Macquarie Point Multipurpose Stadium Hobart

(Hobart, Tasmania, Australia)

Wind Comfort Assessment for Visitors and the Precinct Area

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Birkenfeld, 21st of August 2024

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1. INTRODUCTION

A new Stadium is planned in Hobart, Tasmania, Australia (see Fig. 1.1 and Fig. 1.2).

The purpose of this report is to address the requirements relating to wind effects as required by the Tasmanian Planning Commission's Guidelines for a Project of State Significance (PoSS), dated 16 February 2024, Chapter 8.1. The items addressed in this report relate to the following:

8.1	**Wind Effects**
8.1.1	The reports are to describe the existing wind conditions of the project site and analyse the effects of the proposed project on the patterns of air movement and pressure, including, but not limited to:
	Downwards-deflection (downdraft);
	Upwards-deflection causing high wind speed and pressure effects;
	Flow through narrow spaces between buildings (Venturi effect) causing high wind speed and high turbulence (wind tunnels);
	Low velocity eddies on the downwind side of the proposed Stadium building;
	Counter-current effects (reversed or cross-wind direction); and
	Consideration of the cumulative impact, taking into account the effects of surrounding development.
8.1.2	The reports are to analyse the effects of any impacts of the wind on the comfort experience and safety of the public, including pedestrians, cyclists, and people using open spaces, and any measures to minimise or manage wind effects.
8.1.3	The reports are to review and detail appropriate wind assessment methodology, standards, and acceptable limits. Where relevant, the choice of a particular methodology over alternative methodologies is to be explained. Assessment of impacts and effects is to include information on the significance and duration of the impact. Assumptions and judgements are to be stated clearly and the nature and magnitude of uncertainties are to be clearly defined.

Within the permit procedure (PoSS procedure) among other points, the impact of the Stadium on the wind comfort in and near the Stadium (seating areas, concourse, and surrounding plaza (external perimeter of the Stadium) and precinct) must be considered. In this specialist consultant assessment report (which includes a description of wind comfort studies to be done after the schematic design stage) the following specific aspects in accordance with the PoSS submission document (Chapters 8.1.1, 8.1.2 and 8.1.3) are considered:

- Annotation of wind-related points listed in the PoSS submission document; description of those listed elements (phenomena) that may be of minor relevance with regard to the Stadium project;
- Description of the methodology to be used to be evaluate wind comfort; description of different steps of wind comfort study;
- Analysis and description of the local wind climate (apparent distribution of wind speed and direction);
- Description of analysis of wind comfort;
- Description of the evaluation criteria to be used to assess wind comfort and wind safety;
- Provision of a drawing / map which contains the points (locations) where detailed wind speed measurements for different wind directions (and corresponding wind comfort assessment) are planned to be done for the final wind comfort report;

