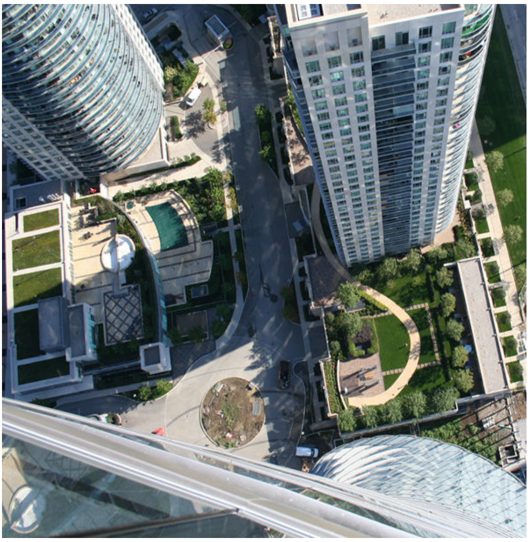
Urban Design Terms of Reference



Pedestrian

Wind Comfort and Safety Studies

February 2023

MISSISSAUGA

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1 Introduction

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Introduction

1.1 Purpose

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

Mississauga Official Plan, Section 19.4.5, identifies a Wind Study as a study that staff may request as one of the requirements for a complete application.

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 sidewalks and street frontages, pathways, building entrance areas, open spaces, amenity areas, outdoor sitting areas, and accessible roof top areas among others.

Tall buildings can have major impacts on the wind conditions in their surrounding context especially when a building is considerably taller than surrounding buildings. Tall buildings tend to intercept the stronger winds that exist at high elevations and redirect them downwards towards the ground level. Winds around the base of such buildings can be accelerated up to several times the values that existed prior to the tall buildings, thus creating uncomfortable and sometimes dangerous conditions for pedestrians.

It is important to consider the potential impacts of a proposed development on the local microclimate early in the planning and design process as this allows sufficient time to consider appropriate wind control and mitigation strategies, including significant changes to site and building designs.

Where mitigation is required to achieve acceptable pedestrian wind comfort and safety levels, the wind study shall state the mitigation plan with all the recommended mitigation measures. The proposed and future configurations shall be evaluated/tested with all recommended mitigation measures in order to demonstrate the benefits of the mitigation strategy.

All recommended mitigation measures/features shall be incorporated into the detailed concept plan, site plan, landscape plan, building elevations and all applicable drawings.

Where extreme wind conditions such as safety exceedances and uncomfortable wind comfort conditions are predicted, soft landscaping (e.g. trees, shrubs etc.) is not acceptable as wind mitigation. Other forms of wind mitigation including massing and built form changes, hard landscaping (e.g. architectural features, screens, etc.) will be required in such instances.

1.2 Who can conduct a wind study?

Pedestrian wind comfort and safety studies are to be conducted by professionals who specialize in, and can demonstrate extensive experience in dealing with wind and microclimate issues in the built environment. The studies are to be signed and sealed by a Professional Engineer.

If the Planning and Building Department is not satisfied with the level of experience demonstrated, a peer review of the wind study will be required. The cost of the peer review is to be borne by the applicant.

