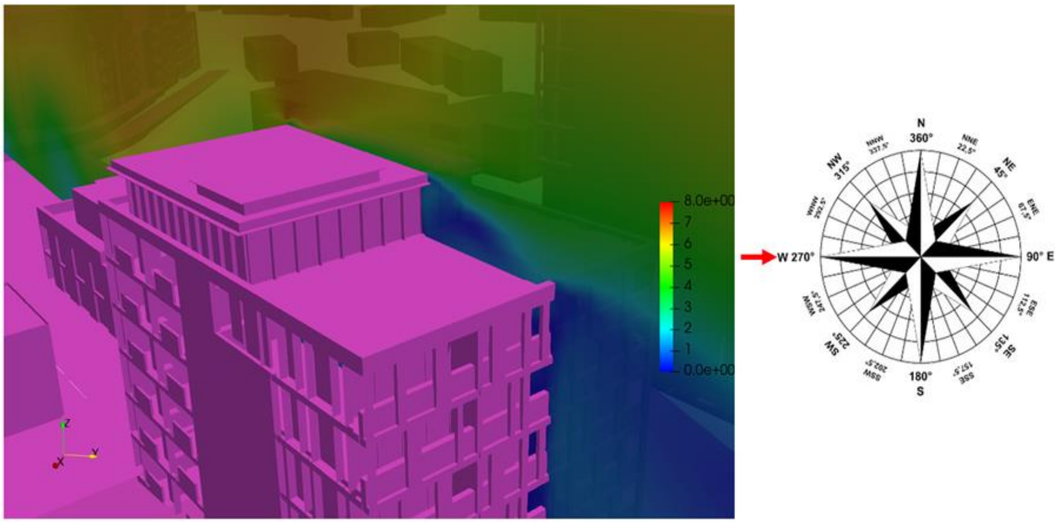


Figure 10.67.: Roof Terraces - Velocity Results across the terrace Wind Direction: 270°

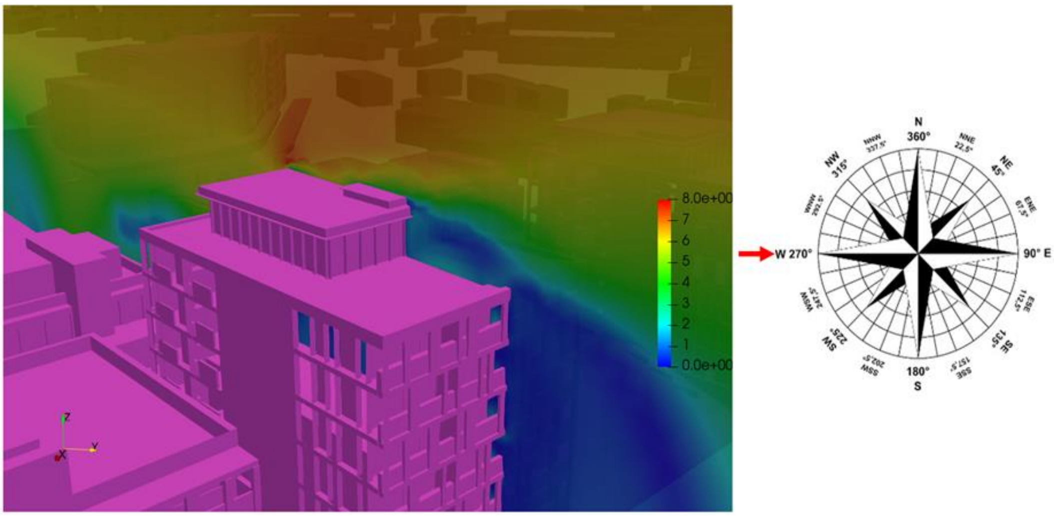


Figure 10.68.: Roof Terraces - Velocity Results across the terrace Wind Direction: 270°

