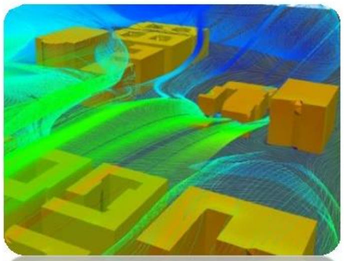
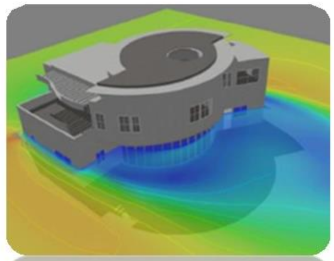
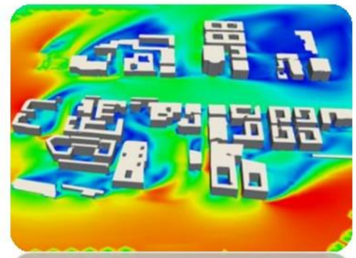

WIND MICROCLIMATE MODELLING

Victoria Cross Road Development

Cork

Prepared by: B-Fluid Ltd.| Buildings Fluid Dynamics Consultants

For: Bellmount Developments Limited.

B-Fluid
Buildings Fluid Dynamics

Document Reference		
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Site location	Victoria Cross Road, Cork	
CFD Study by	B-Fluid Ltd.	
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Contents

1. INTRODUCTION

B-Fluid Limited has been commissioned by 'Bellmount Developments Limited.' to perform a Wind Microclimate Study for the Victoria Cross Road Development in Victoria Cross Road, Cork.

Figure 1.1 shows a view of the proposed development (colored blocks) in the existing urban context.

Figure 1.1: Proposed Victoria Cross Road Development

This report is completed by Dr.Cristina Paduano, Dr.Chino Uzoka and Dr.Arman Safdari.

Dr.Cristina Paduano is a Chartered Engineer (CEng) and member of Engineers Ireland who specialises in computational fluid dynamics applications for urban environment and the construction industry with over 10 years experience. She holds a PhD in Mechanical Engineering from Trinity College Dublin, with M.Eng and B.Eng in Aerospace Engineering.

Dr.Chino Uzoka is a CFD Specialist Engineer who specialises in computational fluid dynamics applications. He holds a PhD in Mechanical Engineering and MSc in Engineering Management from the University of Huddersfield.

Dr.Arman Safdari is a CFD Moelling Engineer who specialises in computational fluid dynamics applications. He is an expert in airflow modeling, heat and mass transfer and multi-phase flow simulations. He holds a PhD in Mechanical Engineering from Pusan National University, a M.Sc. and B.Sc. in Mechanical Engineering.

A wind microclimate study considers the possible wind patterns formed under both mean and peak wind conditions typically occurring on the site area, accounting for a scenario where the proposed development is inserted in the existing environment (potential impact) and, for a scenario where the proposed development is analysed together with the existing environment and any permitted development (not constructed yet) that can be influenced by the wind patterns generated by the proposed one (cumulative impact).

The potential receptors include those areas, in the surrounding of the development, which can be exposed to potential risks generated by the elevated wind speed or building massing wind effects. In particular:

- Amenity areas (pedestrian level), areas likely to be utilised for leisure purposes and as such should be comfortable surroundings.
- Pedestrian routes and seating areas – to determine if locations are comfortable for leisure activities.
- Entrance to the buildings – to determine if there is potential for pressure related issues for entrances or lobbies.
- Landscaped areas – where there are sheltered areas.
- Impact to existing or adjoining developments – where the proposed buildings will cause discomfort conditions through proximity related issues.

The acceptance criteria which define the acceptable wind velocities in relation to the perception of comfort level experienced while carrying out a specific pedestrian activity is known as the "Lawson Criteria for Pedestrian Comfort and Distress". A wind microclimate study analyses the wind flow in an urban context (considering the wind conditions typically occurring on the site during a typical year) to develop the so called "Lawson Comfort and Distress Map"; the map identifies where a specific pedestrian activity can be carried out comfortably during most of the time.

The assessment can be performed by physical testing in wind tunnels or by performing "virtual wind tunnel testing" through numerical simulation using Computational Fluid Dynamics (CFD), as done for this project. The scope of the numerical study is to simulate the wind around the development this to predicting under which wind speeds pedestrians will be exposed and what level of comfort pedestrian will experience when carrying out a specific activity (i.e. walking, strolling, sitting).

The following sections details the methodology, acceptance criteria, CFD wind simulations and the impact of the proposed development on the local wind microclimate against best practice guidelines for pedestrian comfort and safety.

1.1 GUIDANCE and LEGISLATION

According to the 'Urban Development and Building Heights, Guidelines for Planning Authorities (Government of Ireland, December 2020)' document, specific wind impact assessment of the microclimatic 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 Cork standards.

The recommended approach to wind microclimate studies is outlined in the "Wind Microclimate Guidelines for Developments in the City of London '(August 2019) and in the guidelines and recommendations contained in BRE Digest (DG) 520, "Wind Microclimate Around Buildings" (BRE, 2011). The Lawson Criteria of Comfort and Distress is used to benchmark the pedestrian wind microclimate.

The document also indicates how to use Computational fluid dynamics (CFD) to assess wind microclimate conditions and how to generate high quality outputs to provide a good understanding of the fundamental flow features around an urban context.

Usually, the recommended approach to wind microclimate studies is based on the building height, as presented in Figure 1.2.

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 1.2: 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)

1.2 URBAN WIND EFFECTS

Buildings and topography affect the speed and direction of wind flows. Wind speed increases with increasing height above the ground, assuming a parabolic profile.

Flow near the ground level encounters obstacles represented by terrain roughness/buildings 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 wind velocity profile is given by a fluctuating velocity along a mean velocity value. Figure 1.3 shows the wind velocity profile, as described above.

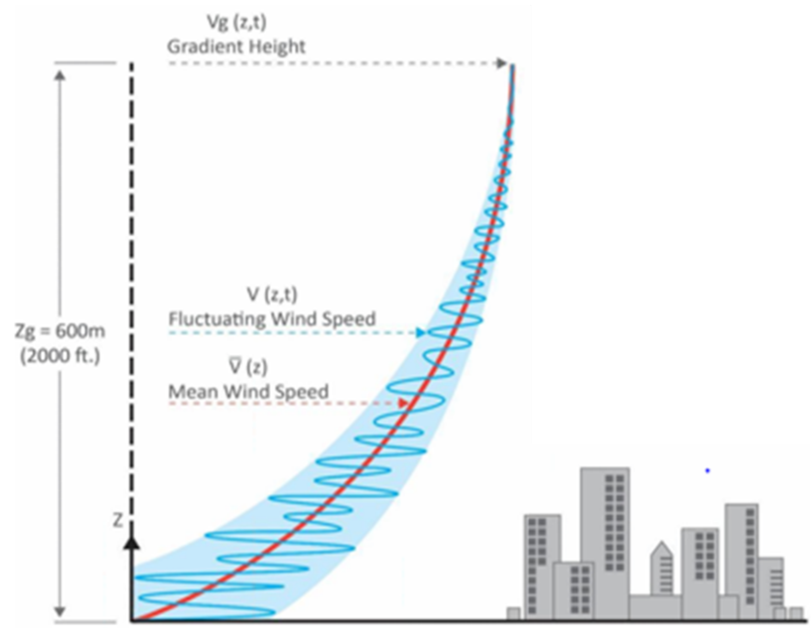


Figure 1.3: Wind Velocity Profile

In an urban context, wind speeds at pedestrian level are generally low compared with upper-level wind speeds, however, the wind can create adverse patterns when flowing in between buildings which can cause local wind accelerations or re-circulations. This wind patterns effect pedestrian safety and comfort. In general, the wind effects to be avoided/mitigated in an urban context include the following:

- **Funnelling Effects**: The wind can accelerate significantly when flowing through a narrow passage between building structures. The highest speeds are experienced at the point where the restriction of the area is the greatest.

- **Downwash Effects**: The air stream when striking a tall building can flow around it, over it and a part can deflected towards the ground. This downward component is called downwash effect and its intensity depends on the pressure difference driving the wind. The higher the building, the higher this pressure difference can be.

- **Corner Effects**: Wind can accelerate around the corners of the buildings. Pedestrians can experience higher wind speeds as well as more sudden changes in wind speeds. The reason for this is that there are narrow transition zones between the accelerated flows and the adjacent quiescent regions. This effect is linked to the downwash effect as the downward stream component subsequently flows around the corners towards the leeward side of the building.

- **Wake Effect**: Excessive turbulence can occur in the leeward side of the building. This can cause sudden changes in wind velocity and can raise dust or lead to accumulation of debris. This effect is also dependent on the height of the building.

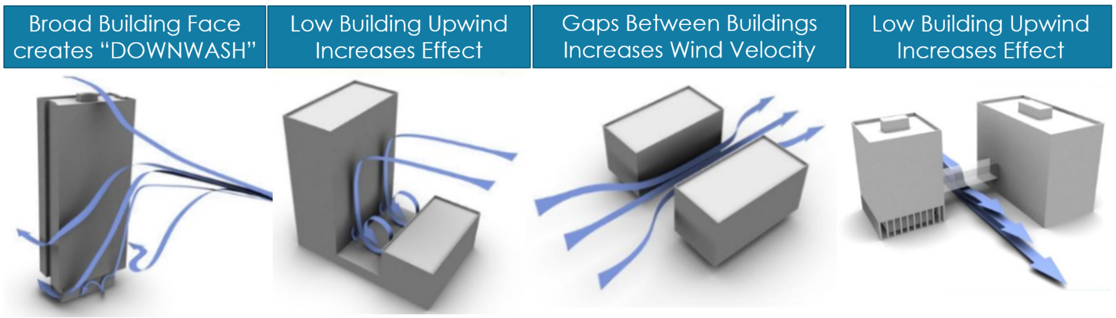


Figure 1.4: Parameters to know for Wind Conditions Assessment

The anticipation of the likely wind conditions resulting from new developments are important considerations in the context of pedestrian comfort and the safe use of the public realm. While it is not always practical to design out all the risks associated with the wind environment, it is possible to provide local mitigation to minimise risk or discomfort where required.

2. ASSESSMENT METHODOLOGY

2.1 ASSESSMENT METHODOLOGY

The method for the study of wind microclimate combines the use of Computational Fluid Dynamics (CFD) to predict wind velocities and wind flow patterns, with the use of wind data from suitable meteorological station and the recommended comfort and safety standards (Lawson Criteria). The effect of the geometry, height and massing of the proposed development and existing surroundings including topography, ground roughness and landscaping of the site, on local wind speed and direction is considered as well as the pedestrian activity to be expected (sitting, standing, strolling and fast walking). The results of the assessment are presented in the form of contours of the Lawson criteria at pedestrian level. The assessment has comprised the following scenarios:

- **Baseline Existing Scenario**: this consist of the existing wind microclimate at the site.

- **Proposed Development in the Existing Scenario**: this consist of the assessment of the wind microclimate of the site with the proposed development surrounded by existing buildings.

- **Cumulative Scenario**: this consist of the assessment of the wind microclimate of the site with the proposed development surrounded by existing and permitted buildings.

In accordance with the guideline cited in section 1.1, the wind microclimate study should consider the effect of the proposed development together with buildings (existing and/or permitted) 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.

Figure 2.1: Area of interest to be modelled

In particular, the following has been undertaken:

- Topography of the site with buildings (proposed and adjacent existing/permitted developments massing, depending on the scenario assessed “baseline, proposed or cumulative”) have been modelled using OpenFOAM Software.

- Suitable wind conditions have been determined based on historic wind data. Criteria and selected wind scenarios included means and peaks wind conditions that need to be assessed in relation to the Lawson Criteria.

- Computational Fluid Dynamics (CFD) has been used to simulate the local wind environment for the required scenarios (‘baseline, proposed, cumulative”).

- The impact of the proposed development massing on the local wind environment has been determined (showing the wind flows obtained at pedestrian level).

- Potential receptors (pedestrian areas) have been assessed through review of external amenity/public areas (generating the Lawson Comfort and Distress Map).

- Potential mitigation strategies for any building related discomfort conditions (where necessary) have been explored and their effect introduced in the CFD model produced.

2.1.1 ACCEPTANCE CRITERIA for PEDESTRIAN COMFORT and DISTRESS

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 municipal 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 2.2. 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. 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.

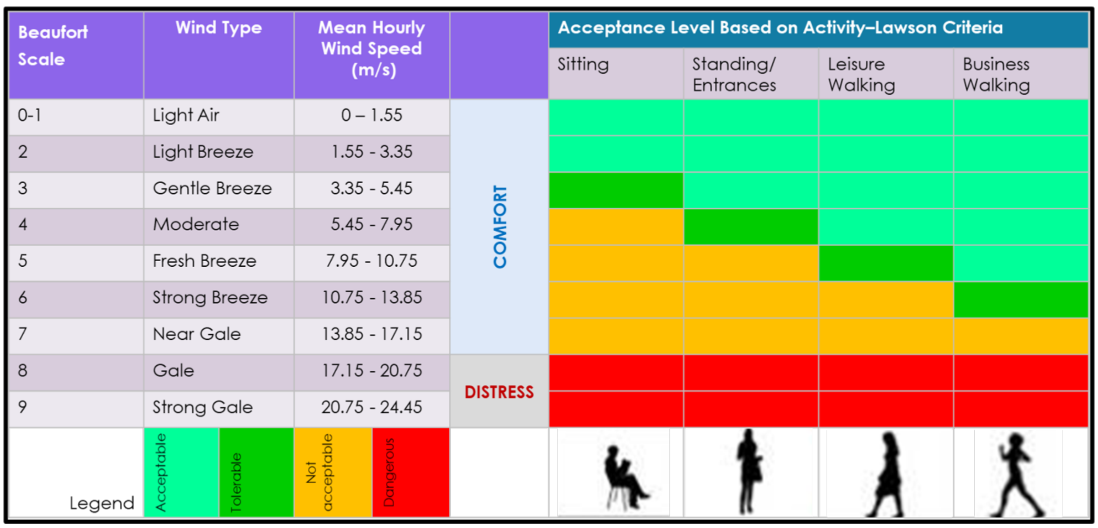


Figure 2.2: Lawson Scale

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.

Pedestrian Comfort Category (Lawson Scale)	Mean and Gem wind speed not to be exceeded more than 5% of the time	Description
Long-Term Sitting	4m/s	Acceptable for frequent outdoor sitting use, i.e. restaurant /café
Standing	6m/s	Acceptable for occasional outdoor sitting use, i.e. public outdoor spaces
Walking/Strolling	8m/s	Acceptable for entrances/bus stops /covered walkaways
Business Walking	10m/s	Acceptable for external pavements, walkways
Unacceptable/Distress	>10m/s	Start of not comfortable/distress level for pedestrian access

Figure 2.3: Lawson Categories Scale - Comfort

Pedestrian Safety Category (Lawson Scale)	Mean and Gem wind speed not to be exceeded more than 0.0022% of the time	Description
Unsafe for public	>20m/s	Distress/safety concern for pedestrian
Unsafe for cyclists or frail person	>15m/s	Distress/safety concern for cyclist/frail person

Figure 2.4: Lawson Categories Scale - Distress/Safety

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

2.1.2 SIGNIFICANCE CRITERIA

The significance of on-site measurement locations are defined by comparing the wind comfort/safety levels with the intended pedestrian activity at each location, using the table provided by the Lawson Comfort and Distress Criteria.

The significance of off-site measurement locations are defined by comparing the wind comfort/safety levels with the intended pedestrian activity at each location, prior and after the introduction of the proposed development.

