Pedestrian Level Wind Extent of Assessment Area

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ABSTRACT

Pedestrian-level winds have been a primary focus of wind engineering for many years. In new developments, project wind engineers traditionally determined the assessment area for pedestrian-level winds. This decision was based on project requirements, experimental challenges, and limitations, which varied from project to project. The introduction of the AWES Guidelines for Pedestrian Wind Effects Criteria in 2014 provided a standardized assessment framework. However, this guideline for assessment area was based on the anticipated areas likely to be affected by new developments, leading to ongoing debate since its inception.

In 2017, GWTS developed a pedestrian-level wind assessment area for the Victorian Planning Authority. The current assessment area in Victoria differs from the AWES Guidelines. Recently, the discussion on the appropriate pedestrian-level wind assessment area has intensified. This paper reviews the literature and conducts simple isolated building CFD simulations to shed light on this discussion. Based on the literature review and simulation results, recommendations for the extent of the pedestrian-level wind assessment area were derived. To accommodate practical application, two approaches to delineating the assessment area boundary are proposed. The details of these recommendations and their implications will be thoroughly discussed.

BACKGROUND

Pedestrian-level wind is a crucial area of study in wind engineering. Everyone experiences wind effects at the pedestrian level during their daily activities. New developments alter the existing pedestrian-level environment. The extent of this change depends on the size, shape, orientation, and surrounding structures. These changes can result in increased wind speeds due to corner acceleration, downwash, and channelling. This increase can exceed desired wind speed limits for safety and comfort. Conversely, wind speeds can also decrease due to shielding in some scenarios.

In many cities, development approval authorities require determining the new wind environment and comparing it with recommended criteria for new developments. However, the area that needs to be assessed for the effects of a new development is rarely specified. This lack of clarity leads to wide differences in the areas investigated by different studies. Assessment area guidelines can reduce these discrepancies between practitioners.

The flow field generated by a bluff body immersed in a boundary layer flow has been investigated by many researchers (Counihan et al., 1974; Peterka and Cermak, 1975; Fang and Tachie, 2019). Their research, motivated by various wind engineering applications, provides insights into the historical research on the flow field generated by bluff bodies.

The following sections will present the current assessment area guidelines to provide a perspective on current applications. A discussion on the wind environment expected to be significantly impacted is presented under the "elevated wind speed" subheading. The CFD simulations undertaken to investigate the elevated wind speed area for various aspect ratios are presented under the heading "CFD study." The recommended assessment area and conclusions drawn from the literature review, climate considerations, and CFD study are presented in the last section.

Flow field generated by a bluff body

Researchers have extensively studied the flow field generated by a bluff body in a boundary layer flow (Hunt, 1973; Peterka and Cermak, 1975; etc.). Most studies focus on wake formation and the decay of the mean velocity deficit behind the bluff body.

Peterka and Cermak (1975) investigated the wake flow of various aspect ratios. Their study explored the mean velocity and turbulence intensity deficit on the centreline of the wake behind a bluff body. They determined the distance required for the velocity deficit to recover. Their findings indicate the maximum downstream distance the wake disturbance can extend in both vertical (4-5 building heights) and lateral directions (4-5 building widths) for buildings with strong three-dimensionality. This highlights the significant influence bluff bodies can have on the surrounding wind environment.

AWES Recommended Assessment Area

The 2014 AWES Guidelines for Pedestrian Wind Effects Criteria (AWES, 2014) introduced a recommended assessment area for evaluation, alongside minimum safety criteria for public safety. The guideline defines the assessment area as follows:

"Assessment of proposed development should consider adjacent public and private property areas within a distance 'R' from the building envelope, where R is defined as the minimum of h/2 and b/2, where h is the building height and b is the largest plan dimension of the building (Figure 1)."