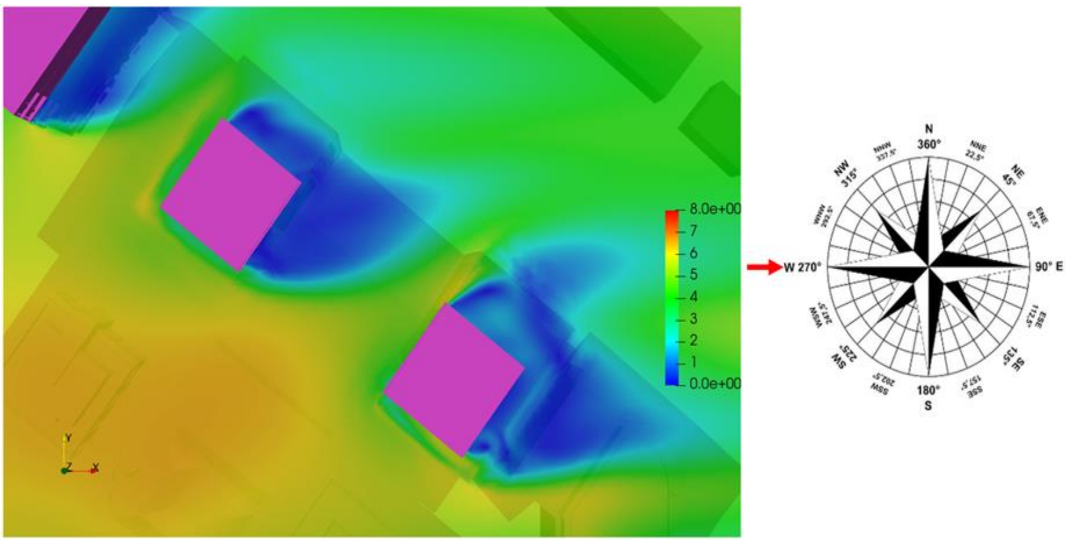


Figure 10.69.: Roof Terraces - Velocity Results at Z=1.5m above the terrace Wind Direction: 270°

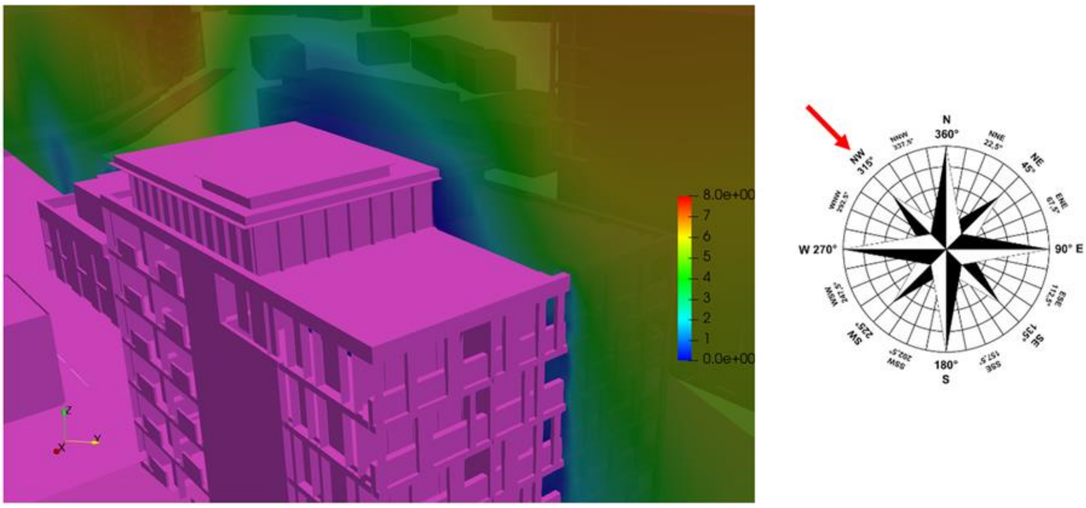


Figure 10.70.: Roof Terraces - Velocity Results across the terrace Wind Direction: 315°

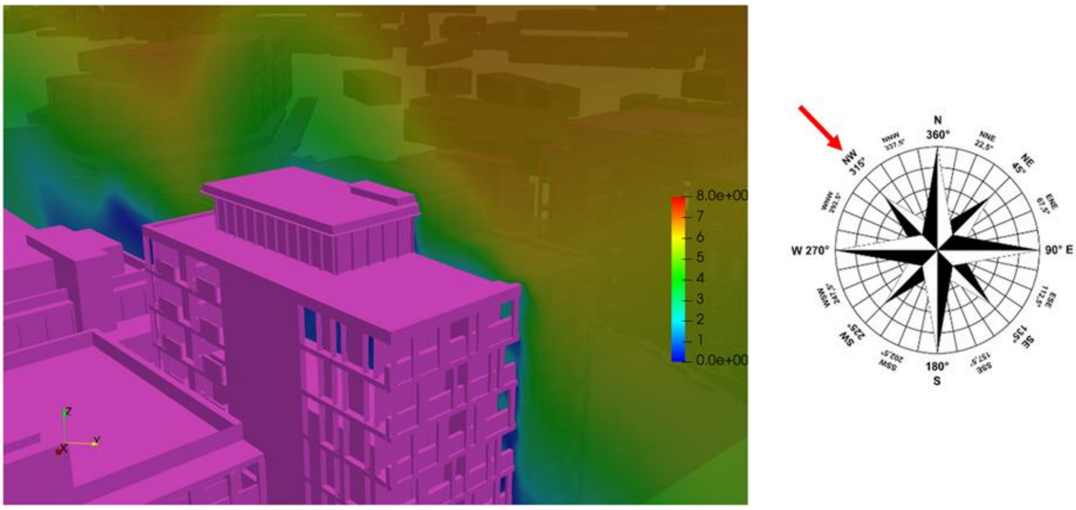


Figure 10.71.: Roof Terraces - Velocity Results across the terrace Wind Direction: 315°