Significance	Trigger	Mitigation required?
Major Adverse	Conditions are "unsafe"	Yes
Moderate Adverse	Conditions are "unsuitable" (in terms of comfort) for the intended pedestrian use.	Yes
Negligible	Conditions are "suitable" for the intended pedestrian use.	No
Moderate Beneficial	Conditions are calmer than required for the intended pedestrian use (by at least one comfort category).	No

Figure 2.5: Significance Criteria for On-site Receptors

Significance	**Trigger**	**Mitigation required?**
Major Adverse	Conditions that were "safe" in the baseline scenario became "unsafe" as a result of the Proposed Development. *OR* Conditions that were "suitable" in terms of comfort in the baseline scenario became "unsuitable" as a result of the Proposed Development. *OR* Conditions that were "unsafe" in the baseline scenario are made worse as a result of the Proposed Development.	Yes
Moderate Adverse	Conditions that were "suitable" in terms of comfort in the baseline scenario are made windier (by at least one comfort category) as a result of the Proposed Development but remain "suitable" for the intended pedestrian activity.	No
Negligible	Conditions remain the same as in the baseline scenario.	No
Major Beneficial	Conditions that were "unsafe" in the baseline scenario became "safe" as a result of the Proposed Development.	No
Moderate BeneficialPotetial REceptors	Conditions that were "unsuitable" in terms of comfort in the baseline scenario became "suitable" as a result of the Proposed Development. *OR* Conditions that were "unsafe" in the baseline scenario are made better as a result of the Proposed Development (but not so as to make them "safe".	No

Figure 2.6: Significance Criteria for Off-site Receptors

3. CFD MODELLING METHOD

3.1 CFD MODELLING METHOD

The wind microclimate study is conducted through Computational Fluid Dynamics (CFD). This 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. Wind flow is described by Navier-Stokes equations which are solved within the CFD analysis using a finite volume algorithm based on the volumetric mesh/grid in which the geometry is divided. CFD modelling includes three main stages: pre-processing, simulation, and post-processing as described in the image that follows.

PRE-PROCESSING

This is the construction of a representative geometric model to be utilized within a flow domain of interest and the subsequent division of this domain into small control volumes (cells), a process often called "meshing." After setting up the model and mesh, the model is completed by setting appropriate boundary and initial conditions.

SIMULATION

The equations governing the behaviour of fluid particles (Navier-Stokes equations) are solved iteratively over each control volume within the computational domain, until the results change no more; i.e. a converged solution is reached. In a transient simulation this process is repeated and convergence verified at each time step, whereas in a steady-state simulation, this is only done at one time step, since it is assumed conditions do not vary over time. The field solutions of pressure, velocity, air temperature, and other properties are obtained for each control volume, at cell centre, nodal point, or face centre in order to render the flow field.

POST-PROCESSIONG

This is the plotting and viewing of the predicted flow field from the CFD model simulations at selected locations, surfaces, or planes of interest.

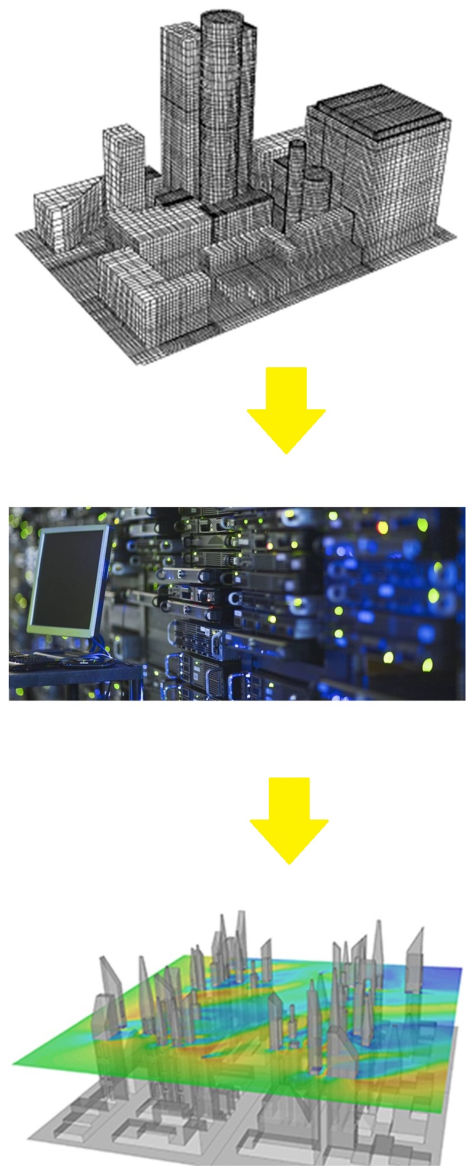


Figure 3.1: CFD Modelling Procedure Concept

3.2 CFD SOFTWARE DETAILS

The analysis of this chapter 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).

3.3 CFD MODEL DETAILS

This section describes all features included in the geometrical and physical representation of Victoria Cross Road 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

A 3D view of the proposed development massing model in the domain is presented in Figures 3.2 and 3.3.

The modelled layout and dimensions of the surrounding environment are outlined in the table below (Table 3.1).

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 400m radius around the Victoria Cross Road Development, as shown.

	MODELLED CFD ENVIRONMENT DIMENSIONS		
	Width	Length	Height
CFD Mesh Domain	1200m approx	1200m approx	120m approx

Table 3.1: Modelled Environment Dimensions

Figure 3.2: 3D View of the Proposed Victoria Cross Road Development and Adjacent Buildings - North Side View

Figure 3.3: 3D View of the Proposed Victoria Cross Road Development and Adjacent Buildings - West Side View

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.

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 3.2. Figure 3.4 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 center 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 ρ	$1.2kg/m^3$
Ambient Temperature (T)	$288K(approx.15C^{\circ})$
Gravity Acceleration (g)	$9.8m/s^2$
dx	0.5 m at the building 1m in the surroundings 2m elsewhere
Background Mesh cells ratio	1:1
Total mesh size	Approx. cells number = 20 million

Table 3.2: Paramenters To Calculate Computational Mesh

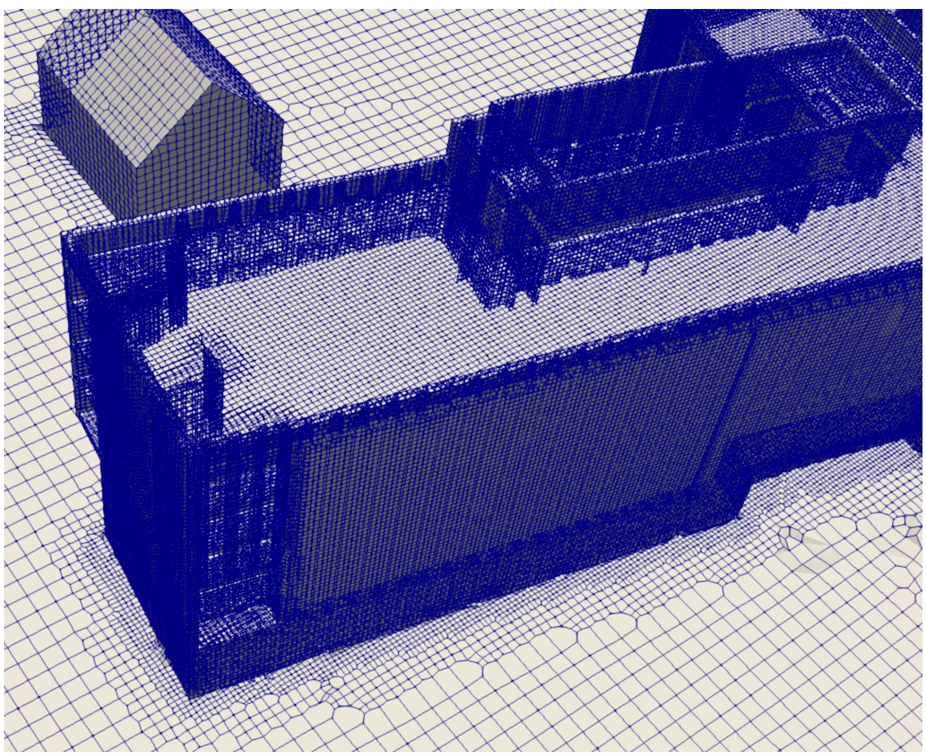


Figure 3.4: Victoria Cross Road Domain Computational Mesh Utilized

4. LOCAL WIND CLIMATE

4.1 THE EXISTING RECEIVING ENVIRONMENT

In this chapter, wind impact has been assessed on the existing receiving environment considered the existing buildings and the topography of the site prior of the 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 pedestrians comfort criteria.

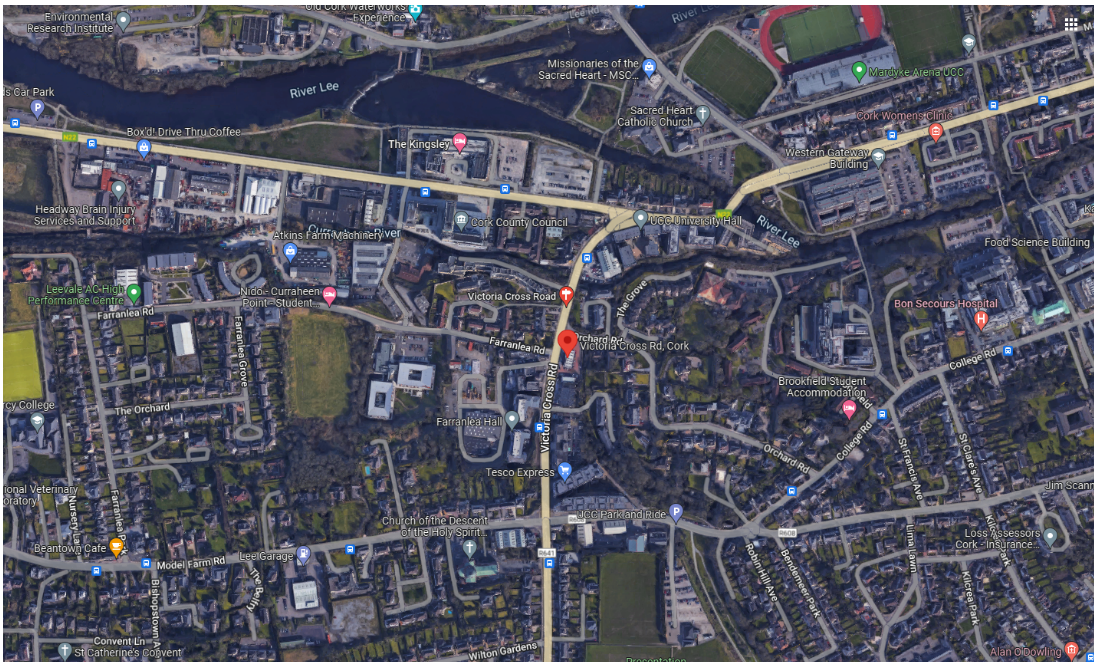


Figure 4.1: Existing Receiving Environment (Baseline Situation)

Topography And Built In Environment

Figure 4.2 shows an aerial photograph of the terrain surrounding the construction site at Victoria Cross Road Development. The Victoria Cross Road Site is located in Cork, near the center of Cork city. Therefore, the area surrounding the site can be characterised as urban environment.

Figure 4.2: Built-in Environment Around Construction Site at Victoria Cross Road Development

4.1.1 LOCAL WIND CONDITIONS

This analysis consider 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 Cork Airport Weather Station. Figure 4.3 shows on the map the position of Victoria Cross Road Development and the position of Cork Airport.

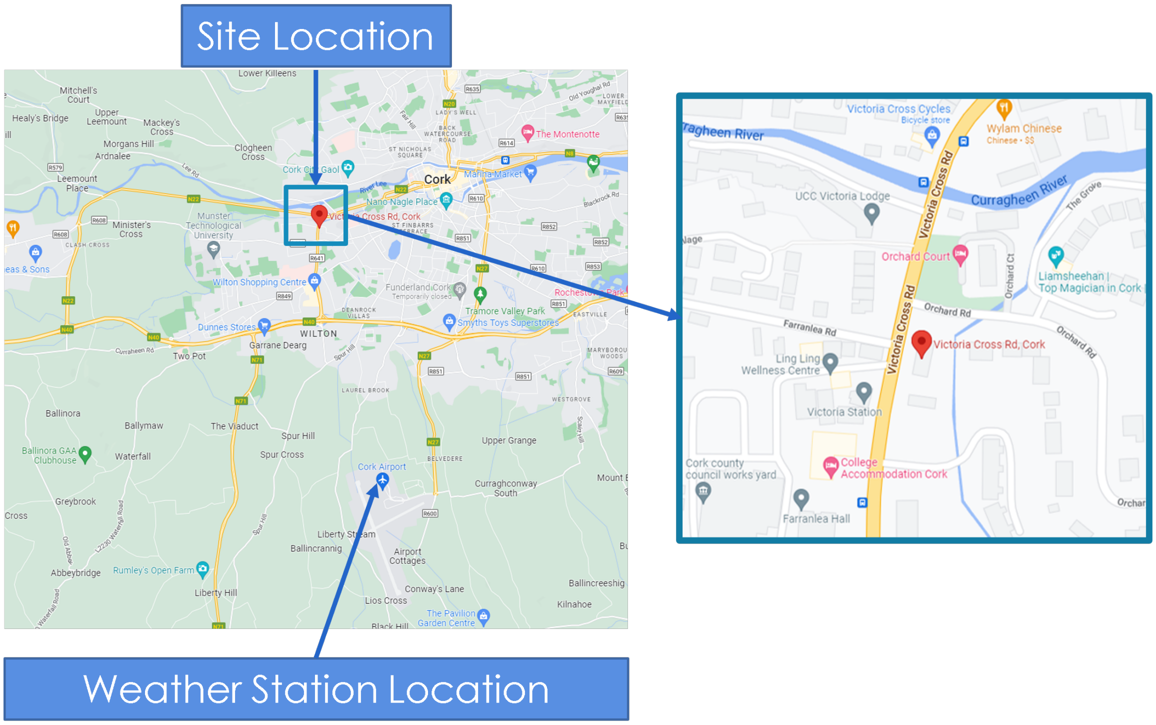


Figure 4.3: Map showing the position of Victoria Cross Road Development and Cork Airport

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

- *Terrain*: The meteorological station is located on the flat open terrain of the airport, whereas the development site is in an urban area with dense built-in structure with buildings of more than 20 m height in average and with some buildings even taller.

- *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 Cork Airport are applicable for the desktop assessment of the wind comfort at the development site.

The assessment of the wind comfort conditions at the new 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 Cork Airport. The data set analyzed for this assessment is as follows:

- The mean hourly wind speeds recorded over a 4 year period between 2017 and 2021.

The data is recorded at a weather station at the airport, which is located 10m above ground or 71mOD.

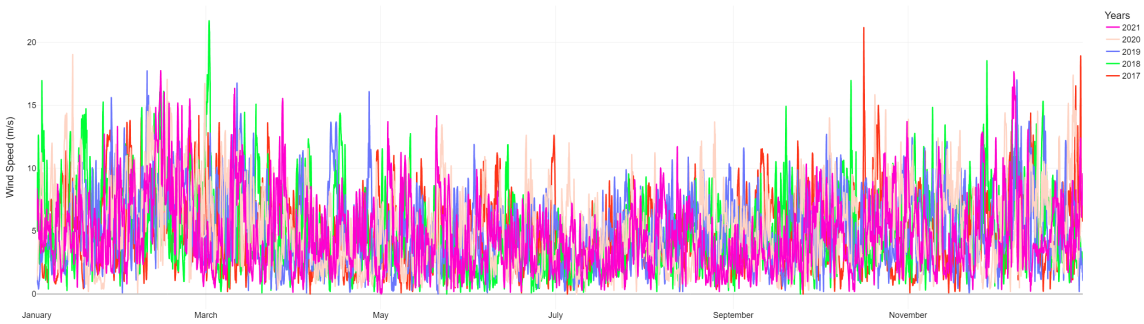


Figure 4.4: Local Wind Conditions - Wind Speed - 2017-2021

Figure 4.5, presenting the wind speed diagram for Cork, shows the days per month, during which the wind reaches a certain speed. In Figure 4.6, the wind rose for Cork shows how many hours per year the wind blows from the indicated direction, confirming how the predominant directions are West, South, West-South-West and South-North.