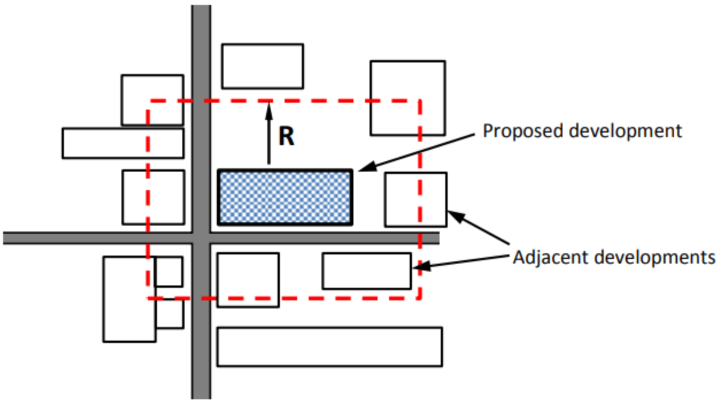


Figure 1. Schematic plan view of a proposed development and existing developments showing the extent of the minimum recommended area to be considered in the pedestrian wind assessment

The specified guideline area can be insufficient, potentially neglecting zones significantly affected by wind. For instance, a 100-meter-tall building with a 30m x 20m footprint would only require assessment within 15 meters according to the guideline. This example, along with others, highlights the shortcomings of the AWES recommendations in capturing the full extent of wind-impacted areas.

Victoria Planning Authority Assessment Area

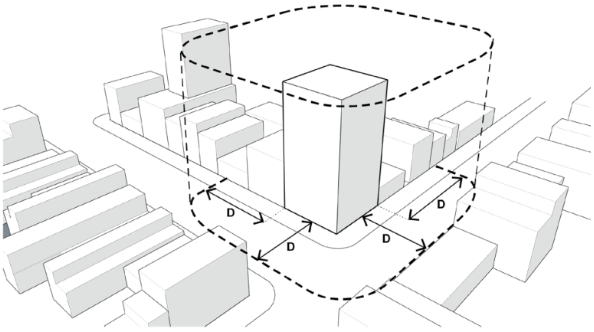
The Victoria Department of Environment, Land, Water, and Planning authority provides guidelines on the assessment area of wind effects (PPN93, 2021) as follows:

Wind impact assessments of proposed developments are required to consider impacts on all outdoor areas, including the public domain and private and communal open spaces, within a distance ‘D’ from the building.

The assessment distance for the building is defined by the greater of either:

- Half the longest width of the building, or
- Half the overall height of the building.

The assessment distance is measured from the external façade of the building at the ground floor.



ASSESSMENT DISTANCE D = GREATER OF:

L/2 (HALF LONGEST WIDTH OF BUILDING) OR
H/2 (HALF OVERALL HEIGHT OF BUILDING)

Figure 2. Example of the application of the assessment distance in perspective view

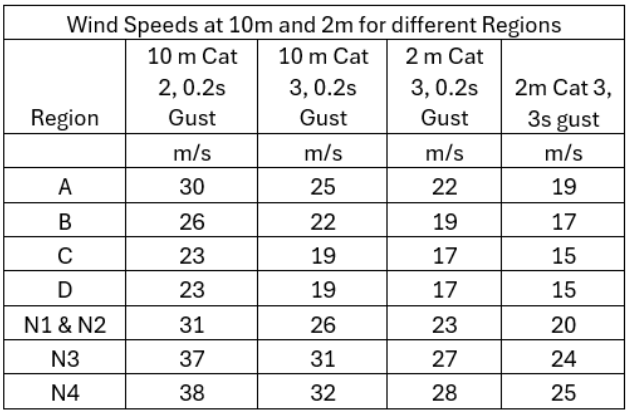
This guideline is similar to the AWES guideline in considering the building dimensions. However, while the AWES considers the minimum dimension, the Victoria authority considers the maximum dimension. The Victoria guideline presents a practical challenge for low-rise developments in terms of the area of assessment to model in a wind tunnel. To generate a good resolution, low-rise buildings are typically modelled at a scale of 1:300 or 1:200. At this scale, accommodating a proposed development with a large width is difficult in most wind tunnels.

ELEVATED WIND SPEED

New developments can alter the existing wind environment, resulting in elevated wind speeds. The impact of this change varies depending on the existing wind conditions. In windy locations, even minor changes in the wind environment can lead to exceeding comfort or safety criteria. Conversely, areas with moderate or low wind speeds may not experience wind exceeding recommended criteria due to the development. As a result, the area affected by elevated wind can vary significantly based on climate.

Considering the wind zones defined in the Australia and New Zealand Standard (AS/NZS 1170.2:2021), Table 1 shows the one-year wind speed at a 10 m height in terrain Category 2 and a 2 m height in terrain Category 3 for a one-year mean recurrence interval.