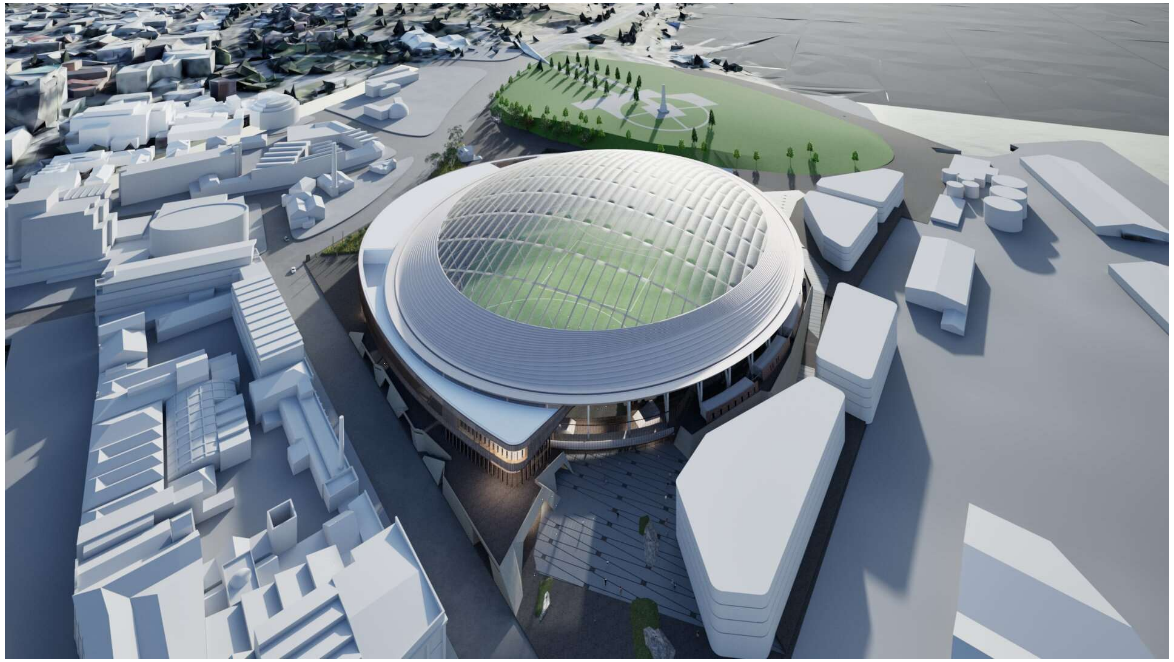

Fig. 1.1: 3D model of the Macquarie Point Multipurpose Stadium Hobart, Tasmania, Australia (Cox, 2024)

Fig. 1.2: Project site of the Macquarie Point Multipurpose Stadium Hobart, Hobart, Tasmania, Australia (Google Earth 2024)

2. ANNOTATION OF WIND RELATED POINTS LISTED IN THE POSS SUBMISSION DOCUMENT

The relevant conditions regarding the pedestrian comfort situation at the precinct and at the concourse of the Stadium addressed in this report are outlined in Tab. 2.1.

	Wind related point (PoSS)	Comments
1.4.3	Prevailing winds and wind patterns associated with existing built form	The wind climate at the project site was analysed based on wind data from meteorological stations. The main wind direction is northwest, especially during the winter. With south-easterly occurring in summer.
8.1.1	Downwards-deflection (downdraft)	Due to the domed shape of the stadium, this is of minor importance.
	Upwards-deflection causing high wind speed and pressure effects	This is mainly expected at the roof surface and is therefore of minor interest with regard to the pedestrian comfort.
	Flow through narrow spaces between buildings (Venturi effect) causing high wind speed and turbulence	This will have an impact on the pedestrian comfort, though appropriate comfort levels appear achievable. There should be a requirement to achieve appropriate comfort levels and further modelling, including wind tunnel modelling, should occur during the detailed design stage to ensure appropriate comfort levels are achieved.
	Low velocity eddies on the downwind side of the proposed Stadium	This is expected to have a minor impact on the pedestrian comfort but will also be

		investigated by velocity measurements in the wind tunnel (inside wind tunnel model) as part of the detailed design stage.
	Counter-current effects (reversed or cross-wind direction)	This is expected to have a minor impact on the pedestrian comfort but will also be investigated by velocity measurements in the wind tunnel (inside wind tunnel model) as part of the detailed design stage.
	Cumulative impact, taking into account the effects of surrounding development	This will have an impact on the pedestrian comfort and will be taken into account by terrain roughness investigations.
8.1.2	Analyse the effects of any impacts of the wind on the comfort experience and safety of the public, including pedestrians, cyclists, and people using open spaces, and any measures to minimise or manage wind effects.	High-level analysis of these impacts has occurred based on the initial concept plans. As part of any approval there should be a requirement for appropriate comfort levels to be achieved and for wind comfort studies (including wind tunnel study) to be done in the detailed design stage to confirm the design achieves.
8.1.3	Review and detail appropriate wind assessment methodology, standards, and acceptable limits. Where relevant, the choice of a particular methodology over alternative methodologies is to be explained. Assessment of impacts and effects is to include information on the significance and duration of the impact. Assumptions and judgements are to be stated clearly and the nature and magnitude of uncertainties are to be clearly defined.	This work has been undertaken based on the initial concept plans but it should continue during the detailed design stage.