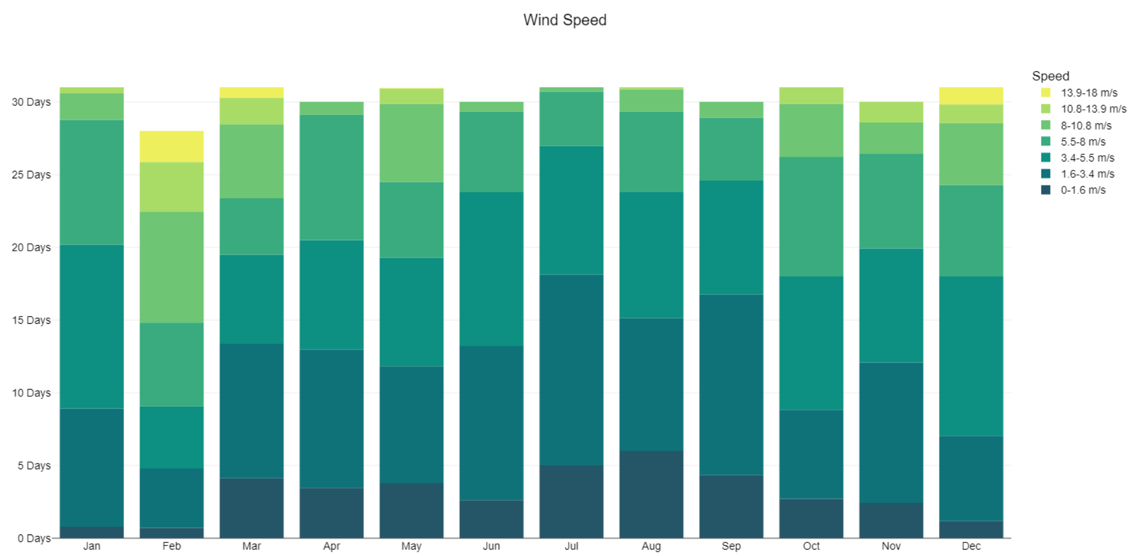


Figure 4.5: Cork Wind Speed Diagram

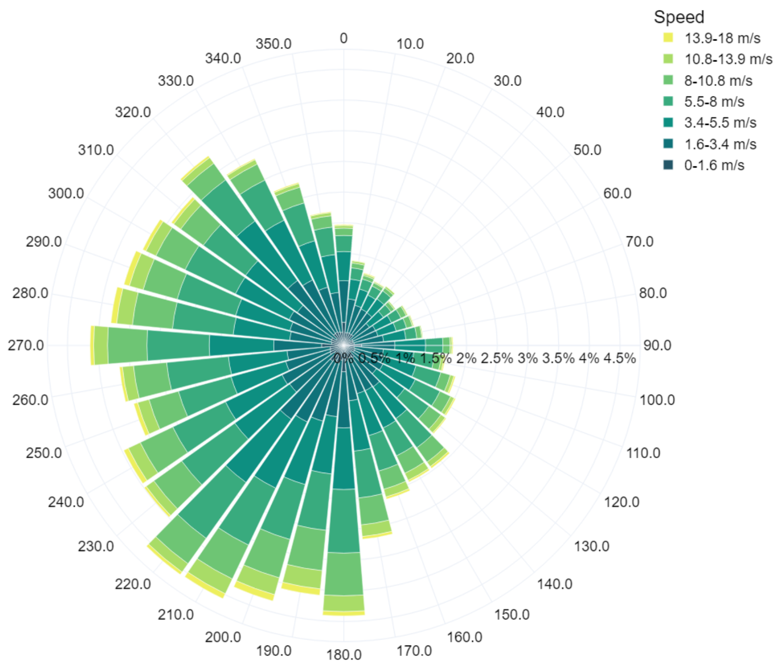
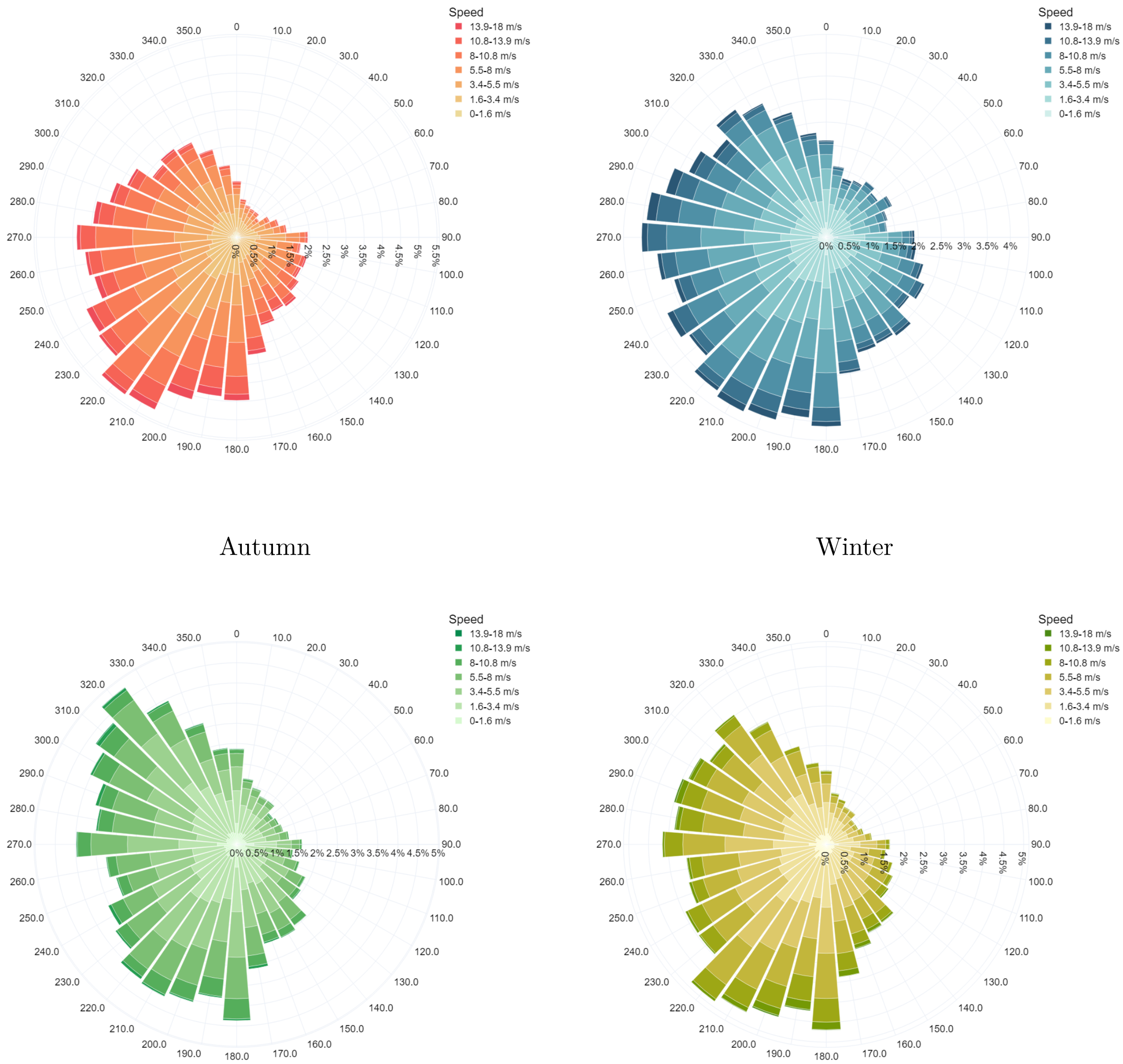


Figure 4.6: Cork Wind Rose

Statistical analysis of the number of hours and magnitudes of wind is performed in order to indicate the pedestrian comfort and distress analysis as per Lawson Criteria. Each of the wind directions were interpolated to calculate the probability that a velocity threshold will be exceeded.

Based on the criterion of occurrence frequency, if the proposed site is exposed to a wind from a specific direction for more than 5 percent of the time, then the microclimate analysis should consider the impact of this wind (accounting for its direction and most frequent speed) on the local microclimate. In addition, seasonal changes were analysed in order to indicate the prevailing wind directions (Fig 4.7).



Autumn Winter

Spring Summer

Figure 4.7: Wind speeds and wind directions at different seasons

5. CHARACTERISTICS OF THE PROPOSED DEVELOPMENT

5.1 DESCRIPTION OF PROPOSED DEVELOPMENT

Bellmount Developments Limited intend to apply to An Bord Pleanála for planning permission for a strategic housing development at The Former Finbarr Galvin Motor Dealership, Fronting on to Victoria Cross Road and Orchard Road, Bishopstown, Cork. The development will consist of:

1. The demolition of existing structures on site; and
2. The construction of 78 no. student accommodation apartments (ranging in size from single bed studio apartments to 8-bed apartments) comprising a total of 206 no. bed spaces in 1 no. 6 storey block;
3. Student amenity facilities including a study area, games room, lounge space, laundry room and server/ICT room;
4. The provision of landscaping and amenity areas including a courtyard space (including modifications to the external amenity area of the student accommodation scheme permitted under An Bord Pleanála Ref. 19/38385), 1 no. rooftop terrace and a riverfront amenity incorporating a pedestrian and cycle path accessing onto Ashbrook Heights and Orchard Road;
5. The provision of a set down area, 1 no. access point (for emergency vehicles only), footpaths and repositioned pedestrian crossing and associated tactile paving on Orchard Road;
6. The provision of a new junction build out at the junction of Orchard Road and Victoria Cross Road;
7. The provision of footpaths and landscaped areas along Victoria Cross Road; and
8. All associated ancillary development including pedestrian/cyclist facilities, lighting, drainage, boundary treatments, bin and bicycle storage and plant at ground and roof top levels.

5.1.1 POTENTIAL RECEPTORS

Potential receptors for the wind assessment are all pedestrian circulation routes, building entrances and leisure open areas within the site and in neighboring adjacent areas. The pedestrian level is considered at 1.5m above ground.

In addition to the roads and entrances, some sensitive receptors such as courtyard and terraces for this assessment are discussed below, these areas are designed for public use activities such as for long term sittings and need to be particularly comfortable/safe.

Figure 5.1 shows a view of the proposed development. Figure 5.2 shows the pedestrian activity area (green color) which are considered a sensitive potential receptor for the wind microclimate.

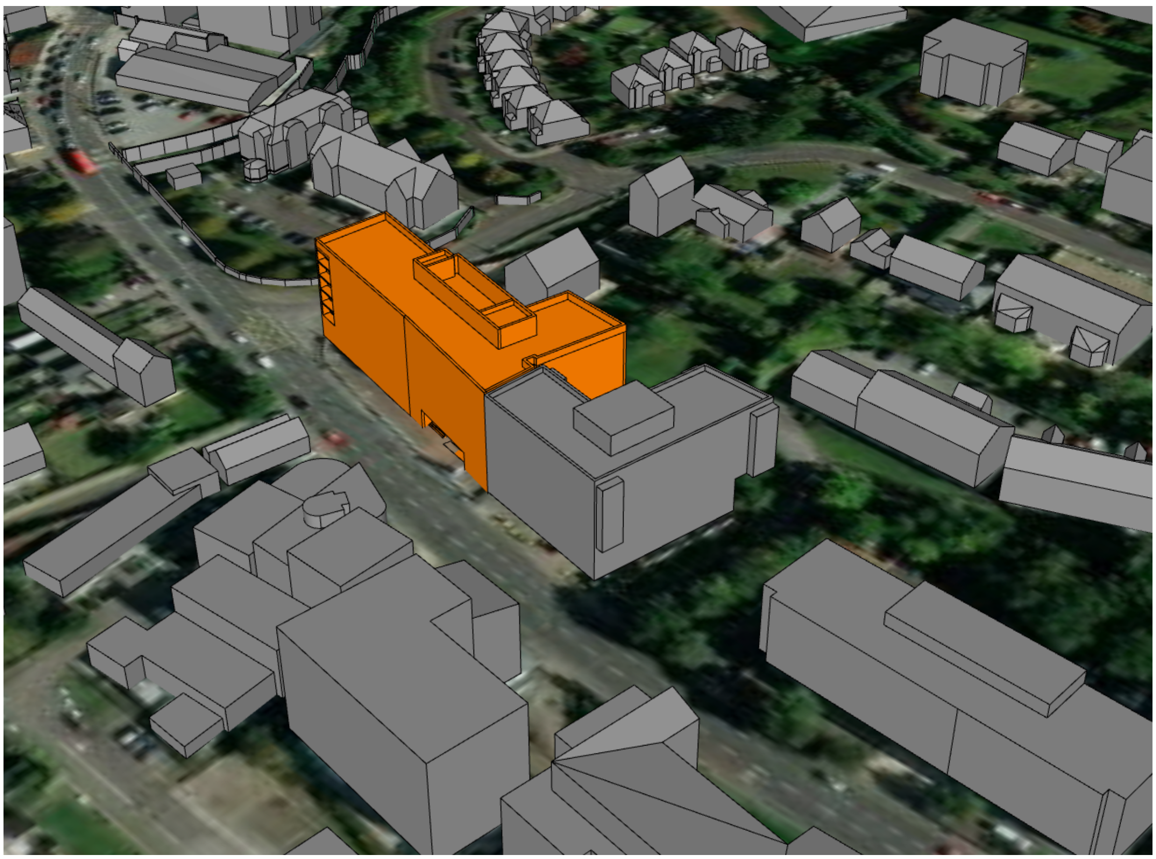


Figure 5.1: Proposed Victoria Cross Road Development

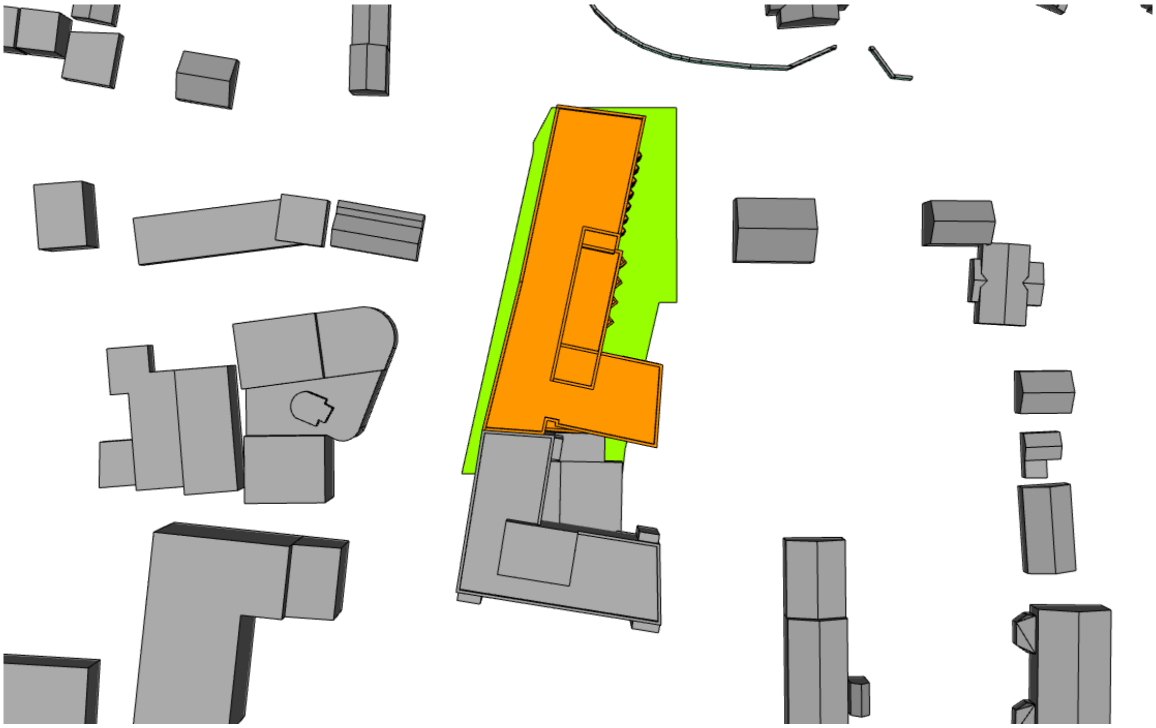


Figure 5.2: Proposed Victoria Cross Road Development - Potential Sensitive Receptors - Pedestrian Activities Area (green color)

6. BASELINE WIND MICROCLIMATE

6.1 BASELINE SCENARIO

The wind microclimate of the baseline scenario is defined by the wind patterns that develop on the site and it's the surroundings (existing buildings and topography) under the local wind conditions relevant for the assessment of the Pedestrian Comfort and Distress.

In this scenario the assessment has considered the impact of wind on the existing area. Results of wind microclimate at pedestrian level (1.5m height - flow speeds) are collected throughout the modelled site. These flow velocities identify if locally, wind speeds at pedestrian-level are accelerated or decelerated in relation to the undisturbed reference wind speed due to the presence of the existing baseline environment.

The impact of these speeds are then combined with their specific frequency of occurrence and presented in the maps that show the area of comfort and distress in accordance with Lawson Criteria, these maps are produced at pedestrian level on the ground and identify the suitability of each areas to its prescribed level of usage and activity.

Figure 6.1: CFD Model of the Baseline Scenario

6.1.1 WIND SPEEDS - Pedestrian Level

Results of wind speeds and their circulations at pedestrian level of 1.5m above the development ground are presented in Figures **??** to 6.7 in order to assess wind flows at ground floor level of Victoria Cross Road Development.