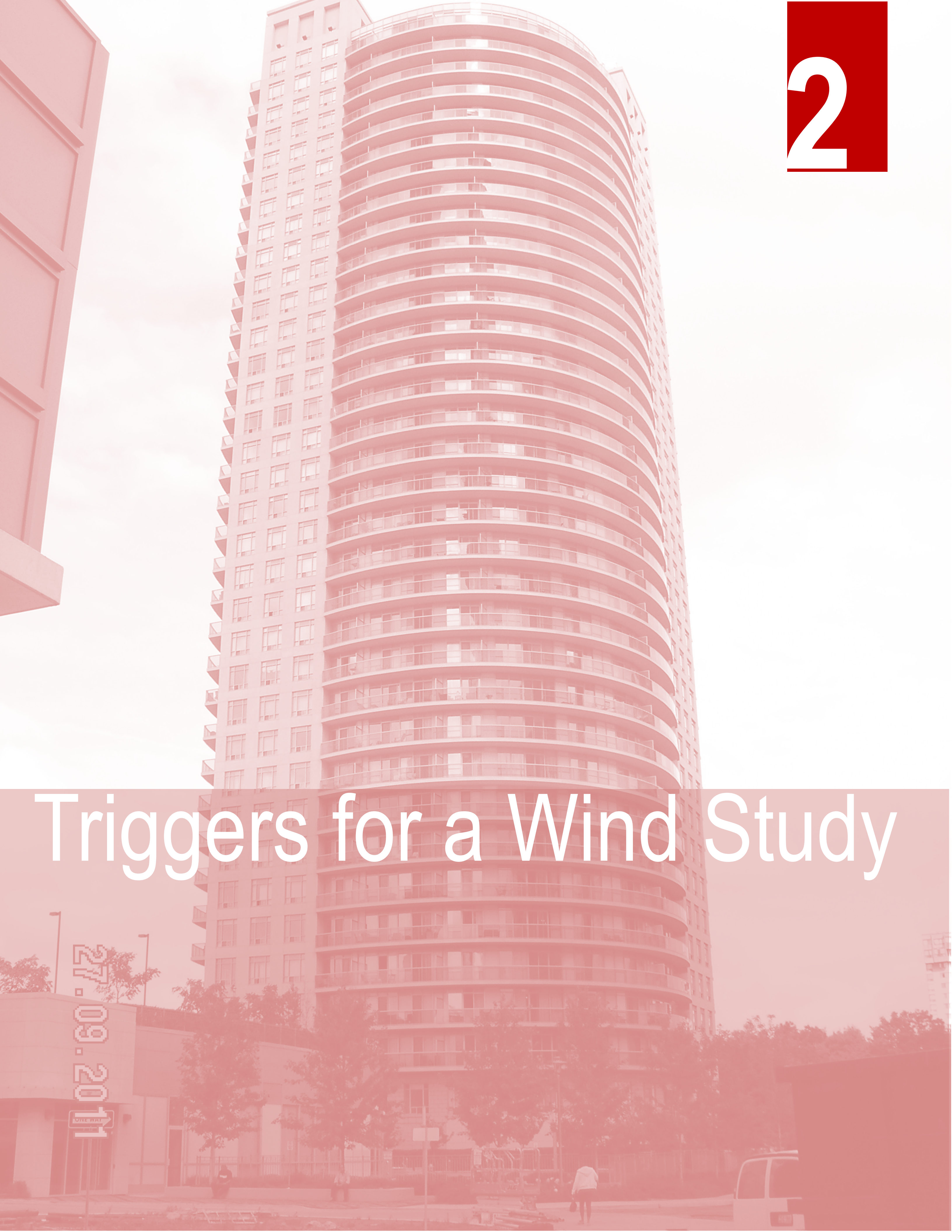
1.3 Consultation with Planning and Building Department

Prior to the preparation of pedestrian wind comfort and safety studies for submission to the City, the microclimate specialist shall consult with the Planning and Building Department as follows:

- Consult with the Development Planner and Urban Designer processing the development application, to agree upon the most appropriate approach for the wind comfort and safety study, based on the triggers described in Section 2 of this document.

- At the discretion of the City, the microclimate specialist may be asked to submit the intended test configurations and sensor locations for review by the City's Development Planner and Urban Designer prior to any wind tunnel testing.

- In the event that the proposed development is predicted to produce wind conditions that are considered unacceptable or unsafe, the City's Development Planner and Urban Designer shall be consulted to discuss potential strategies going forward.