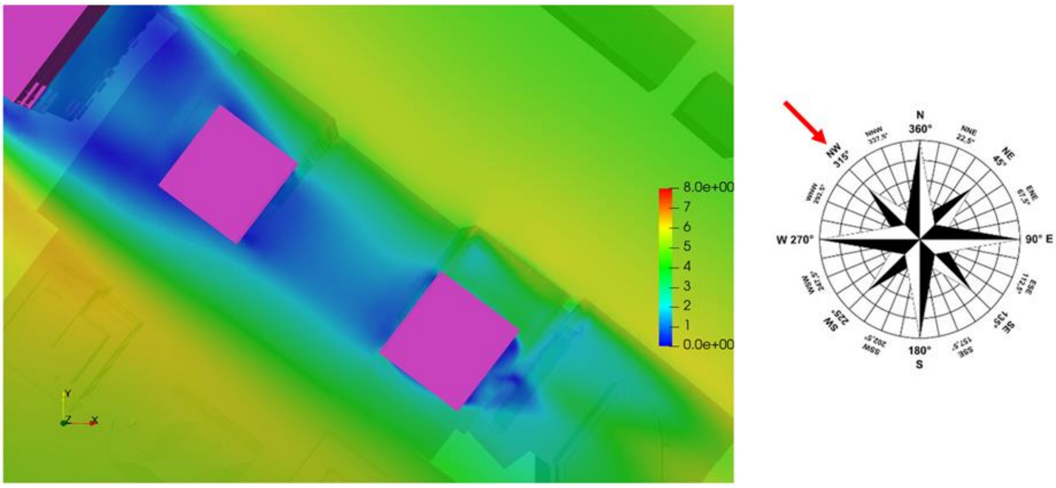


Figure 10.72.: Roof Terraces - Velocity Results at Z=1.5m above the terrace Wind Direction: 315°

10.8. Predicted Impacts of the Proposed Development

The existing environment and proposed development will receive prevailing winds from South-West and South-East. As discussed in the previous sections and demonstrated through this assessment of CFD modelling, all adverse wind impacts have been considered and shown to be suitable to its intended use.

The existing site cumulative assessment has accounted for the modelling and simulation of all the topography and existing developments in the surrounding as the presence of adjacent buildings dictates how the wind will approach the proposed development.

From the wind modelling results, it is predicted that the proposed development will introduce no negative wind effects on adjacent, nearby or future developments within its vicinity.

10.9. Risks to Human Health

This subsection aims to identify areas of proposed development where the pedestrian safety and comfort could be compromised (in accordance with the Lawson Acceptance Criteria previously described). Pedestrian comfort criteria are assessed at 1.5m above ground level.

Discomfort Criteria

Figures from 10.75. to 10.77. show the Lawson comfort categories over the ground floor area around Proposed development. In all cases, the scale used is set out in Figure 10.73.

For the Lawson discomfort criteria, the onset of discomfort depends on the activity in which the individual is engaged, and it is defined in terms of a mean hourly wind speed (or GEM) which is exceeded for 5% of the time. Depending on the wind direction, the suitability of the different areas can be assessed using the maps. It can be seen that the wind conditions range from "suitable for long-term sitting" to "suitable for walking and strolling" and really rarely are only suitable for "business walking" or "unacceptable for pedestrian comfort".

The results shown in these maps show that there are no critical areas which are unacceptable for pedestrian comfort. Some higher velocity indicating minor funnelling effects are found near the South-West side of the development and the area between Block D and F. However, as it can be seen, both areas were mitigated with landscaping and the flow velocities shown in the Lawson map indicate that the areas can be utilised for the intended use.