Wind flow speeds are shown to be within tenable conditions. Some higher velocity indicating minor existing funnelling effects are found near the East and south sides of the site.

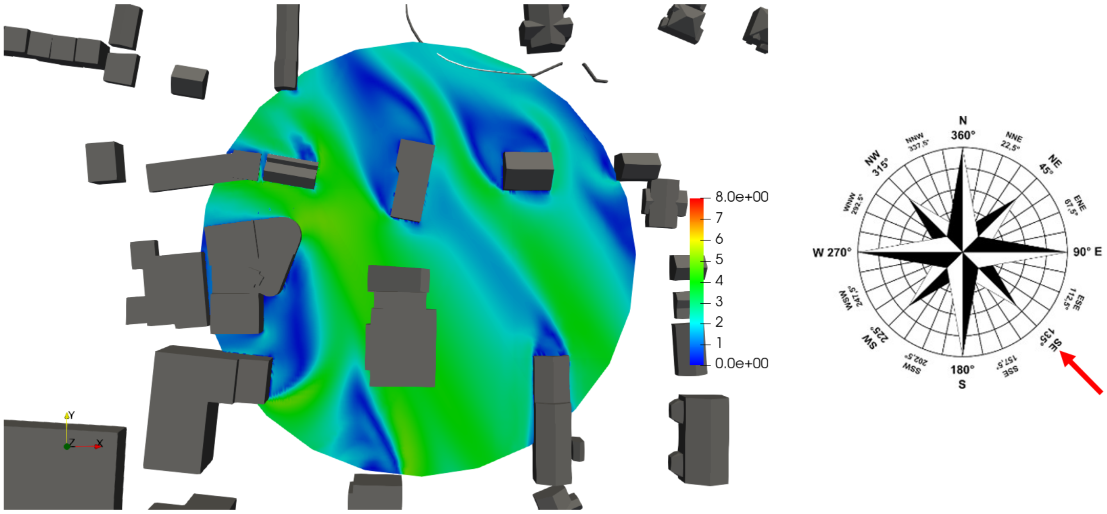


Figure 6.2: Ground Floor Level - Flow Velocity Results at Z=1.5m above the ground - Wind Direction: 135°

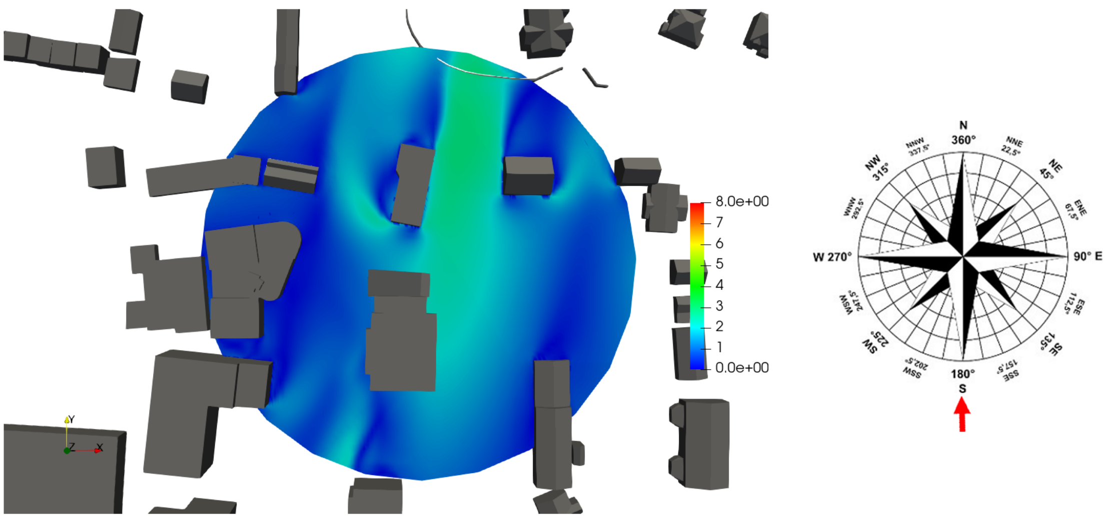


Figure 6.3: Ground Floor Level - Flow Velocity Results at Z=1.5m above the ground - Wind Direction: 180°

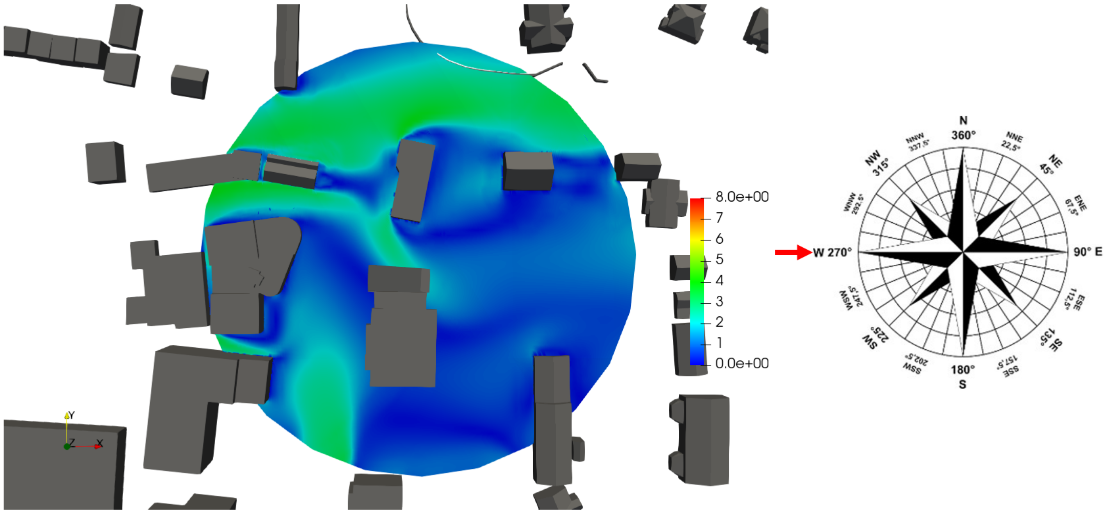


Figure 6.4: Ground Floor Level - Flow Velocity Results at Z=1.5m above the ground - Wind Direction: 270°

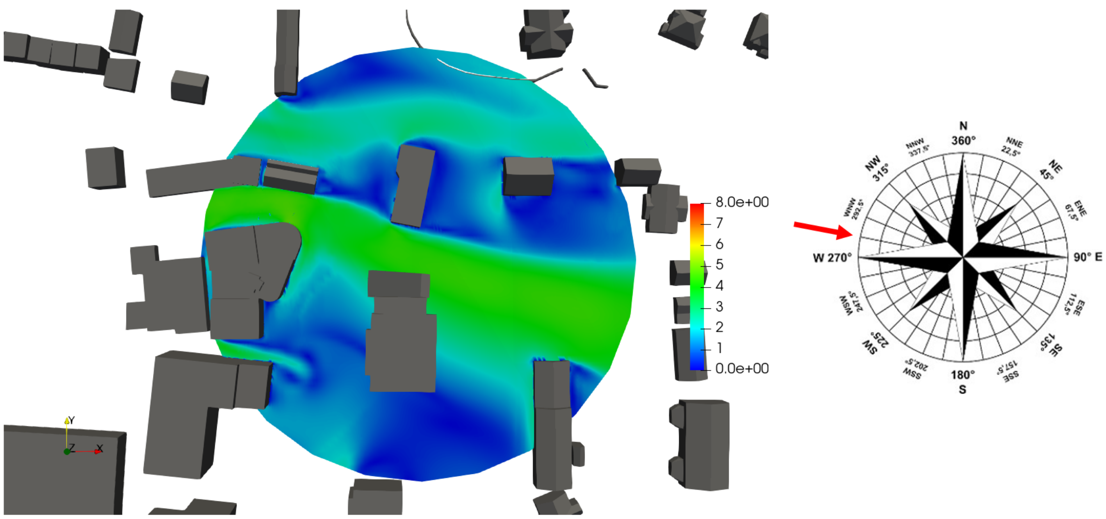


Figure 6.5: Ground Floor Level - Flow Velocity Results at Z=1.5m above the ground - Wind Direction: 281°

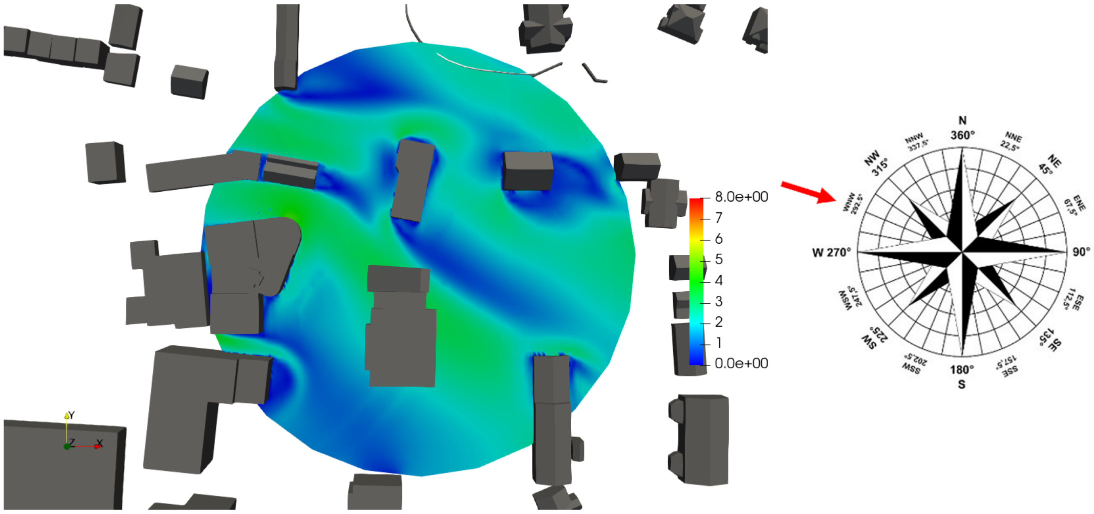


Figure 6.6: Ground Floor Level - Flow Velocity Results at Z=1.5m above the ground - Wind Direction: 292°

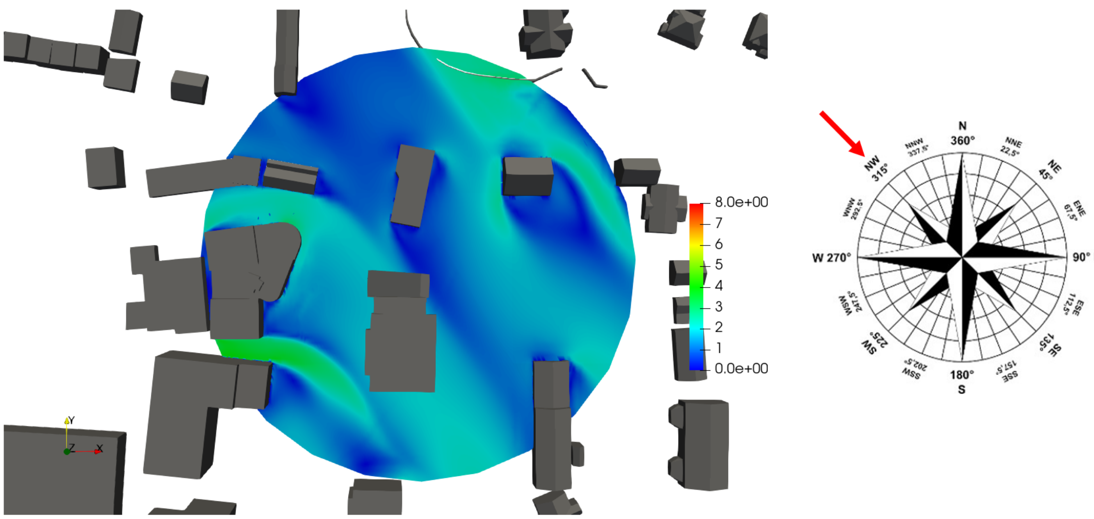


Figure 6.7: Ground Floor Level - Flow Velocity Results at Z=1.5m above the ground - Wind Direction: 315°

6.1.2 BASELINE WIND MICROCLIMATE - Lawson Criteria

The wind flow results obtained simulating the different direction and wind speeds, are combined with wind frequencies of occurrence to obtain comfort ratings at pedestrian level in all areas included within the model. The comparison of comfort ratings with intended pedestrian activities is shown in the Lawson Comfort and Distress Map that follows. The comfort/distress conditions are presented using a colour coded diagram below formulated in accordance with the Lawson Criteria.

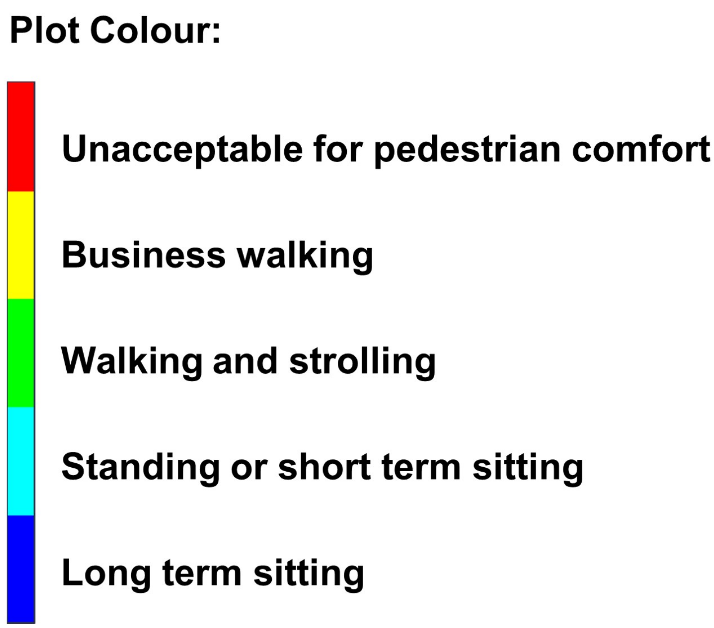


Figure 6.8: Lawson Comfort Categories

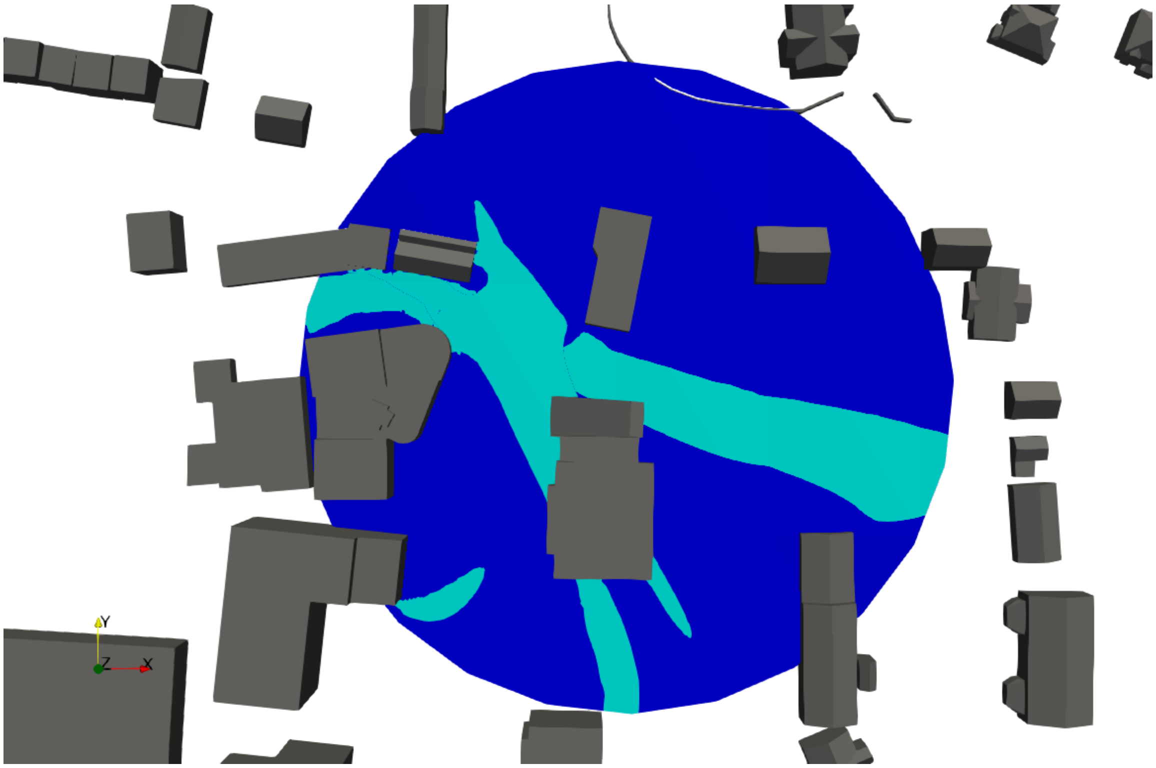


Figure 6.9: Ground Floor - Lawson Discomfort Map - Top View

From the simulation results the following observations are pointed out:

- The assessment of the baseline scenario has shown that no area is unsafe and no conditions of distress are created in the existing environment under the local wind climate.