Tab 2.1: Comments on the wind related points listed in the PoSS submission document

3. METHODOLOGY: WIND TUNNEL TESTS

The assessment of the pedestrian comfort at the project site is based on an analysis of the regional wind climate at the nearest meteorological stations and a detailed study of wind velocity changes due to the influence of the buildings. The wind conditions around the building complex are investigated by means of a wind tunnel study in a boundary layer wind tunnel. As a result, wind speeds with certain probabilities of exceedance representative for the different locations of interest are obtained. These results are further evaluated applying standard wind comfort criteria in order to predict the wind comfort level for the study site.

Wind tunnel tests are performed in accordance with standard procedure for wind tunnel testing in civil engineering as described in codes and standards including American Society of Civil Engineers (ASCE) standards ASCE 7, ASCE 49-12, WtG 199+6, EN 1991-1-4 2005 and Australian Wind Engineering Society AWES-QUAM-1-2019. All significant modelling laws (geometric similarity of construction, similarity of the approach flow) are considered. Wind tunnel tests concerning wind comfort / wind safety aspects will be undertaken as soon as practical during design development when the cubature of the Stadium has been widely fixed (schematic design). For the measurements of the flow velocities, a 1:300 or 1:350 scale model of the project site will be built (tentative value).

Wind velocity measurements will be carried out at different points of interest. The tests will be carried out in a low-speed open circuit boundary layer wind tunnel provided with a test section with dimensions of 12m length, 2.50m width, and 1.85m height. The turbulent boundary layer flow corresponding to the atmospheric boundary layer flow at the project site is simulated by means of vortex generators at the entrance of the test section and roughness elements on the tunnel floor.

The model will be mounted on a turntable with large inertial mass, allowing any wind direction to be simulated by rotating the model to the appropriate angle in the wind tunnel, exposing the model to 24 different wind directions spaced in steps of 15 degrees (0° to 345°).

4. WIND CLIMATE AT PROJECT SITE

The wind climate at the project site was analysed based on the wind data from the meteorological stations at Hobart City, Ellerslie Rd (WMO 949700) located about 1.3 km southwest from the Stadium. Since the wind field at town stations is often affected by local surrounding buildings, additional wind data from the station Hobart Airport (WMO 949750) about 15 km northwest from the Stadium was considered. In both cases data from the years 1993 to 2023 were investigated.

Since activities will occur all through the year, the wind climate for the summer half year (October to March) and the winter half year (April to September) were evaluated separately for each station (Fig. 4.1 to Fig. 4.4).

The wind climate analyses for both stations show qualitatively similar results. The main wind direction at the site is northwest, especially during the winter half year, with south-easterly wind occurring in the summer half year. The highest wind speeds occurring at both stations and for both seasons are north-westerly winds (300° and 330°).

The mean wind speed at the Hobart Airport station is 4.9 m/s and at the Hobart City station somewhat lower (4.5 m/s). This is the effect of the different terrain conditions and eventually different heights of the wind sensors.