Table 1. Wind speeds for different Regions



Wind Speeds at 10m and 2m for different Regions				
Region	10 m Cat 2, 0.2s Gust	10 m Cat 3, 0.2s Gust	2 m Cat 3, 0.2s Gust	2m Cat 3, 3s gust
	m/s	m/s	m/s	m/s
A	30	25	22	19
B	26	22	19	17
C	23	19	17	15
D	23	19	17	15
N1 & N2	31	26	23	20
N3	37	31	27	24
N4	38	32	28	25

As can be seen in Table 1, Region N already experiences wind speeds exceeding the safety criteria. Therefore, any area impacted by the development that shows an increase in wind speed needs to be evaluated for potential safety concerns. In Region A, areas where the elevated wind speed due to the development is more than 5% of the existing wind environment require assessment for potential comfort or safety issues. Regions B, C, and D have existing wind speeds that are 15% to 25% below the safety criteria. Consequently, the likelihood of these regions exceeding the criteria due to a development is much lower compared to Region N or A. This highlights the importance of considering the existing wind climate when determining the assessment area for potential wind speed impacts.

CFD STUDY

Real-world building environments involve various mechanisms that can amplify or reduce wind flow due to a proposed development. Since each building project has unique characteristics like building shape, height, and surrounding structures, it's not possible to represent all scenarios. However, variations in building dimensions within the CFD simulations provide a valuable basis to assess the extent of elevated wind speed and identify areas that require further evaluation.

To investigate the wind environment and assess the area affected by elevated wind speeds, CFD simulations were conducted on various aspect ratios of a single building for four cases of full-scale and eight cases of model-scale (with similar dimensions as described in Peterka and Cermak, 1975) buildings using ANSYS Fluent 2023 R2.

The computational domain extended 6D upwind, 5D laterally and vertically, and 12D downwind from the building. Where D is the largest dimension of the building. The inlet velocity profile corresponded to Terrain Category 3 of AS/NZS 1170.2 for full-scale simulations and a power law profile as described in (Peterka and Cermak, 1975) for model-scale simulations. Symmetry boundary conditions were applied to the sides and top, and a pressure outlet condition was used at the outflow. A k-ω SST turbulence model was employed for steady-state simulations, with turbulent intensity and length scale specified at the inlet.

The simulation results are presented in Figure 3 as velocity contour plots at 2m above the ground. These plots illustrate the area where wind speeds exceed the undisturbed flow. White areas indicate regions of mean wind speed deficit (lower than the undisturbed flow), while coloured areas represent wind speeds 3% or more above the undisturbed flow, with red indicating higher values for various aspect ratios of both full-scale (labelled F1-F4 with dimensions in meters) and model-scale geometries (labelled M1-M8 with dimensions in centimetres).