- The site is usable for walking and short term sitting, the roads in the surrounding are usable for their intended scope (walking).

- At the moment there is no designated area for public long term sitting, however some area of the site present comfortable conditions for this activity.

7. IMPACT OF THE PROPOSED DEVELOPMENT

This section assessed 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.

7.0.1 CONSTRUCTION PHASE

As the finalization of the development proceeds, the wind setting at the site would progressively conform to those of the completed development. 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 Victoria Cross Road 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.

7.0.2 OPERATIONAL PHASE

This section shows CFD results of wind microclimate assessment carried out considering the ”Operational Phase” of Victoria Cross Road Development. In this case the assessment has considered the impact of wind on the existing area including the proposed Victoria Cross Road Development. 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.

Results of wind microclimate at pedestrian level (1.5m height - flow speeds) are collected throughout the modelled site and on the roof terraces (potential receptors). These flow velocities identify if locally, wind speeds at pedestrian-level are accelerated or decelerated in relation to the undisturbed reference wind speed due to the presence of the existing baseline environment.

The impact of these speeds are then combined with their specific frequency of occurrence and presented in the maps that show the area of comfort and distress in accordance with Lawson Criteria, these maps are produced at pedestrian level on the ground and on the roof terraces and identify the suitability of each areas to its prescribed level of usage and activity.

Figure 7.1: CFD Model of Proposed Scenario

7.0.3 WIND SPEEDS - Pedestrian Level

Results of wind speeds and their circulations at pedestrian level of 1.5m above the development ground are presented in Figures 7.2 to 7.25 in order to assess wind flows at ground floor level of Victoria Cross Road Development.

Wind flow speeds are shown to be within tenable conditions. Some higher velocity indicating funnelling effects are found South-West side of the development. However, the areas can be utilised for the intended use, according to the Lawson Criteria, as shown in the next sections.

Therefore, it can be concluded that the wind speeds do not attain critical levels around the development.

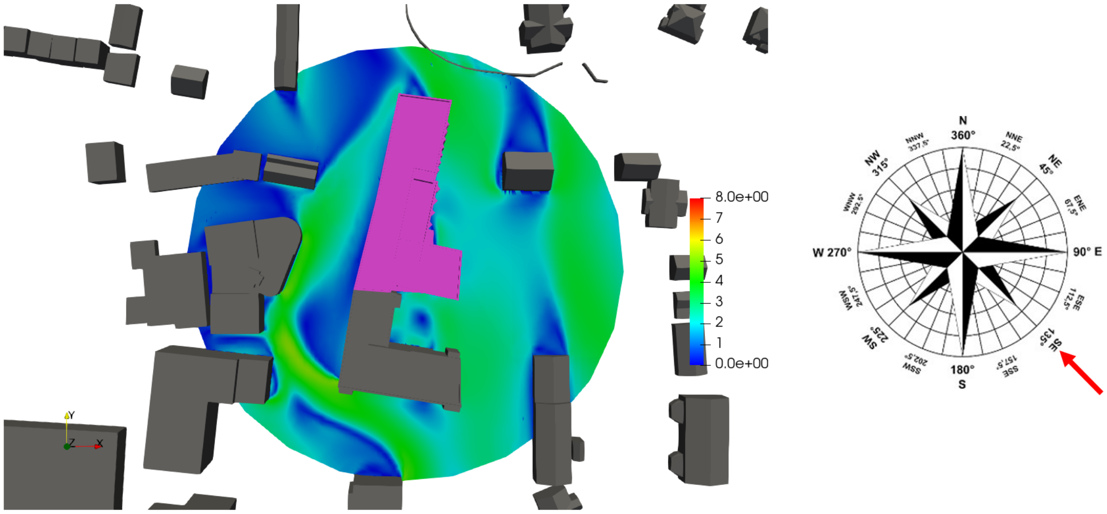


Figure 7.2: Ground Floor Level - Flow Velocity Results at Z=1.5m above the ground - Wind Direction: 135°

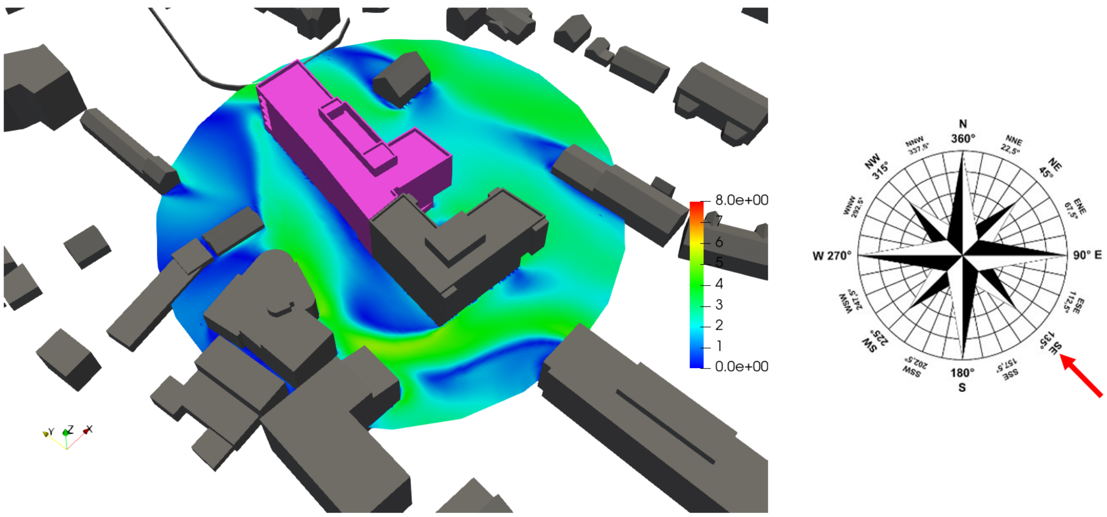


Figure 7.3: Wind Speed Results at 1.5m Above Development Ground Floor - 3D View - Wind Direction: 135°

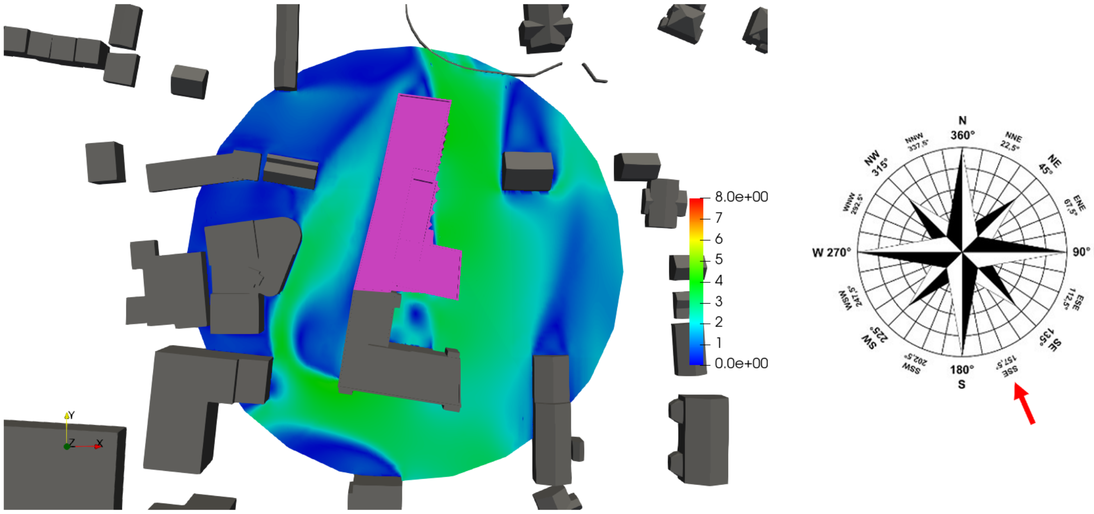


Figure 7.4: Ground Floor Level - Flow Velocity Results at Z=1.5m above the ground - Wind Direction: 157°

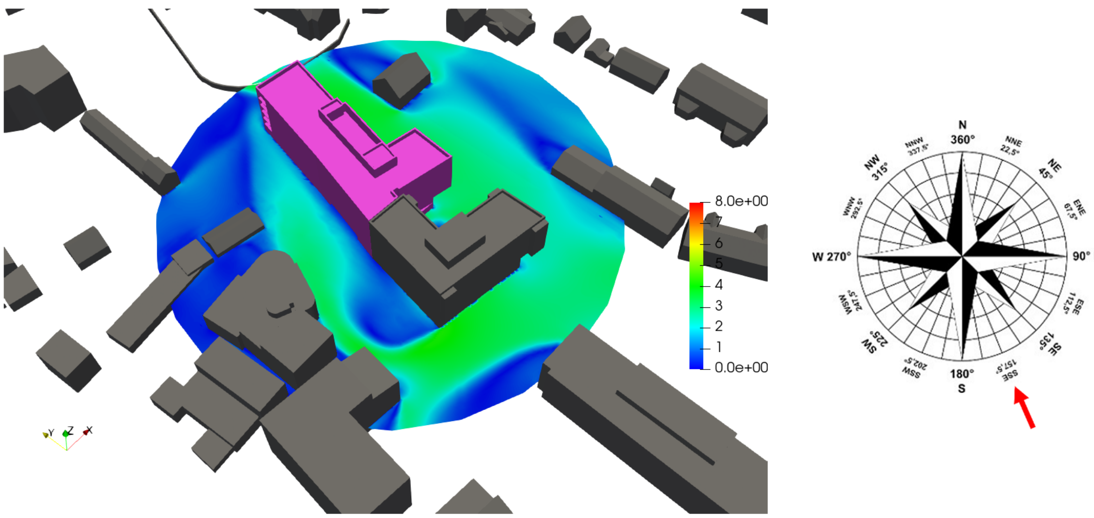


Figure 7.5: Wind Speed Results at 1.5m Above Development Ground Floor - 3D View - Wind Direction: 157°

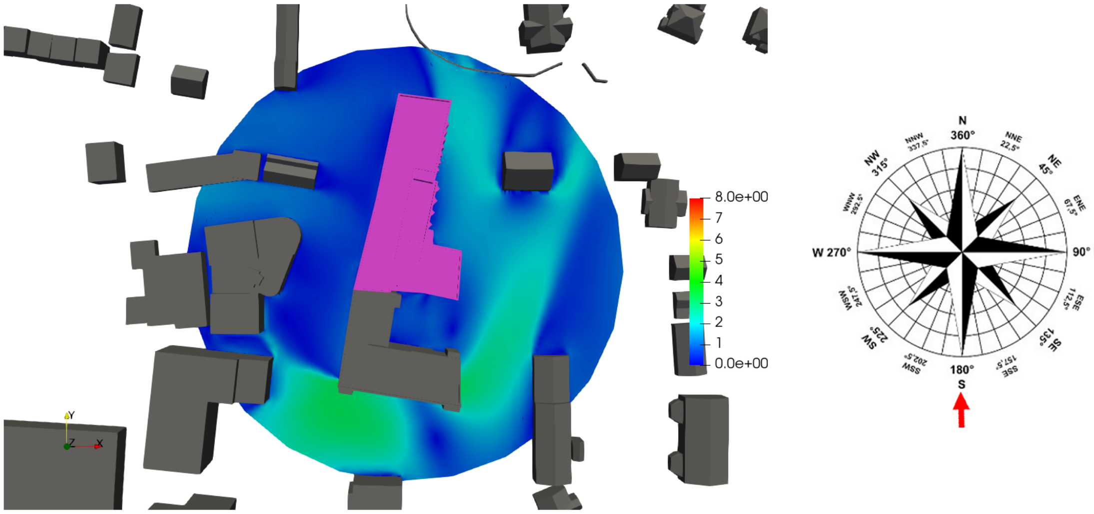


Figure 7.6: Ground Floor Level - Flow Velocity Results at Z=1.5m above the ground - Wind Direction: 180°

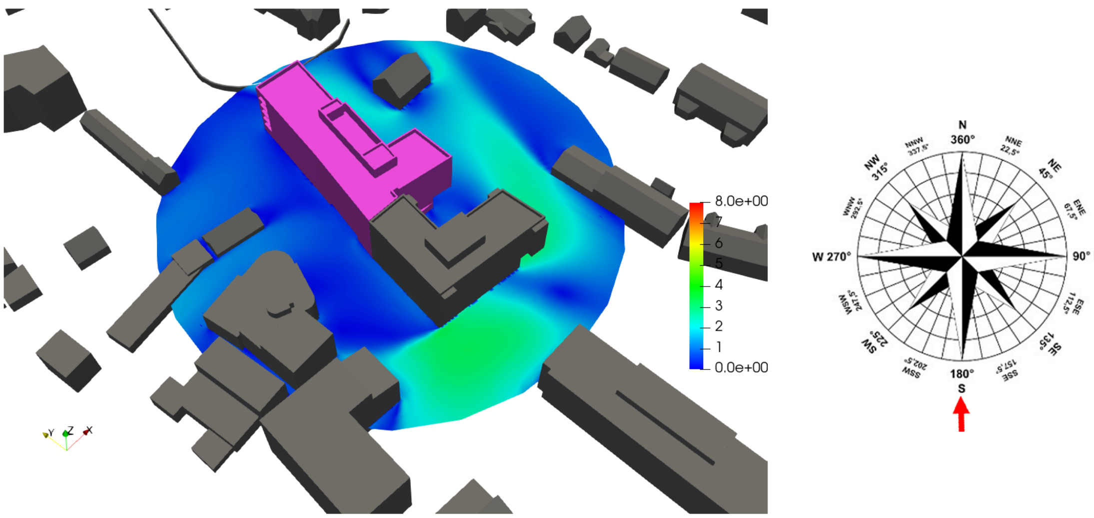


Figure 7.7: Wind Speed Results at 1.5m Above Development Ground Floor - 3D View - Wind Direction: 180°

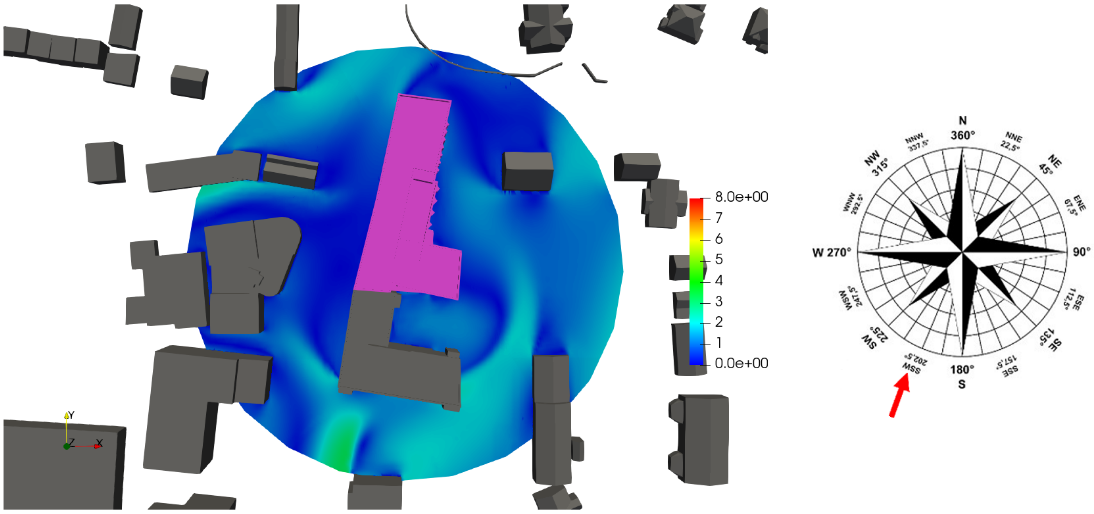


Figure 7.8: Ground Floor Level - Flow Velocity Results at Z=1.5m above the ground - Wind Direction: 202°