Figure 10.73.: Lawson Comfort Categories

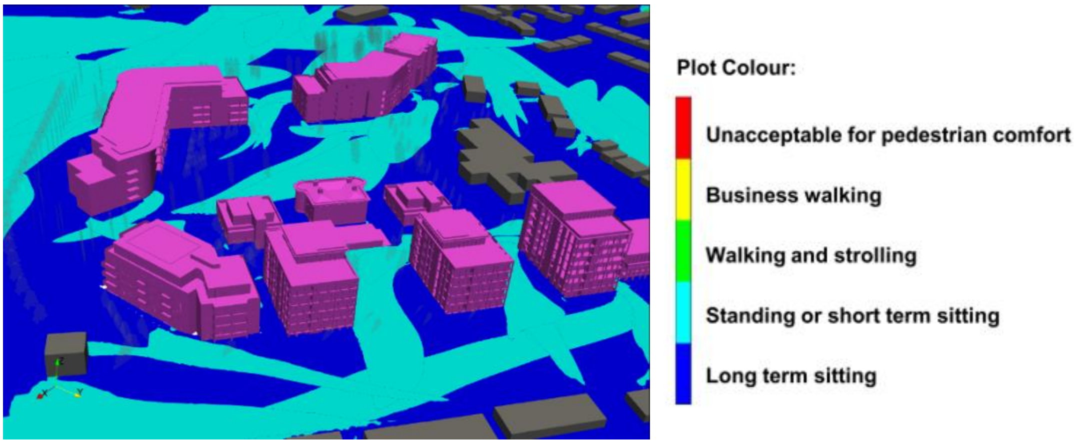


Figure 10.74.: Ground Floor - Lawson Discomfort Map - Top View

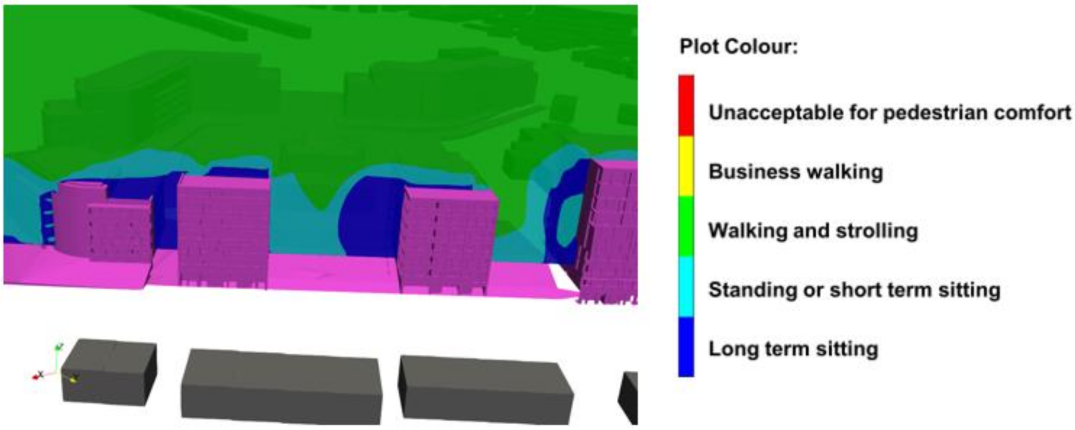


Figure 10.75.: Between Blocks - Lawson Discomfort Map

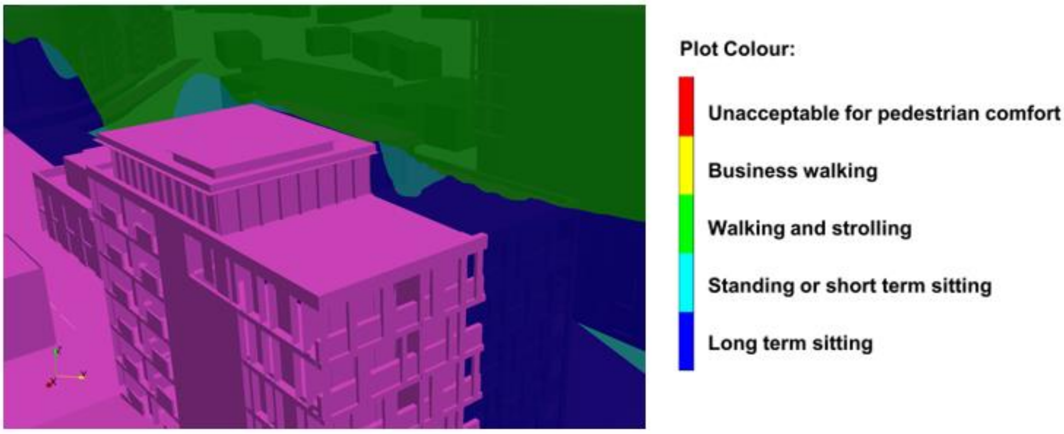


Figure 10.76.: Roof Terrace - Lawson Discomfort Map across the terrace

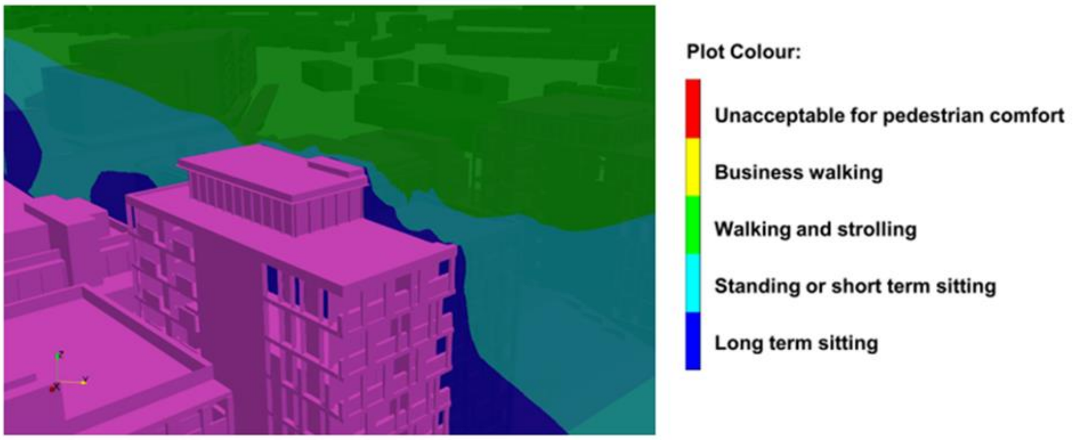


Figure 10.77.: Roof Terrace - Lawson Discomfort Map across the terrace

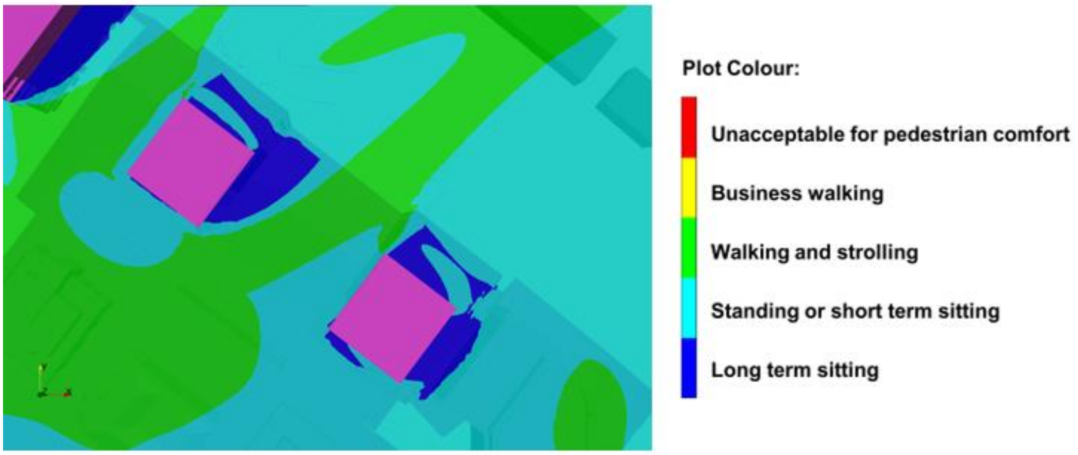


Figure 10.78.: Roof Terrace Z=1.5m above floor - Lawson Discomfort Map across the terrace

Distress Criteria

In addition to the criteria for "discomfort" the Lawson method presents criteria for "distress". The discomfort criteria focus on wind conditions which may be encountered for hundreds of hours per year. The distress criteria require higher wind speeds to be met but focus on two hours per year. These are rare wind conditions but with the potential for injury rather than inconvenience.

Figure 10.79. shows the hourly wind gust rose for Dublin, from 1990 to 2020. This will be necessary to assess how many hours per year on average the velocity exceed the threshold values.