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Triggers for a Wind Study

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Triggers for a Wind Study

The following factors will trigger a wind study:

2.1 Building Height

- A development proposal with a building 20 m in height or more, requires a **Qualitative Wind Assessment** as a minimum. A **Quantitative Wind Tunnel Study** may be required at the discretion of the Planning and Building Department.
- A development proposal with a building that is 20 m in height or more, two or more times the height of surrounding buildings requires a **Quantitative Wind Tunnel Study**
- A development proposal with a building 40 m in height or more requires a **Quantitative Wind Tunnel Study**

2.2 Number of Buildings

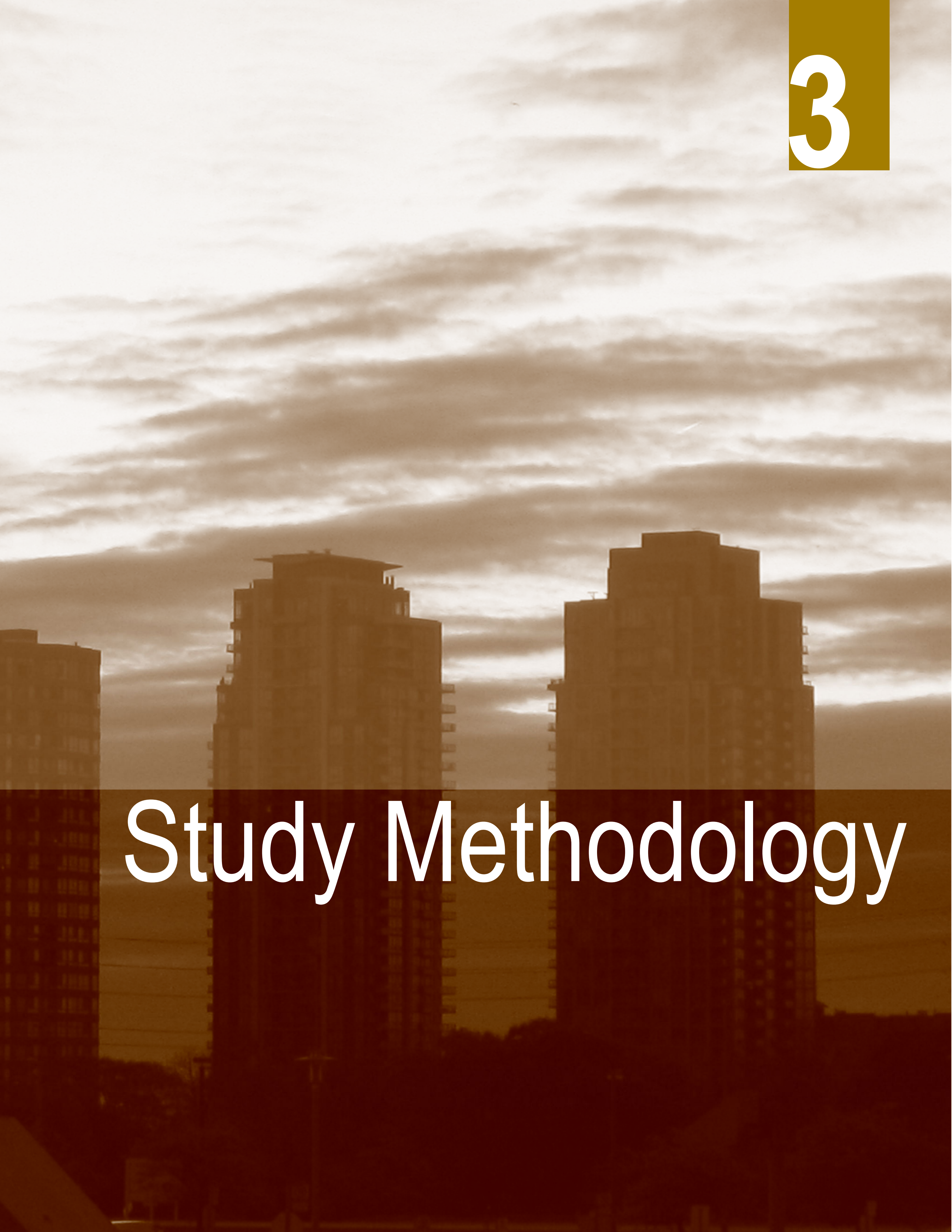
- A development proposal with two or more buildings that are 20 m in height or more, requires a **Quantitative Wind Tunnel Study.**