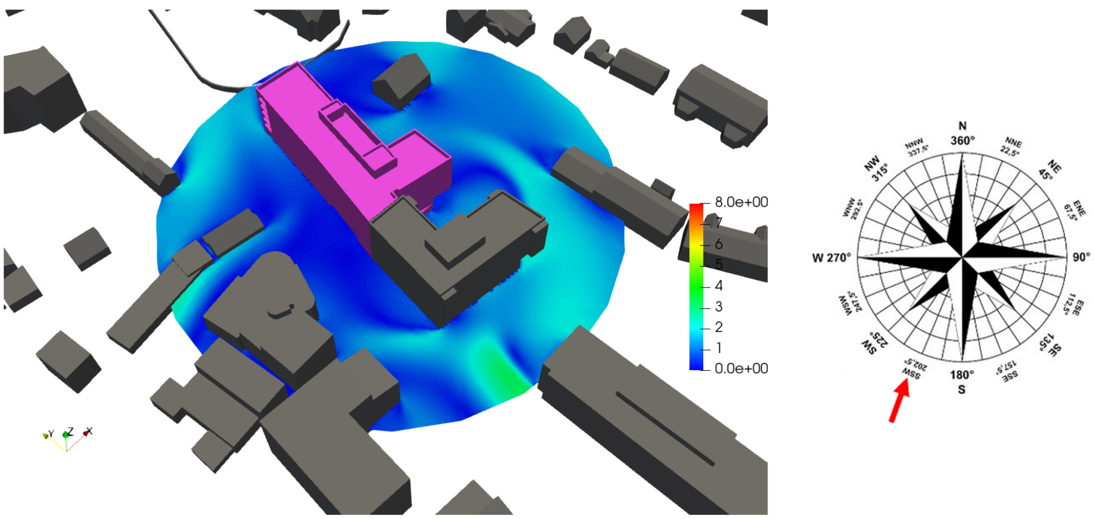


Figure 7.9: Wind Speed Results at 1.5m Above Development Ground Floor - 3D View - Wind Direction: 202°

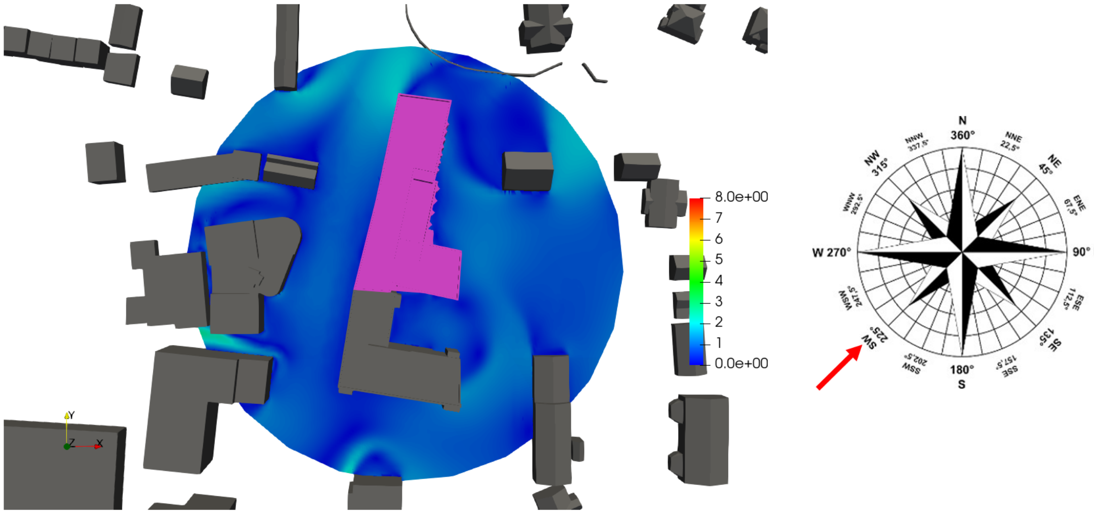


Figure 7.10: Ground Floor Level - Flow Velocity Results at Z=1.5m above the ground - Wind Direction: 225°

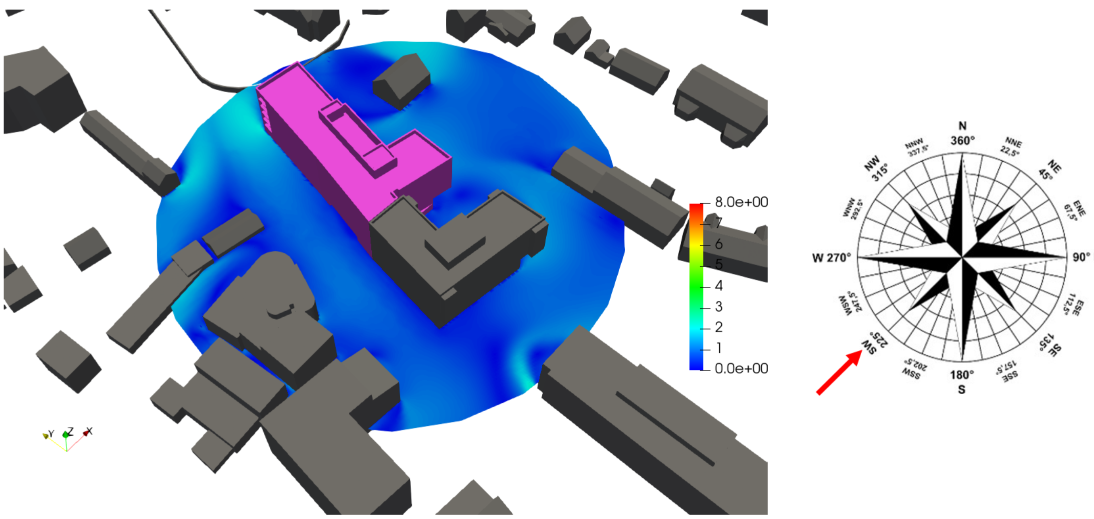


Figure 7.11: Wind Speed Results at 1.5m Above Development Ground Floor - 3D View - Wind Direction: 225°

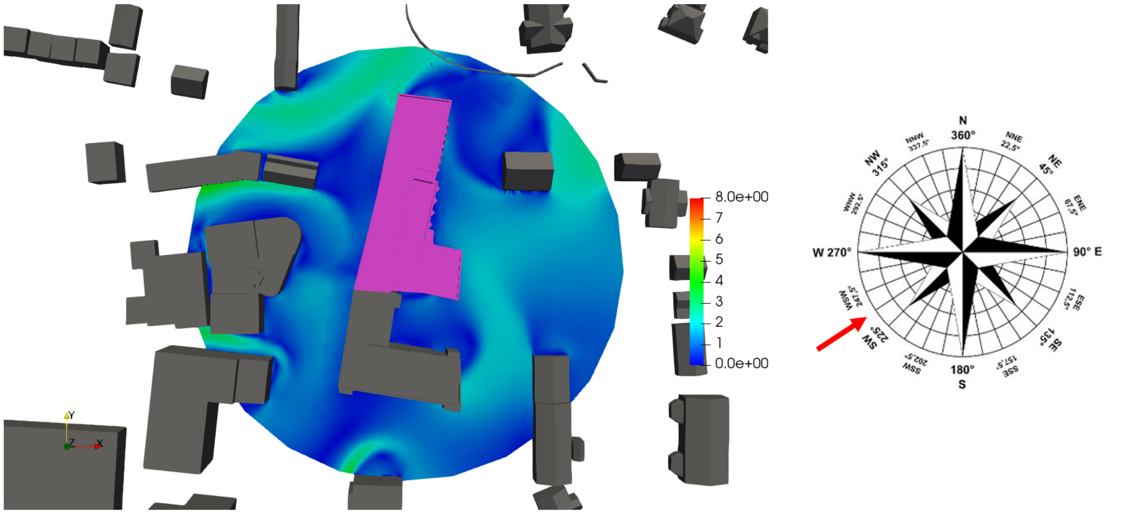


Figure 7.12: Ground Floor Level - Flow Velocity Results at Z=1.5m above the ground - Wind Direction: 236°

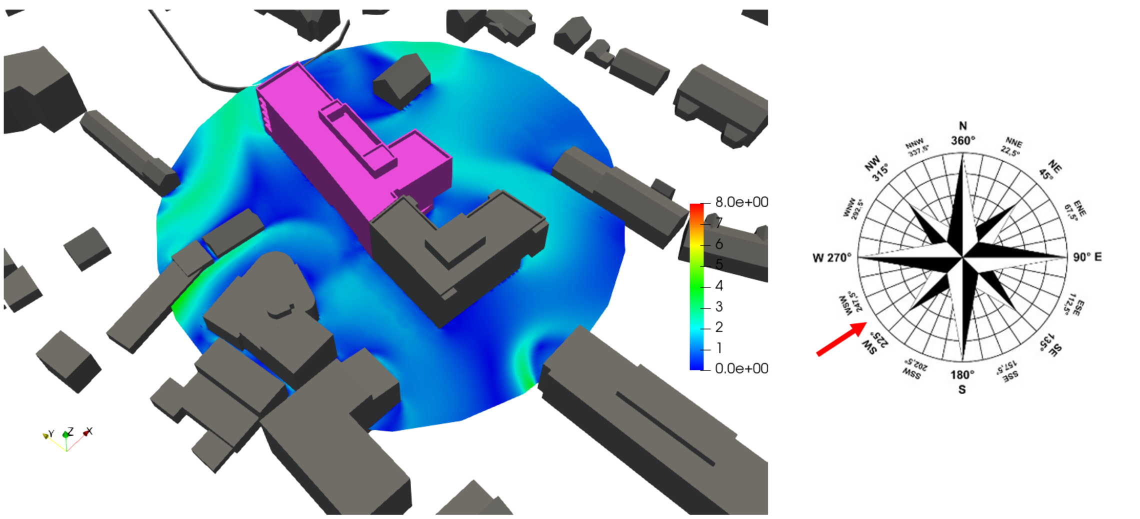


Figure 7.13: Wind Speed Results at 1.5m Above Development Ground Floor - 3D View - Wind Direction: 236°

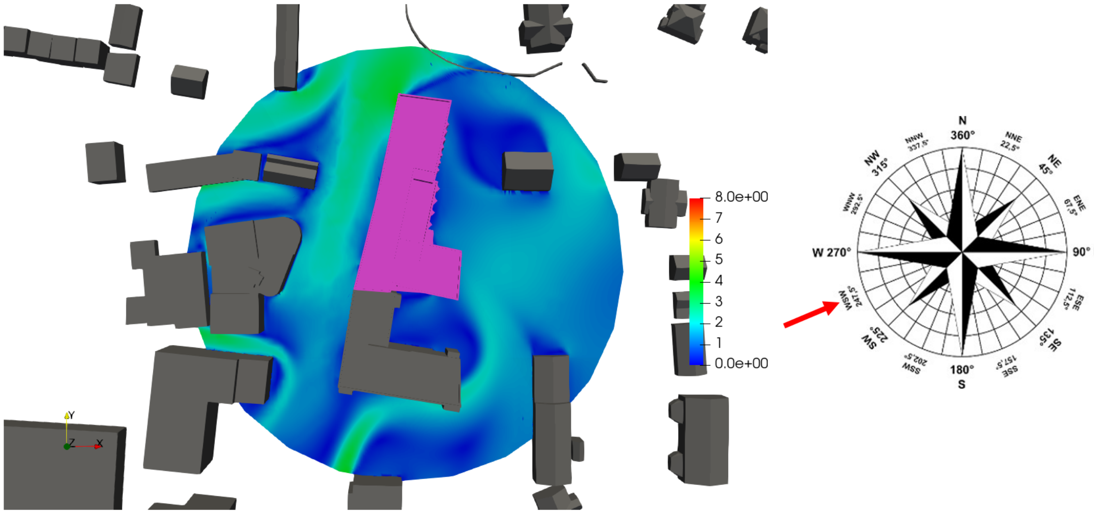


Figure 7.14: Ground Floor Level - Flow Velocity Results at Z=1.5m above the ground - Wind Direction: 247°

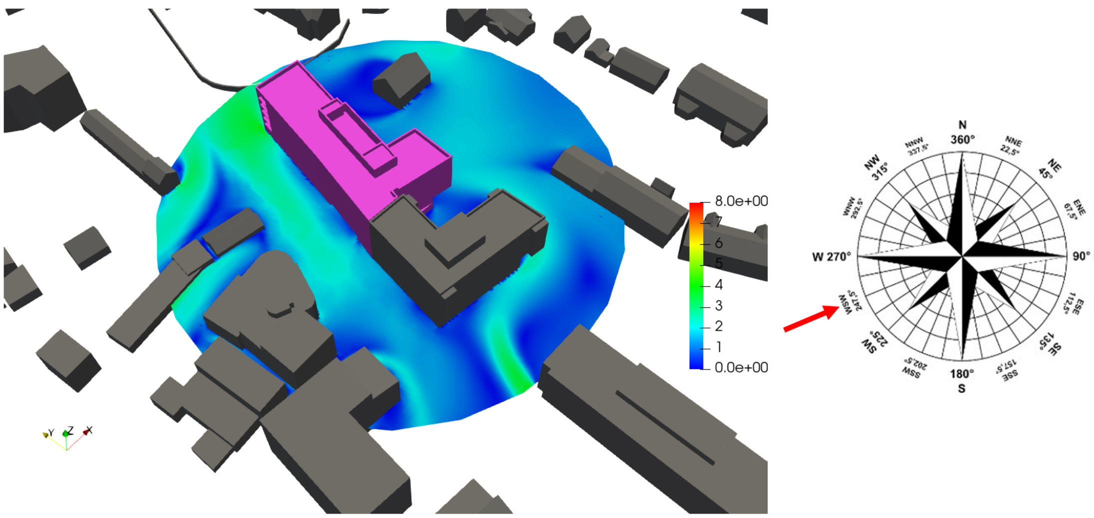


Figure 7.15: Wind Speed Results at 1.5m Above Development Ground Floor - 3D View - Wind Direction: 247°

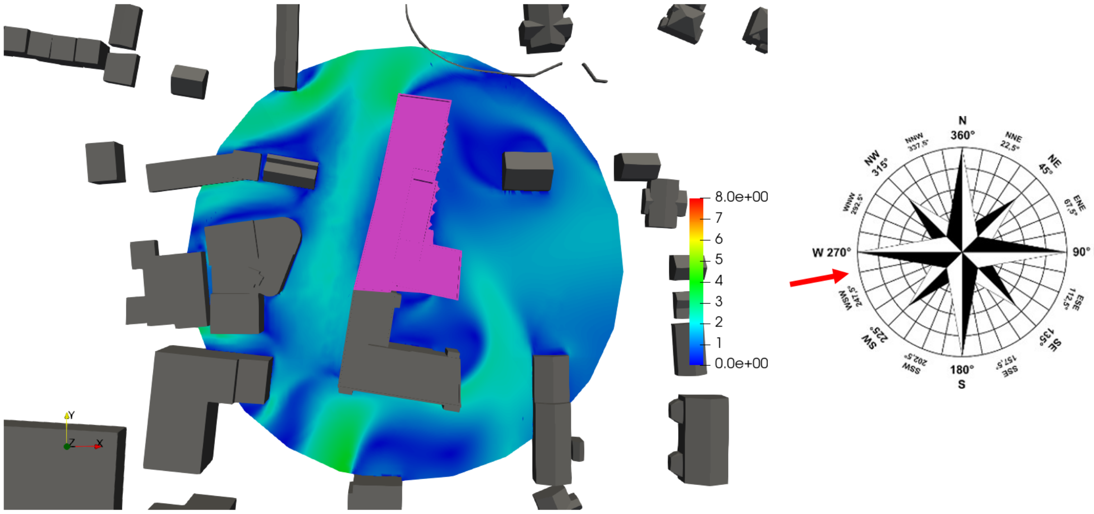


Figure 7.16: Ground Floor Level - Flow Velocity Results at Z=1.5m above the ground - Wind Direction: 258°