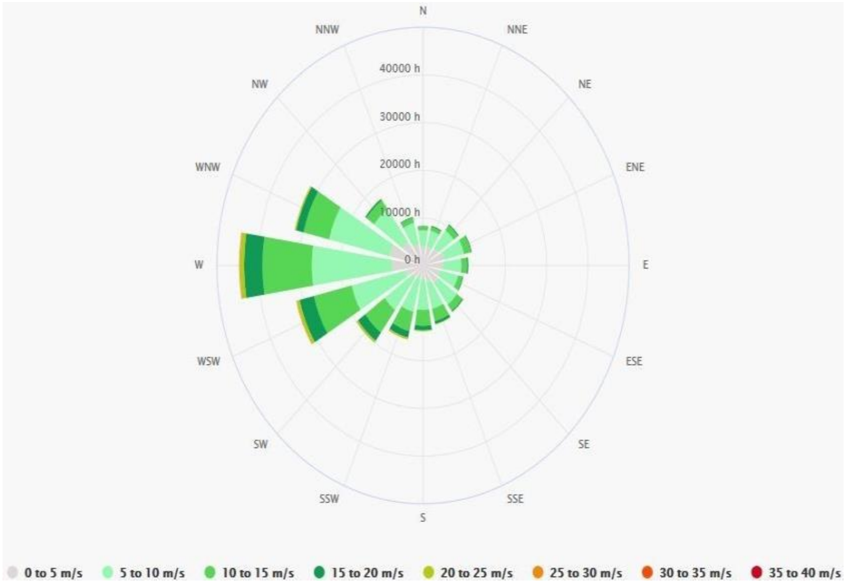


Figure 10.79: Hourly Dublin Wind Gust Rose

The criteria for distress for a frail person or cyclist is 15m/s wind occurring for more than two hours per year. Limiting the results from the above wind rose to the only values above 15m/s (as reported in Figures 10.80. and 10.81. respectively as cumulative hours and cumulative percentage), it is possible to see how many hours in 30 years the gust velocity of 15m/s is exceed at pedestrian level in each direction.

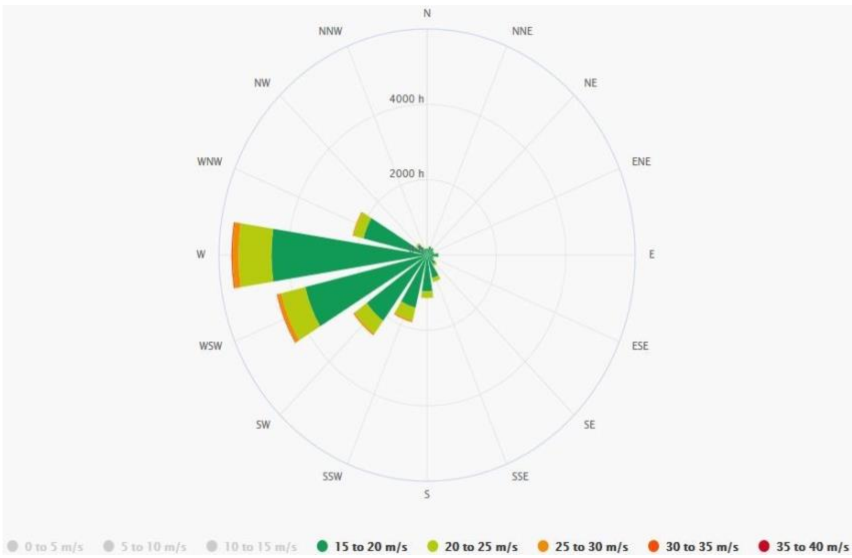


Figure 10.80.: Hourly Dublin Wind Gust Rose - Cumulative hours when the velocity is above 15m/s

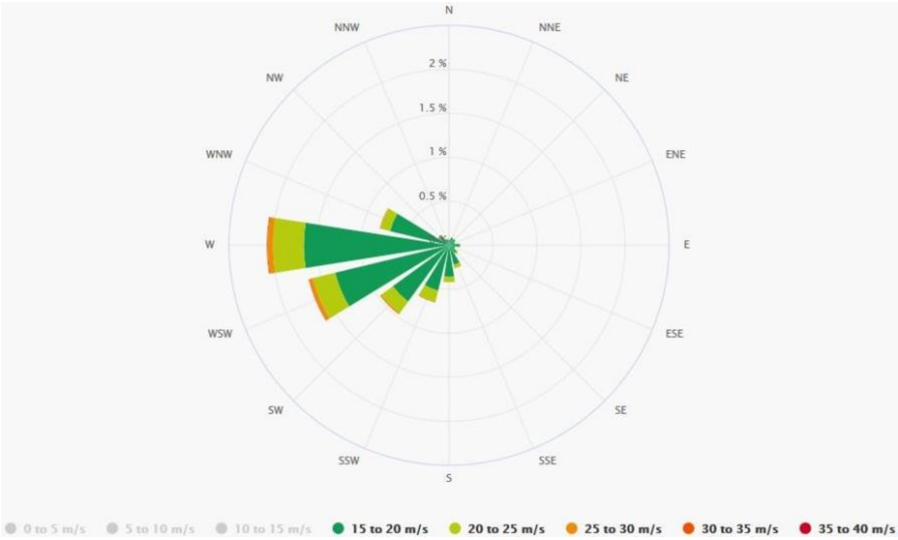


Figure 10.81.: Hourly Dublin Wind Gust Rose - Cumulative percentage of time when the velocity is above 15m/s

A total of 2 hours per year corresponds to 0.02% in one year, which means 0.6% in 30 years. Looking at the wind roses above, it is possible to notice that a velocity of 15m/s was reached in Dublin only for the following directions (in increasing order of percentage) over the years 1990-2020:

1. West 270°
2. West-South-West 247.5°
3. South-West 225°

For this reason, it is of interest to show the distress results for these directions. Figure 10.83 below combines all the above directions together and shows the areas where the measured velocity is above 15 m/s. Figure 10.82 shows the scale used in this case. Results show that there are not critical areas where the velocity increases above 15 m/s, thus the criteria is always satisfied.