2.3 Site Location

- Due to proximity to Lake Ontario, a development proposal with a building that is 20 m in height or more, and is located south of the Queen Elizabeth Way, requires a **Quantitative Wind Tunnel Study**

2.4 Site Area (Size)

- A development proposal with a site area of 3 hectares or more, and a building that is 20 m in height or more, requires a **Quantitative Wind Tunnel Study**



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Study Methodology

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Study Methodology

The following is a description of the general methodology to be used by the microclimate specialist providing wind comfort studies:

3.1 Wind Data Collection

A minimum of 30 years of hourly wind data from Lester B. Pearson International Airport should be used for pedestrian wind comfort and safety studies in the City of Mississauga for developments north of the QEW. Data from Billy Bishop Toronto City Airport should be used for developments south of the QEW. The Data is to be presented and used on a two season basis defined as follows:

Summer: Hourly winds occurring during the period of May through October.

Winter: Hourly winds occurring during the period of November through April.

Note: Appropriate hours of pedestrian usage for a typical project (e.g., between 6:00 and 23:00) should be considered for wind comfort, while data for 24 hours should be used to assess wind safety.

3.2 Criteria

The criteria to be used for assessment of pedestrian wind conditions have been developed through research and practice. They have been widely accepted by municipal authorities as well as the international building design and city planning community. As both mean and gust wind speeds can affect pedestrian comfort, their combined effect is used as the basis of the criteria and defined as a Gust Equivalent Mean (GEM) wind speed. The GEM is defined as the maximum mean wind speed or the gust wind speed divided by 1.85.

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.

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.

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.

The criteria to be used are defined in Table 1.

Table1 – Pedestrian Wind Comfort and Safety Criteria

Comfort Category	GEM Speed (km/h)	Description
Sitting	≤ 10	Calm or light breezes desired for outdoor restaurants and seating areas where one can read a paper without having it blown away
Standing	≤ 15	Gentle breezes suitable for main building entrances and bus stops
Walking	≤ 20	Relatively high speeds that can be tolerated if one's objective is to walk, run or cycle without lingering
Uncomfortable	> 20	Strong winds of this magnitude are considered a nuisance for most activities, and wind mitigation is typically recommended
Notes: (1) Gust Equivalent Mean (GEM) speed = *max*(mean speed, gust speed/1.85); and (2) GEM speeds listed above are based on a seasonal exceedance of 20% of the time (e.g., between 6:00 and 23:00).		
Safety Criterion	**Gust Speed (km/h)**	**Description**
Exceeded	> 90	Excessive gust speeds that can adversely affect a pedestrian's balance and footing. Wind mitigation is typically required.
Note: Based on an annual exceedance of 9 hours or 0.1% of the time for 24 hours a day.		

Soligo, M.J., Irwin, P.A., Williams, C.J. and Schuyler, G.D. (1998). "A Comprehensive Assessment of Pedestrian Comfort Including Thermal Effects," *Journal of Wind Engineering and Industrial Aerodynamics*, Vol.77&78, pp.753-766.

Lawson, T.V. (1973). "Wind Environment of Buildings: A Logical Approach to the Establishment of Criteria", *Report No. TVL 7321*, Department of Aeronautic Engineering, University of Bristol, Bristol, England.

Durgin, F. H. (1997). "Pedestrian Level Wind Criteria Using the Equivalent average", *Journal of Wind Engineering and Industrial Aerodynamics*, Vol. 66, pp. 215-226.

3.3 Configurations

When conducting pedestrian wind comfort and safety studies, the most objective way to assess the impact of a proposed development is to compare it to the existing wind conditions. In some parts of the City it may be prudent to consider a future cumulative configuration.