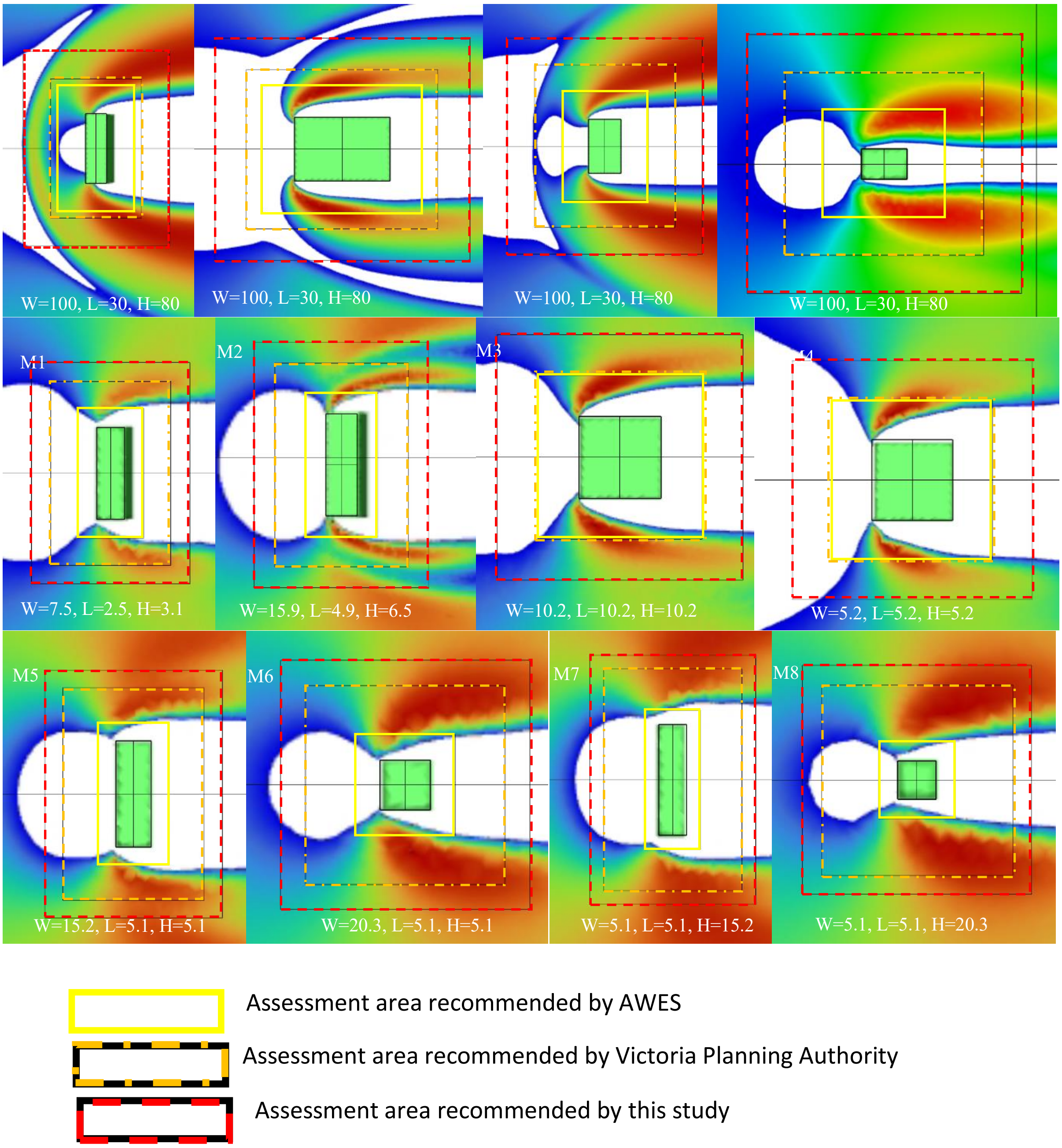


Figure 3. Velocity contour plots at 1.75 m above the ground for areas where the wind speed is above flow field without the bluff body.

The CFD velocity contour plots for various aspect ratios (Figure 3) demonstrate that both building width and height are crucial factors influencing the extent of the elevated wind speed area. The recommended AWES assessment area (yellow solid line) is insufficient in most cases, failing to capture a significant portion of the elevated wind zone. The Victorian Planning Authority assessment area (orange dotted line) offers better coverage compared to AWES. However, for buildings with equal width and height, both assessment areas coincide.

Recognizing the limitations of existing guidelines and the importance of considering both building dimensions, a new assessment distance (R) is proposed:

$$R = \frac{Height + longest\ width}{2}$$

This proposed assessment area (red dotted line in Figure 3) demonstrably encompasses a larger portion of the elevated wind zone compared to the previous two methods.

Wind tunnel studies face challenges replicating the recommended assessment area, particularly regarding resolution and inclusion of surrounding structures for certain aspect ratios. In such cases, employing a two-scale simulation or providing a detailed explanation for safeguarding the unmodeled area becomes necessary.

CONCLUSIONS

This study investigated the factors influencing pedestrian-level wind environments, focusing on the impact of a single building geometry on surrounding wind conditions. The key findings are:

- Pedestrian-level wind assessment areas should consider the local climate. Areas with stronger winds require a larger assessment zone compared to those with lower wind speeds.
- The current AWES recommended area is insufficient to capture the elevated wind speeds generated by various building shapes.
- The Victorian Planning Authority assessment area performs better than AWES but may not fully encompass high wind speed zones for all aspect ratios.
- Building height and width both significantly influence the extent of elevated wind speed.
- A new assessment area based on building height and width is proposed. This method demonstrably covers a larger portion of the elevated wind zone compared to existing guidelines.
- Wind tunnel studies may face challenges replicating the proposed assessment area for specific building shapes. In such cases, two-scale modelling or a well-justified adjustment to the assessment area may be necessary.

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