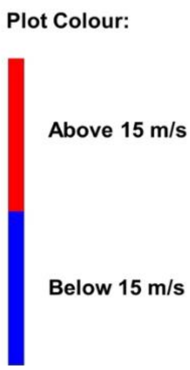


Figure 10.82.: Lawson Distress Categories - Frail Person or Cyclist

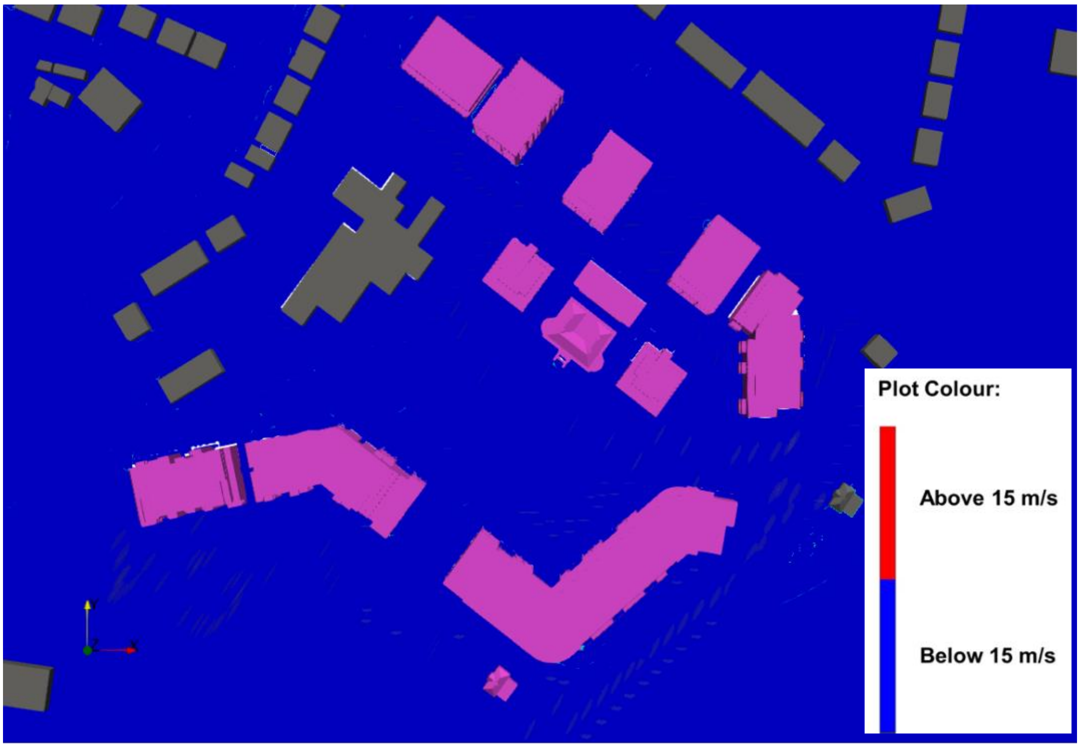


Figure 10.83.: Lawson Distress Map - Frail Person or Cyclist

The criteria for distress for a member of the general population is 20m/s wind occurring for more than two hours per year. As explained above, a velocity of 20m/s was never reached in Dublin over the years 1990-2020. For this reason, it is not of interest to show the distress results for any of the wind directions and the criteria is always satisfied.

10.10. Summary of Predicted Impacts of the Proposed Development

From the simulation results the following observations are pointed out:

- The proposed development has been designed in order to produce a high quality environment that is attractive and comfortable for pedestrians of all categories. To achieve this objective, throughout the design process, the impact of wind has been considered and analysed, in the areas where critical patterns were found, the appropriate mitigation measures were introduced.

- As a result of the final proposed, wind flow speeds at ground floor are shown to be within tenable conditions. Some higher velocity indicating minor funnelling effects are found near the South-West side of the development. However, as it is shown in the Lawson map indicate that the area can be utilised for the intended use.

- Regarding the balconies, higher velocities can be found for some directions, only on some of the balconies. However, these velocities are below the threshold values defined by the acceptance criteria and therefore are not critical for safety.

- Tree planting all around the development has been utilised, with particular attention to the corners of the Blocks has positively mitigated any critical wind effects. Thus, it can be concluded that at ground floor good shielding is achieved everywhere.