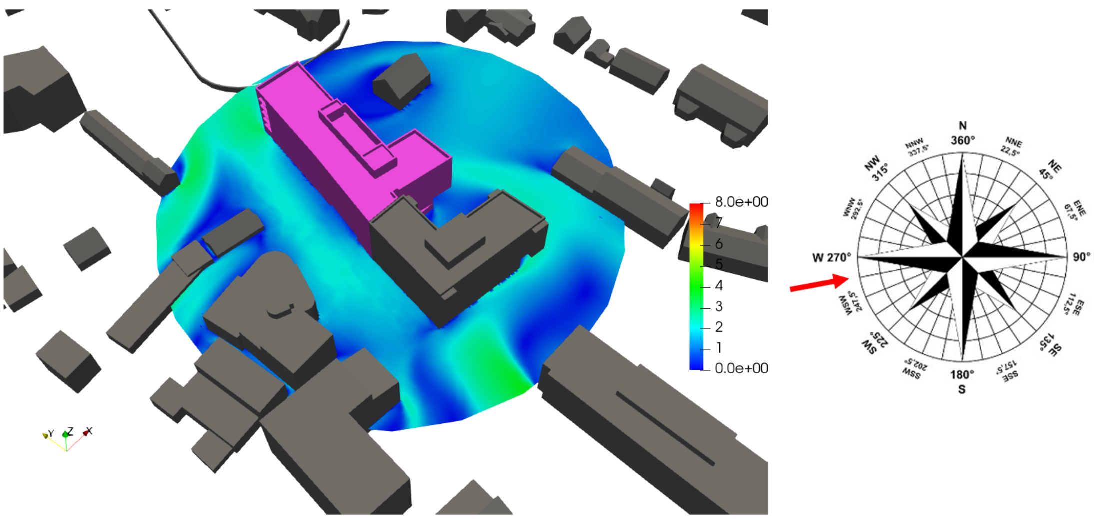


Figure 7.17: Wind Speed Results at 1.5m Above Development Ground Floor - 3D View - Wind Direction: 258°

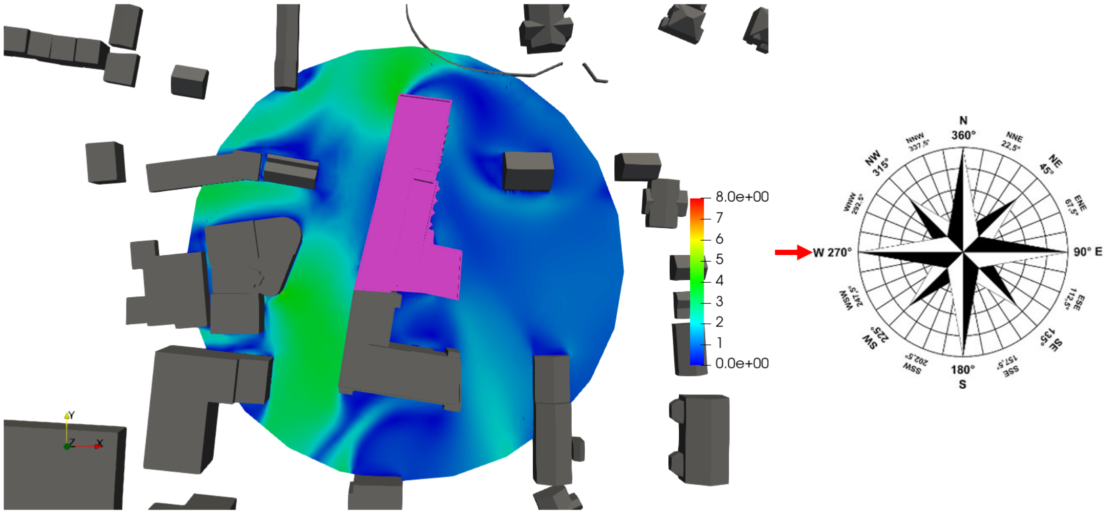


Figure 7.18: Ground Floor Level - Flow Velocity Results at Z=1.5m above the ground - Wind Direction: 270°

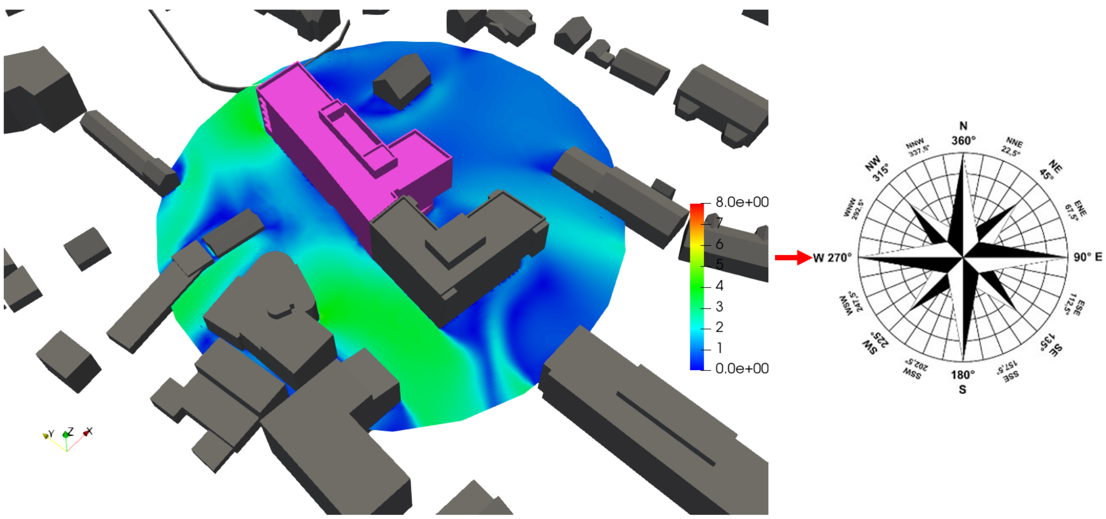


Figure 7.19: Wind Speed Results at 1.5m Above Development Ground Floor - 3D View - Wind Direction: 270°

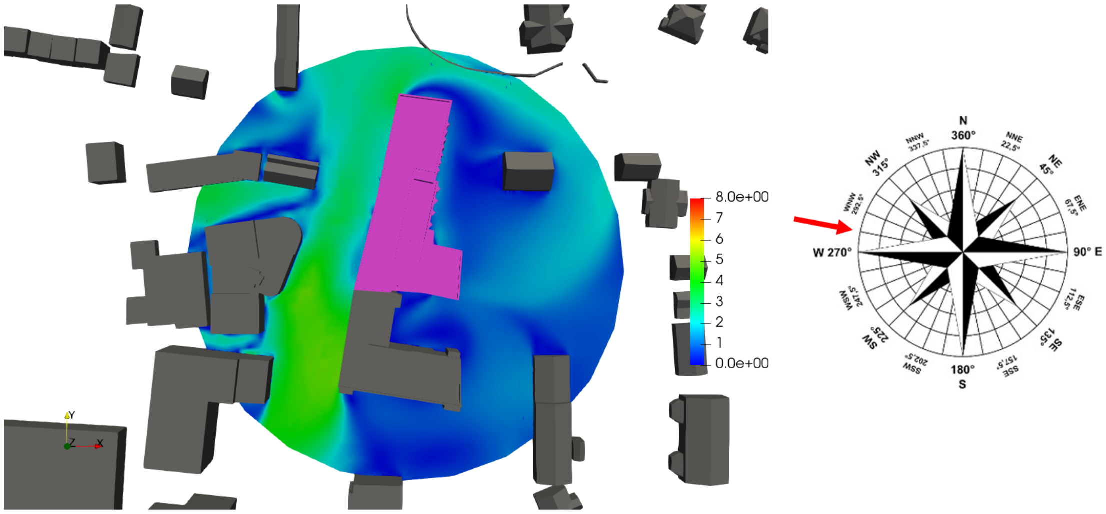


Figure 7.20: Ground Floor Level - Flow Velocity Results at Z=1.5m above the ground - Wind Direction: 281°

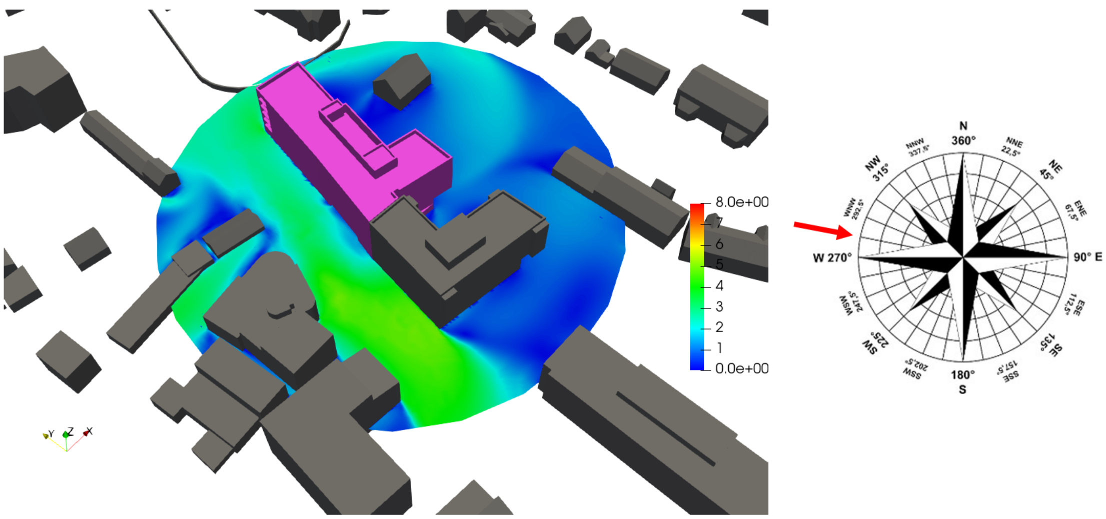


Figure 7.21: Wind Speed Results at 1.5m Above Development Ground Floor - 3D View - Wind Direction: 281°

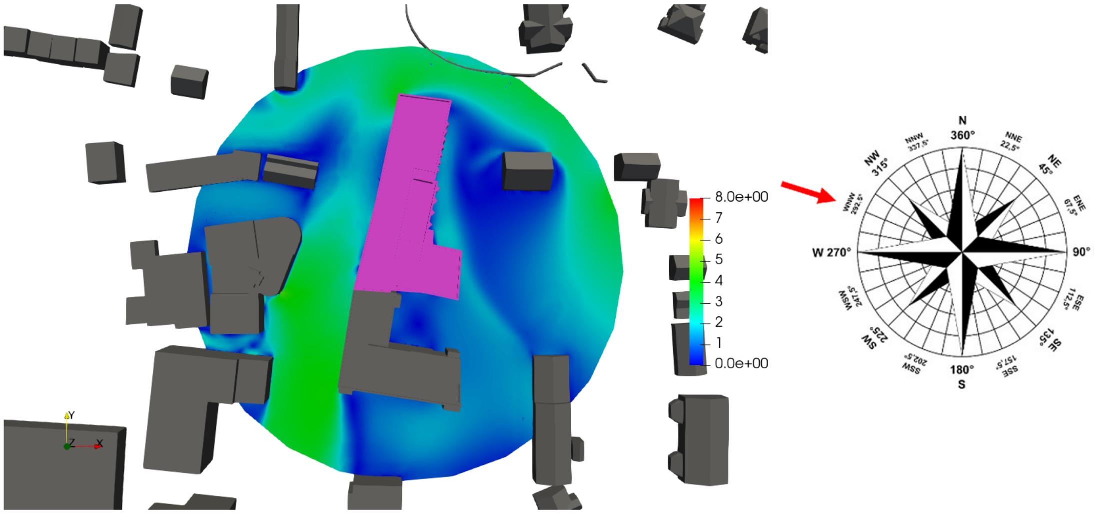


Figure 7.22: Ground Floor Level - Flow Velocity Results at Z=1.5m above the ground - Wind Direction: 292°

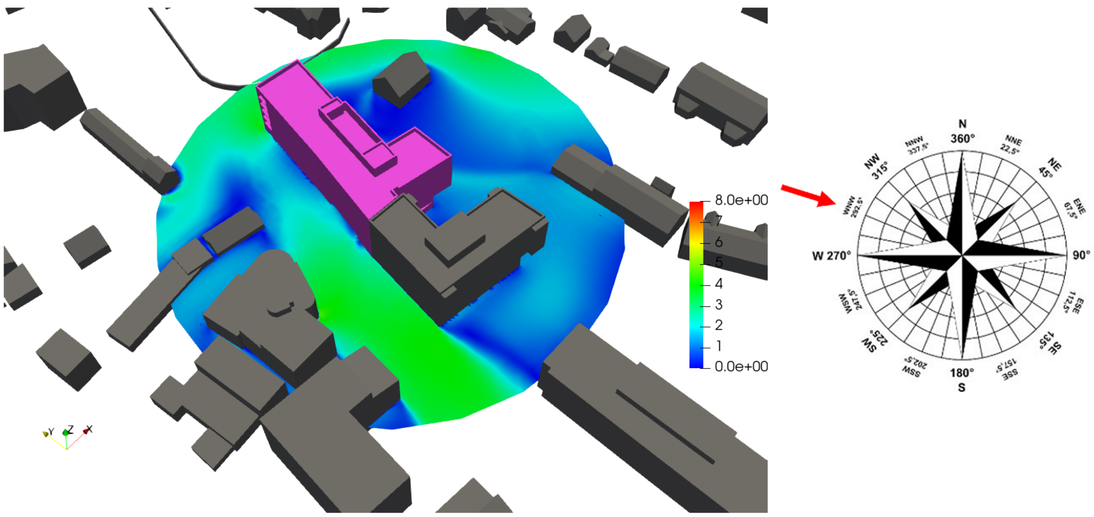


Figure 7.23: Wind Speed Results at 1.5m Above Development Ground Floor - 3D View - Wind Direction: 292°

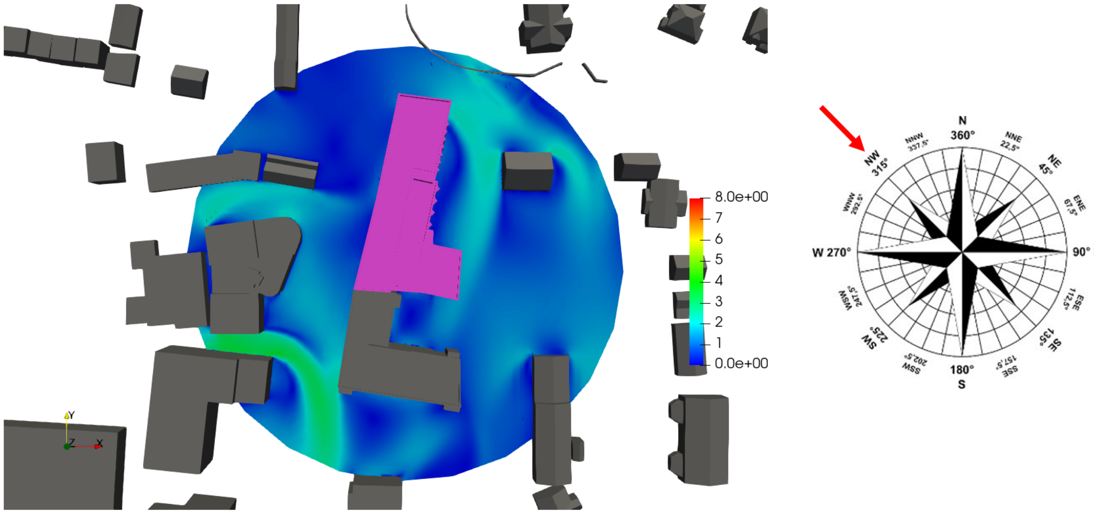


Figure 7.24: Ground Floor Level - Flow Velocity Results at Z=1.5m above the ground - Wind Direction: 315°

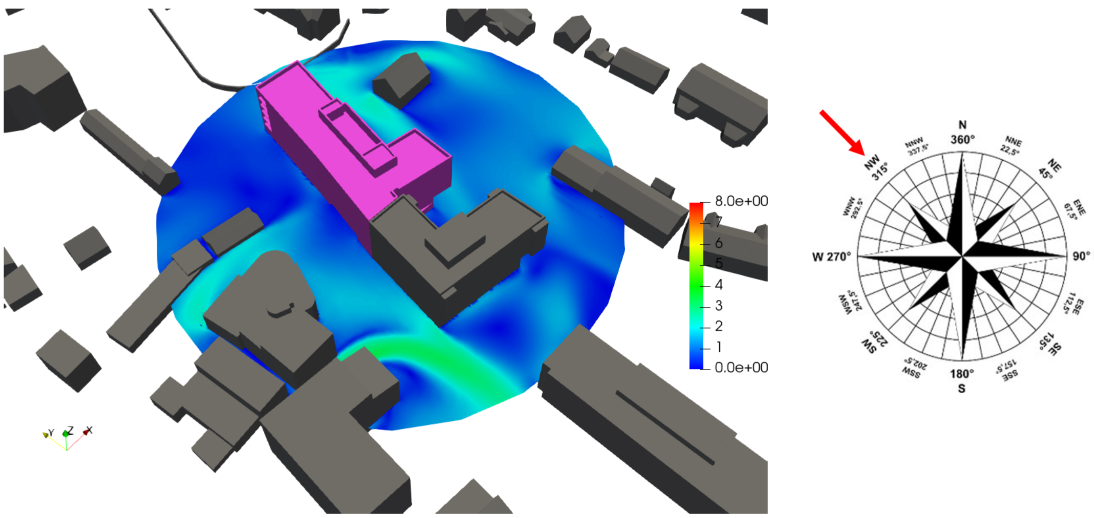


Figure 7.25: Wind Speed Results at 1.5m Above Development Ground Floor - 3D View - Wind Direction: 315°

7.0.4 PROPOSED DEVELOPMENT WIND MICROCLIMATE - Lawson Criteria

The wind flow results obtained simulating the different direction and wind speeds, are combined with wind frequencies of occurrence to obtain comfort ratings at pedestrian level in all areas included within the model. The comparison of comfort ratings with intended pedestrian activities is shown in the Lawson Comfort and Distress Map that follows. The comfort/distress conditions are presented using a colour coded diagram below formulated in accordance with the Lawson Criteria.