The following is a description of the configurations that typically need to be considered:

- **Existing:**

Include all existing buildings, significant topographic features, and developments under construction within a 400 m radius of the site.

- **Proposed:**

Include the proposed development being studied, as well as all existing buildings, significant topographic features, and developments under construction within a 400 m radius of the subject site.

- **Future (only if warranted):**

Add any buildings that are part of a future development identified by the City, and deemed by the wind consultant to have a potential impact on winds at the subject site.

- **Mitigation:**

Where mitigation is required to achieve acceptable pedestrian wind comfort levels, evaluate the proposed configuration with all recommended mitigation measures in order to demonstrate the benefits of the mitigation strategies under the proposed and/or future configurations.

3.4 Qualitative Assessment

A Qualitative Assessment relies on professional observation and interpretation.

A Qualitative Assessment may be conducted either as a Qualitative Desk Top Assessment, or using Computational Fluid Dynamics (CFD) .

Requirements for Qualitative Desktop Assessment

- Predict and estimate the wind speeds at critical locations around the proposed development while giving consideration to the frequency of occurrence of wind speeds.
- Assessment should be based on the standard wind comfort criteria described in this document.
- Where conditions are considered to be unacceptable for the intended pedestrian usage provide mitigation concepts to improve the wind comfort to acceptable levels or suggest appropriate adjustments to pedestrian usage.

Requirements for Computational Fluid Dynamics (CFD)

- It shall be acceptable to simulate only the prevailing wind directions as a basis of assessment using CFD.
- The CFD simulation shall appropriately represent the atmospheric boundary layer for winds approaching the computational model.
- Presentation of the wind speeds shall include horizontal planes at pedestrian level (i.e. 1.5 m above local grade) and vertical slices to understand flow conditions in critical areas.
- The actual assessment of wind conditions at critical pedestrian locations must account for the probability of all wind directions that can occur based on the wind data from the appropriate airport.
- The potential wind comfort and safety categories should be assessed for areas of interest.
  If problematic wind conditions are predicted, design alternatives and wind mitigation measures shall be recommended and described in the final report.

3.5 Quantitative Wind Tunnel Study

A Quantitative Wind Tunnel Study is based on measured data from physical scale model testing.

A Quantitative Wind Tunnel Study shall be conducted in a boundary layer wind simulation facility.

Requirements for Quantitative Wind Tunnel Testing

For wind tunnel testing, the following are the key requirements:

- 36 wind directions shall be tested.
- The wind simulation facility must be capable of simulating the earth's atmospheric boundary layer and appropriate profiles for each of the wind directions tested.
- Wind speeds shall be presented in km/h.
- Wind speed sensors used to measure local wind speeds shall be omni-directional and represent the horizontal wind speed at a full scale height of approximately 1.5 m above local grade. These sensors should be capable of measuring mean wind speed and wind speed fluctuations with time, including peak gusts of three to ten second duration. Sampling time in the wind tunnel shall represent a minimum of one hour of full scale time.
- The model scale should be selected to allow representation of sufficient architectural detail on the proposed development while including the surrounding context within approximately 400 m of the centre of the proposed development site (typically scales of 1:300 or 1:400 have proven to be effective). Structures and natural features beyond the modelled surroundings shall be appropriately represented in the wind tunnel upwind of the scale model.
- Sensors shall be placed at least every 10 m along a street frontage of the study buildings and at all locations where pedestrians will travel or gather. A typical development project would require a minimum of 50 sensor locations on and around the proposed development to provide adequate coverage.
- The final results shall be presented in both tabular and graphic forms for all the test configurations, with seasonal comfort data and annual safety data.

3.6 Assessment

The pedestrian wind comfort level and safety exceedance are determined by the predicted wind speeds for respective exceeding frequencies, as specified in Table 1. The assessment will give consideration to the predicted comfort level and the intended pedestrian usage. In addition, a comparison to existing, and if appropriate future, wind conditions shall be considered.