- The proposed development does not impact or give rise to negative or critical wind speed profiles at the nearby adjacent roads, or nearby buildings. Moreover, in terms of distress, no critical conditions were found for "Frail persons or cyclists" and for members of the" General Public" in the surrounding of the development.

- The proposed development does not impact or give rise to negative or critical wind speed profiles at the nearby adjacent roads, or nearby buildings.

10.11. Monitoring

Construction Phase

There is no particular requirement to monitor wind impact during construction phase as the designated amenity areas will not be in use during this phase of the project.

Operational Phase

During the development operational phase, it has been designed to conform to acceptable Lawson Criteria for Comfort and Distress in accordance with the Wind Beaufort Scale.

10.12. Reinstatement

Not applicable.

10.13. Difficulties Encountered

No difficulties were encountered during the assessment of wind and microclimate impacts on Proposed development or its existing environments.

10.14. Conclusions

This report presents the CFD modelling assumptions and results of Wind and Microclimate Modelling of Proposed development, located at

This study has been carried out to identify the possible wind patterns around the area proposed, under mean and peak wind conditions typically occurring in Dublin, and also to assess impacts of the wind on pedestrian level comfort.

The results of this wind microclimate study are utilized by to configure the optimal layout for Proposed development for the aim of achieving a high-quality environment for the scope of use intended of each areas/building (i.e. comfortable and pleasant for potential pedestrian) and not to introduce any critical wind impact on the surrounding areas and on the existing buildings.

1. **Existing Receiving Environment Summary:**

   The wind desktop study of the existing receiving environment showed that:

   - The wind profile was built using the annual average of meteorology data collected at Dublin Airport Weather Station. In particular, the local wind climate was determined from historical meteorological data recorded 10 m above ground level at Dublin Airport.

     18 different scenarios were selected in order to take into consideration all the different relevant wind directions. In particular, a total of 18 compass directions on the wind rose are selected. For each direction, the reference wind speed is set to the 5% exceedance wind speed for that direction, i.e. the wind speed that is exceeded for over 5% of the time whenever that wind direction occurs.

   - The wind profile built using the data from Dublin Airport, is also compared with the one obtained using the data collected on-site. With a small number of exceptions, both the wind speed daily mean and the wind gust daily mean recorded on site follow the same patterns as the ones recorded at Dublin Airport. The speed levels registered on-site are in few cases slightly lower. This is due to the fact that, despite its vicinity to the coast, the site is located close to the urban environment thus much more shielded if compared with Dublin Airport. This confirms the fact that using wind data from Dublin Airport still ensures a conservative analysis of the wind impact on the development.

- The prevailing wind directions for the site are identified in the West, West South-West, and South-East with magnitude of approximately 6m/s.

2. **Potential And Cumulative Impact Of The Proposed Development Summary:**

Micro-climate Model Assessment of the proposed St. Teresa's SHD and its environment was performed utilizing a CFD (Computational Fluid Dynamics) methodology. 8 no. "worst case" wind scenarios are selected for presentation in this report, as these scenarios and directions showed to be the most relevant wind speeds.

CFD modelled results of the development scheme showed that:

- The Proposed development has been designed in order to produce a high-quality environment that is attractive and comfortable for pedestrians of all categories. To achieve this objective, throughout the design process, the impact of wind has been considered and analysed, in the areas where critical patterns were found, the appropriate mitigation measures were introduced.
- As a result, wind flow speeds at ground floor are shown to be within tenable conditions. Some higher velocity indicating minor funnelling effects are found near the South-West side of the development. However, as shown in the Lawson map, the area can be utilised for the intended use.
- Regarding the balconies, higher velocities can be found for some directions, only on some of the balconies. However, these velocities are below the threshold values defined by the acceptance criteria and therefore are not critical for safety.
- Tree planting all around the development has been utilised, with particular attention to the corners of the Blocks has positively mitigated any critical wind effects. Thus, it can be concluded that at ground floor good shielding is achieved everywhere.
- The proposed development does not impact or give rise to negative or critical wind speed profiles at the nearby adjacent roads, or nearby buildings. Moreover, in terms of distress, no critical conditions were found for "Frail persons or cyclists" and for members of the" General Public" in the surrounding of the development.
- The proposed development does not impact or give rise to negative or critical wind speed profiles at the nearby adjacent roads, or nearby buildings.
- During Proposed development construction phase the predicted impacts are classified as negligible
- Therefore, the CFD study carried out has shown that under the assumed wind conditions typically occurring within Dublin for the past 30 years:
- **The development is designed to be a high-quality environment for the scope of use intended of each areas/building (i.e. comfortable and pleasant for potential pedestrian), and,**

- **The development does not introduce any critical impact on the surrounding buildings, or nearby adjacent roads.**

10.15. References

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