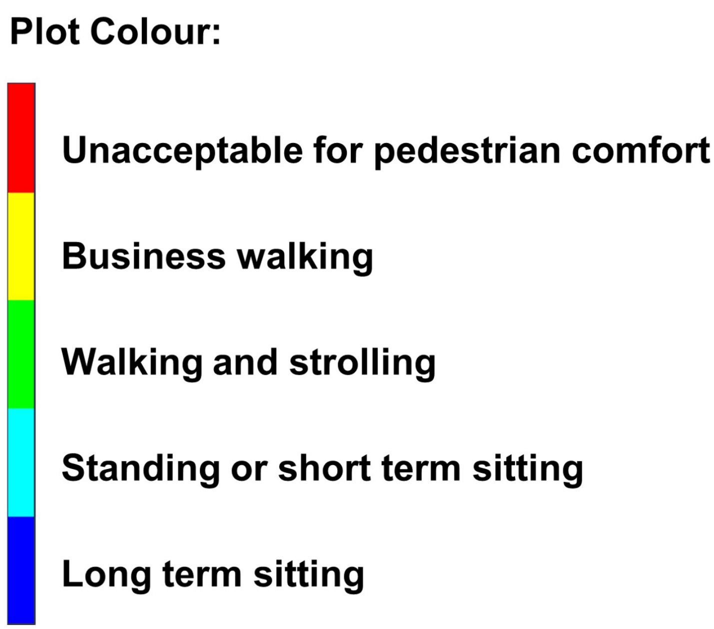


Figure 7.26: Lawson Comfort Categories

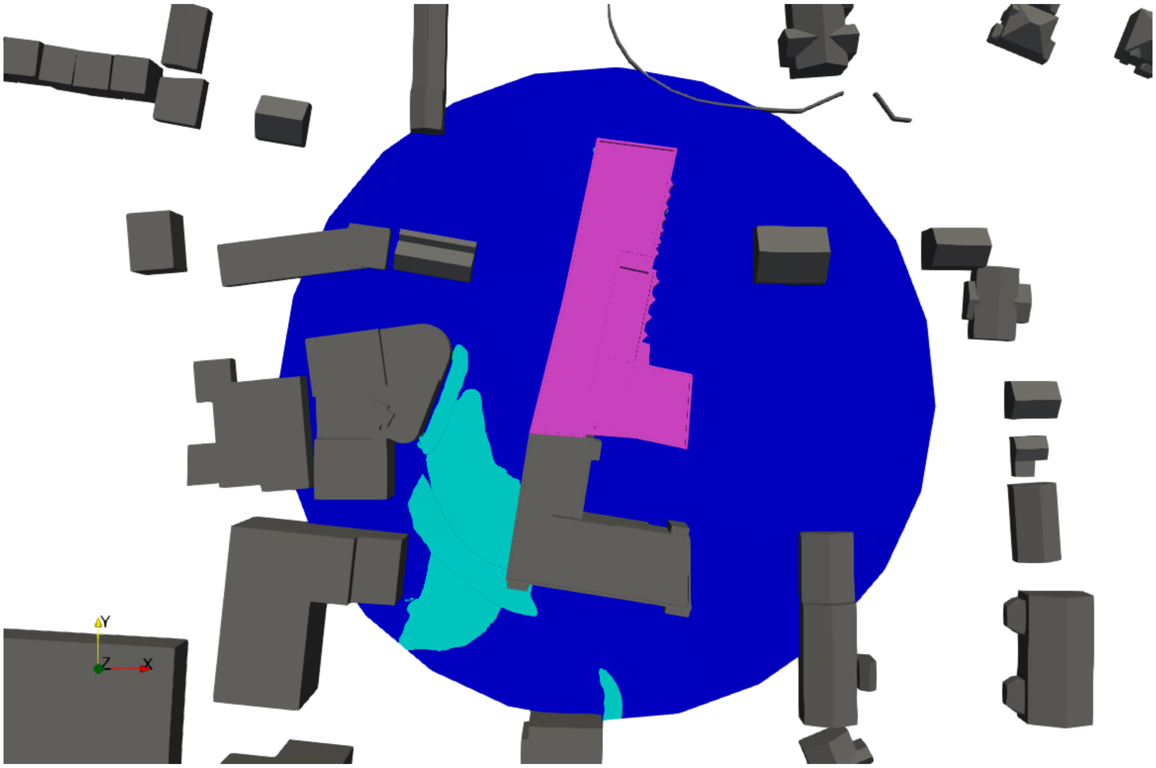


Figure 7.27: Ground Floor - Lawson Discomfort Map - Top View

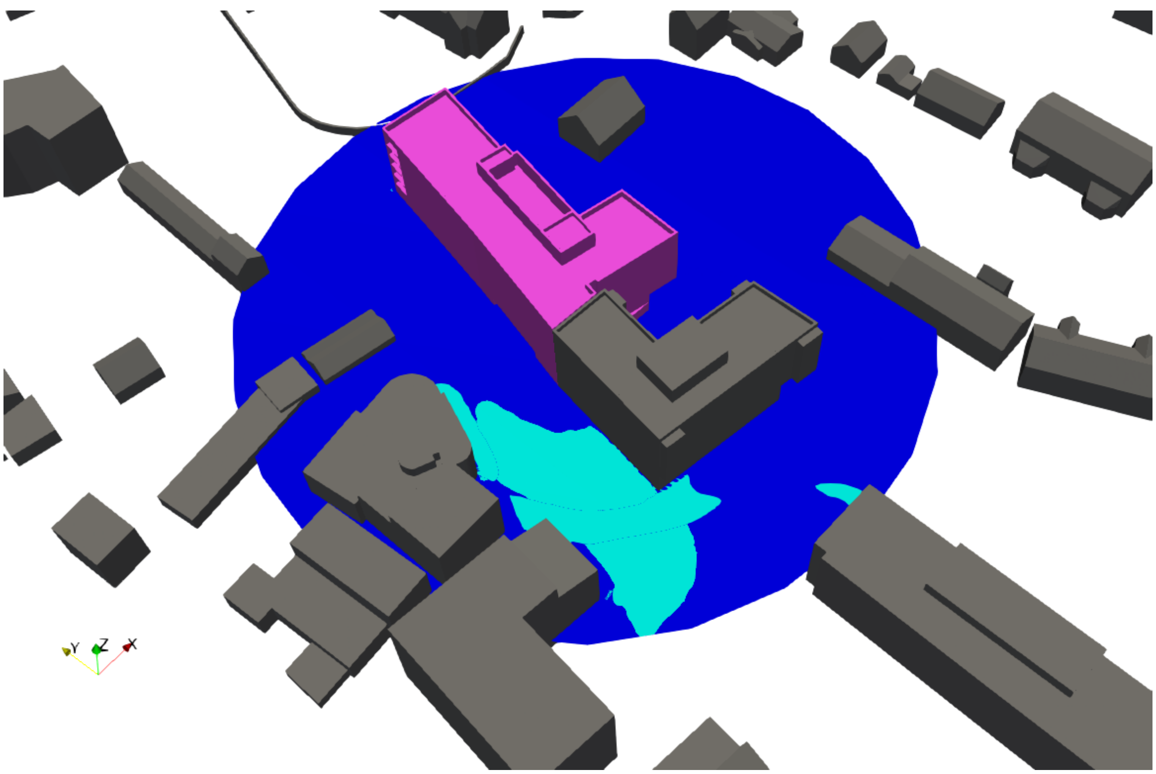


Figure 7.28: Ground Floor - Lawson Discomfort Map - 3D view

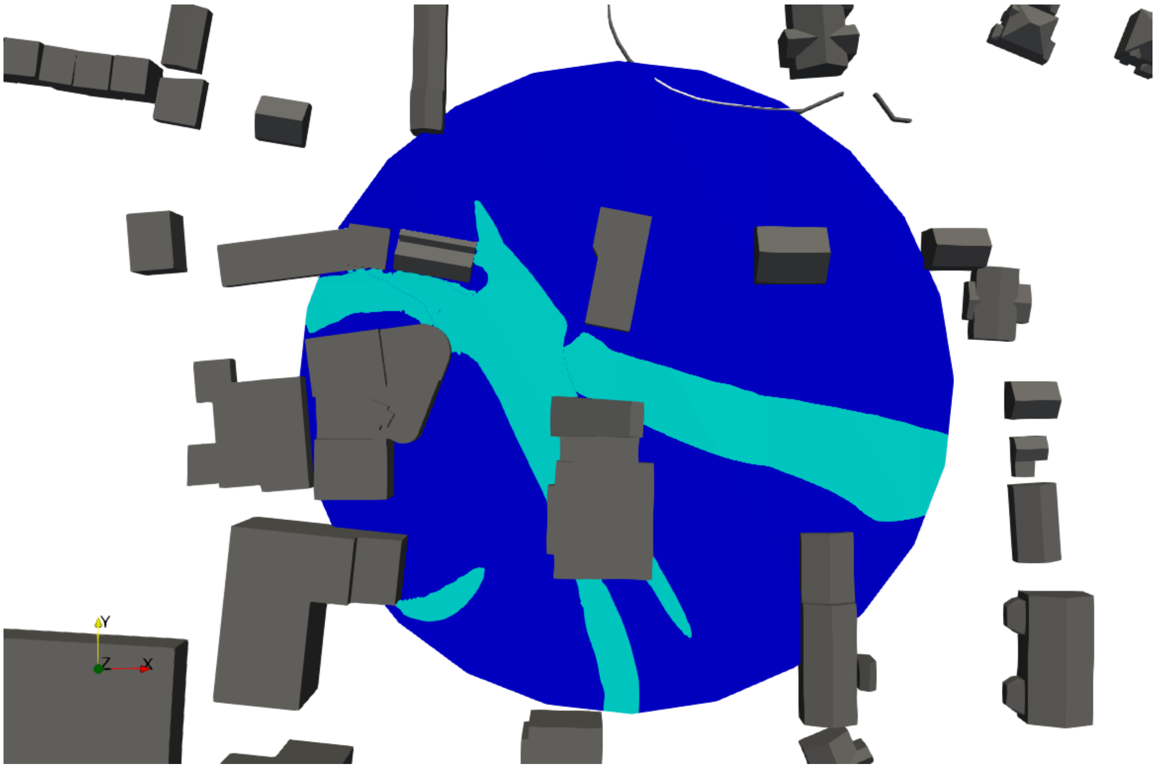
In summary, the following conclusions can be made observing the results of the wind microclimate analysis and comparing the results obtained, under the same wind conditions for the baseline scenario versus the proposed development scenario:

- The assessment of the proposed scenario has shown that no area is unsafe, and no conditions of distress are created by the proposed development.

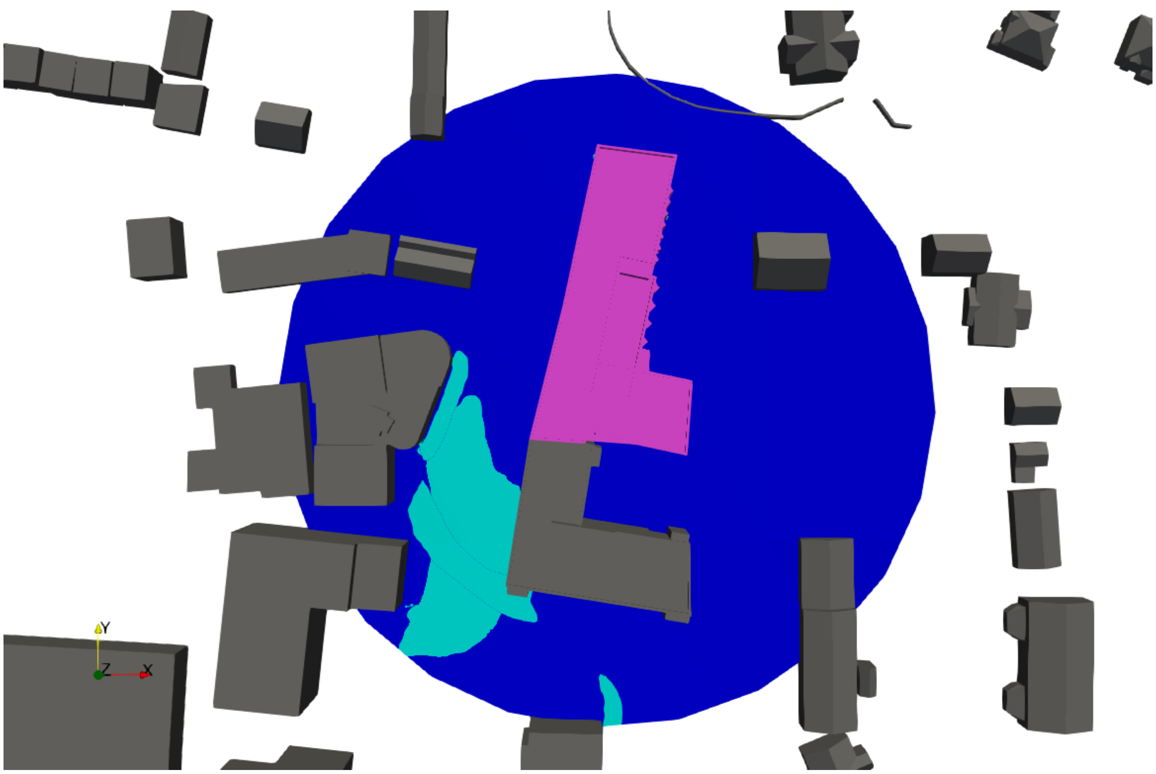
- All the roads proposed can be used for their intended scope (walking).

- The wind microclimate of the proposed development is comfortable and usable for pedestrians.

As result of the proposed development construction, the wind on the surrounding urban context is decreased on the South and West sides of the development when compared with the baseline situation.



Baseline Scenario



Proposed Development Scenario

Figure 7.29: Comparison Wind Microclimate Conditions (Lawson Comfort/Distress Map)

8. CONCLUSIONS

8.1 CONCLUSIONS and COMMENTS ON MICROCLIMATE STUDY

This report presents the CFD modelling assumptions and results of Wind and Microclimate Modelling of Victoria Cross Road Development, Victoria Cross Road, Cork.

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 Cork, and also to assess impacts of the wind on pedestrian levels of comfort/distress.

The results of this wind microclimate study are utilized by Bellmount Developments Limited. to configure the optimal layout for Victoria Cross Road 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.

- The wind profile was built using the annual average of meteorology data collected at Cork Airport Weather Station. In particular, the local wind climate was determined from historical meteorological data recorded 10m above ground level at Dublin Airport.
- The prevailing wind directions for the site are identified in the West, South, West-South-West and South-North.
- Microclimate Assessment of Victoria Cross Road Development and it's environment was performed utilizing a CFD (Computational Fluid Dynamics) methodology.
- The proposed Victoria Cross Road 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 and mitigated design, wind flow speeds at ground floor are shown to be within tenable conditions. Some higher velocity indicating funnelling effects are found South-West side of the development. However, the areas can be utilised for the intended use.
- 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 the construction of Victoria Cross Road Development the predicted impacts are classified as negligible.

Therefore, the CFD study carried out has shown that under the assumed wind conditions typically occurring within Cork 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.**

9. REFERENCES

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