The proposed development shall achieve wind comfort conditions that are considered appropriate for the intended usage (i.e., walking on sidewalks, standing at building entrance areas and sitting or standing in amenity areas where more passive use is anticipated). If the proposed development produces pedestrian comfort conditions that prove to be less than desirable based on the intended use or unsafe (as per the definitions in Table 1) then the developer shall propose mitigation strategies and/or investigate alternatives to the proposed design with the microclimate specialist.

Overall, any proposed development shall improve on existing wind conditions where possible, and as a minimum, shall not significantly degrade wind conditions especially when considering the safety criteria. Some allowance for degradation of wind comfort levels during the winter months may be deemed to be acceptable due to reduced pedestrian usage of outdoor spaces.

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Mitigation Strategies

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Mitigation Strategies

4.1 Wind Control Mitigation Strategies

In areas where wind conditions are considered to be unacceptable for the intended pedestrian use or unsafe (as defined in Table 1) and will be accessible to pedestrians, wind control mitigation strategies shall be developed and tested to demonstrate their efficacy. In more extreme cases the developer in consultation with the microclimate specialist, may need to investigate and prepare design alternatives that can achieve more acceptable wind conditions. All wind mitigation features shall be accommodated within the limits of the subject property.

Wind Control Mitigation Strategies may include the following:

- Building massing changes or alternative designs that are more responsive to the local wind climate.
- Incorporating podiums, tower setbacks, notches and/or colonnades.
- Strategic use of canopies, wind screens, landscaping, planters, public art and/or other features that prove to be effective for mitigating problematic wind conditions.
- Modifications to the pedestrian usage.

The use of landscaping as part of a mitigation strategy is acceptable but must be selected and sized to be effective at the time of installation. Landscaping can only be recommended as a mitigation measure, where the wind conditions are suitable for it to thrive and for its maintenance.

High branching deciduous trees can reduce down washing wind flows in the summer months when they have full foliage. However, they generally do not provide ground level protection from horizontal wind flows. Coniferous trees can provide additional wind protection during the winter months.

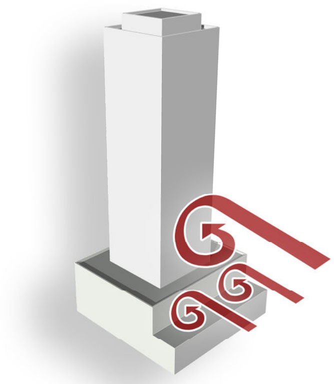
The type of trees (i.e., deciduous, coniferous or **marcescent**), approximate size and location required for wind control shall be specified in the wind study. The landscape architect shall select the species appropriate for the site and which will achieve the stated wind mitigation benefits.

Where extreme wind conditions such as safety **exceedances** and uncomfortable wind comfort conditions are predicted, soft landscaping (e.g. trees, shrubs etc.) will not be considered as acceptable wind mitigation. Hard landscaping (e.g. architectural features, screens, etc.) may be considered where appropriate.

4.2 General Design Strategies for Wind Mitigation

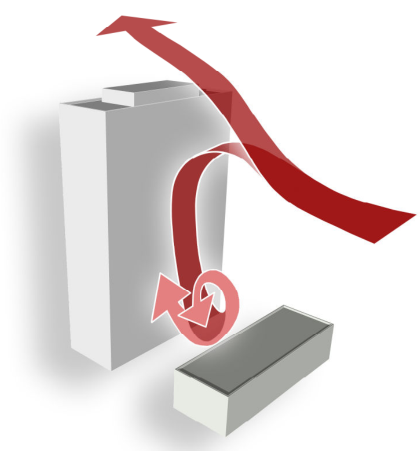
When wind hits the windward face of a tall building, the building tends to deflect the wind downwards, causing accelerated wind speeds at pedestrian level and around the windward corners of the building.

Tall and wide building facades that face the prevailing winds are generally undesirable.



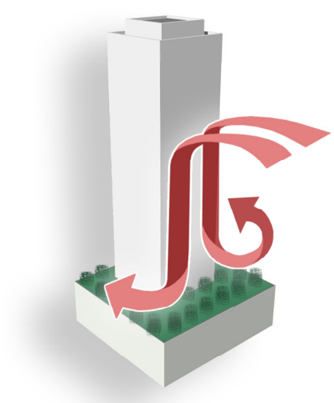
By introducing a base building or podium with a step back, and setting back a tower relative to the base building, the downward wind flow can be deflected, resulting in reduced wind speed at pedestrian level.

The proportions of the base building and tower step backs and their influence on the wind conditions is affected by the heights of surrounding buildings.



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.

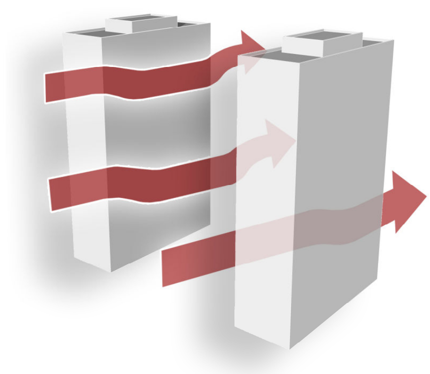
This results in accelerated winds at pedestrian level in the space between the two buildings and around the windward corners of the tall building.



By 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.

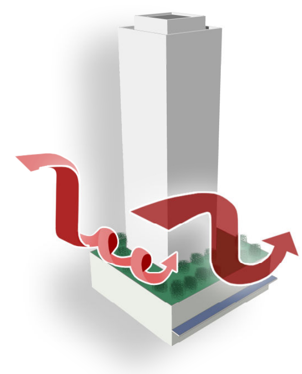
Unmitigated wind conditions on the roof of the base building, are generally undesirable for pedestrians.

4 Mitigation Strategies



Wind speed is accelerated when wind is funneled between two buildings. This is referred to as the “wind canyon effect”

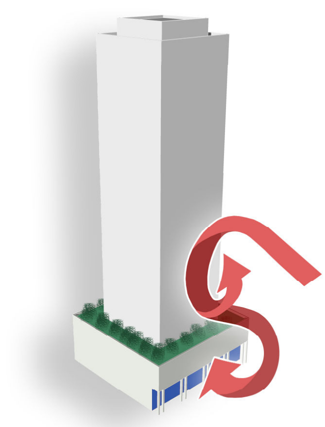
The intensity of the acceleration is influenced by the building heights, size of the facades, building separation distance and building orientation.



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.



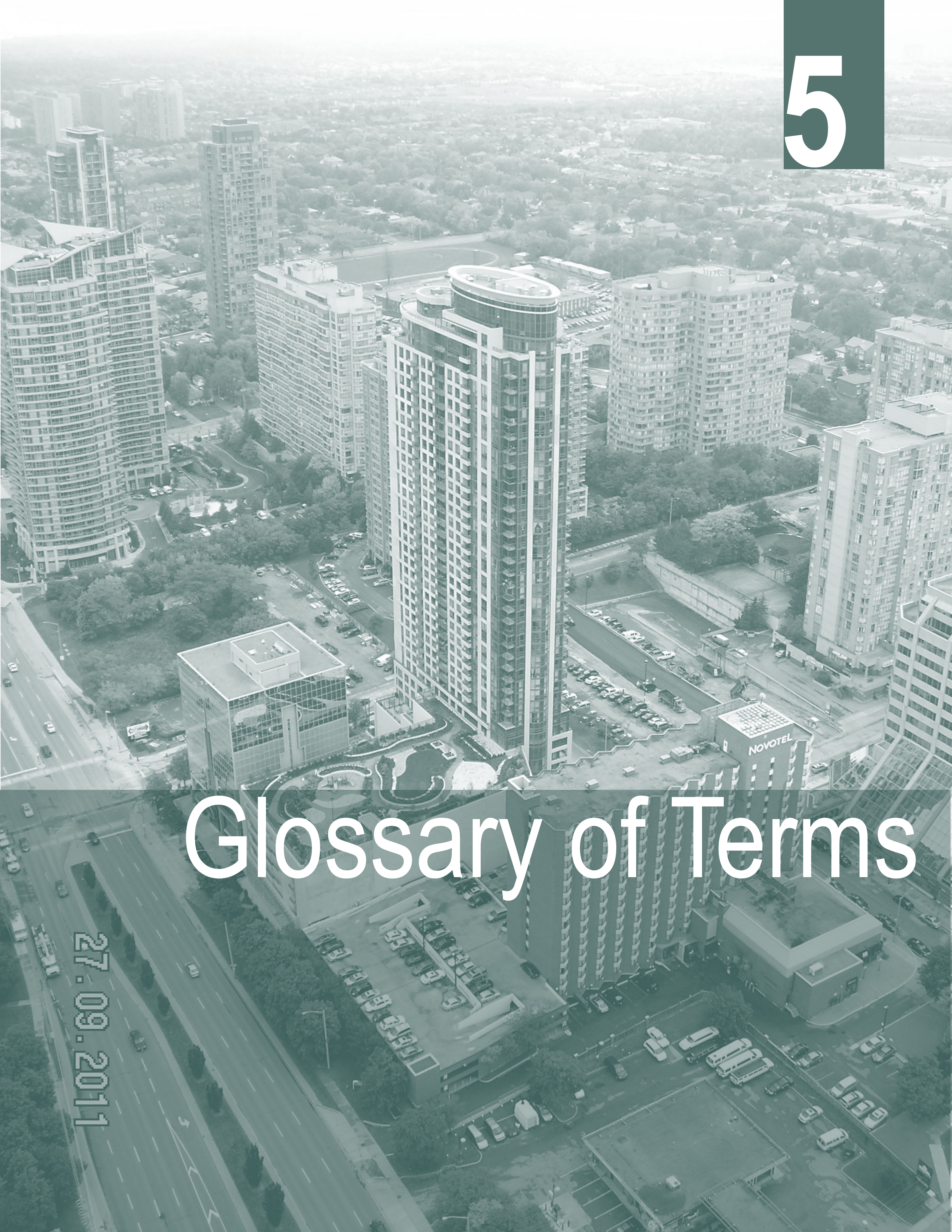
A colonnade on the windward face of a base building provides pedestrians with the option of a protected, calm walking area in the colonnade, or a breezy walk outside the colonnade.

4.3 Confirmation of Proper Implementation

Prior to Site Plan approval for any Building Permit clearance, the following clause shall be included on the Site Plan and all relevant drawings:

"The Microclimate Specialist shall confirm to the satisfaction of the Planning and Building Department that the 'as constructed' buildings and wind mitigation measures are in compliance with the recommendations of the approved Pedestrian Wind Comfort and Safety Studies"

Prior to the final site works inspection by the Planning and Building Department, the Microclimate Specialist shall issue a letter confirming that the wind mitigation measures have been installed in accordance with the recommendations of the approved Pedestrian Wind Comfort and Safety Study. The letter shall be signed and sealed by a Professional Engineer.



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Glossary of Terms

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Glossary of Terms

Colonnade
A row of evenly spaced columns supporting a roof, arches or an entablature.

Configurations
The selection and arrangement of buildings on a scale model for a wind tunnel test.

Downwind
In the direction in which the wind is blowing.

Exceedance
Beyond that which is allowed or stipulated by a set limit.

Leeward
On or towards the side that is sheltered from the wind.

Marcescent
Describes plants with leaves that wither, but remain attached to the stem without falling off.

Qualitative Assessment
Measured by its quality, rather than its quantity.

Quantitative Assessment
Measured by its quantity, rather than its quality.

Step back
The distance by which a tower or upper part of a base building is set back from the lower portion of the building (base building) on which it sits.

Upwind
Against the direction of the wind.

Windward
Facing the wind or on the side that is facing the wind.

City of Mississauga
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