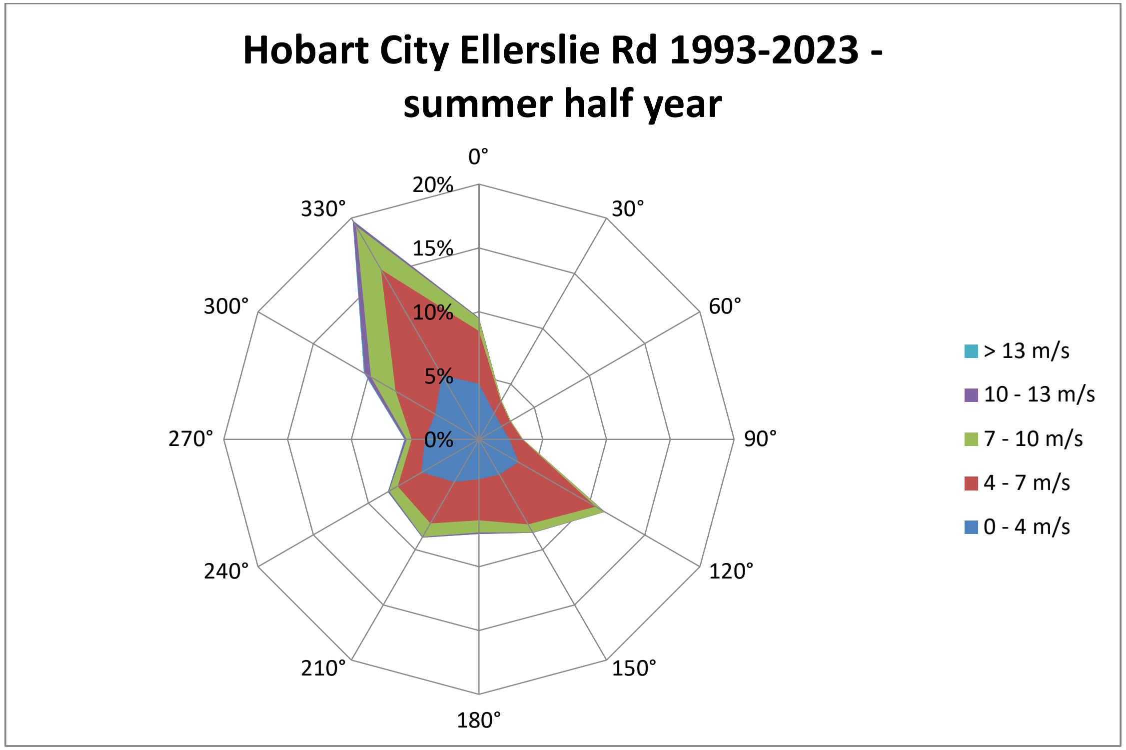

Fig. 4.1: Wind climate for Hobart City/Ellerslie Rd, **summer** half year (October to March)

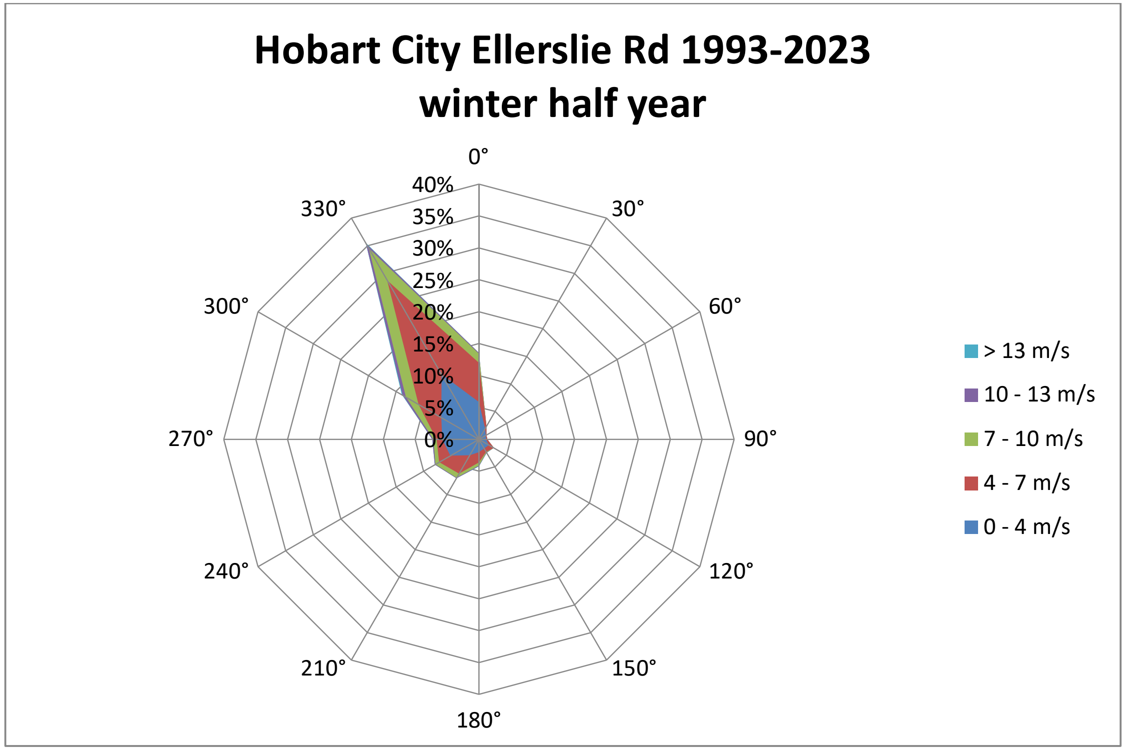

Fig. 4.2: Wind climate for Hobart City/Ellerslie Rd – **winter** half year (April to September)

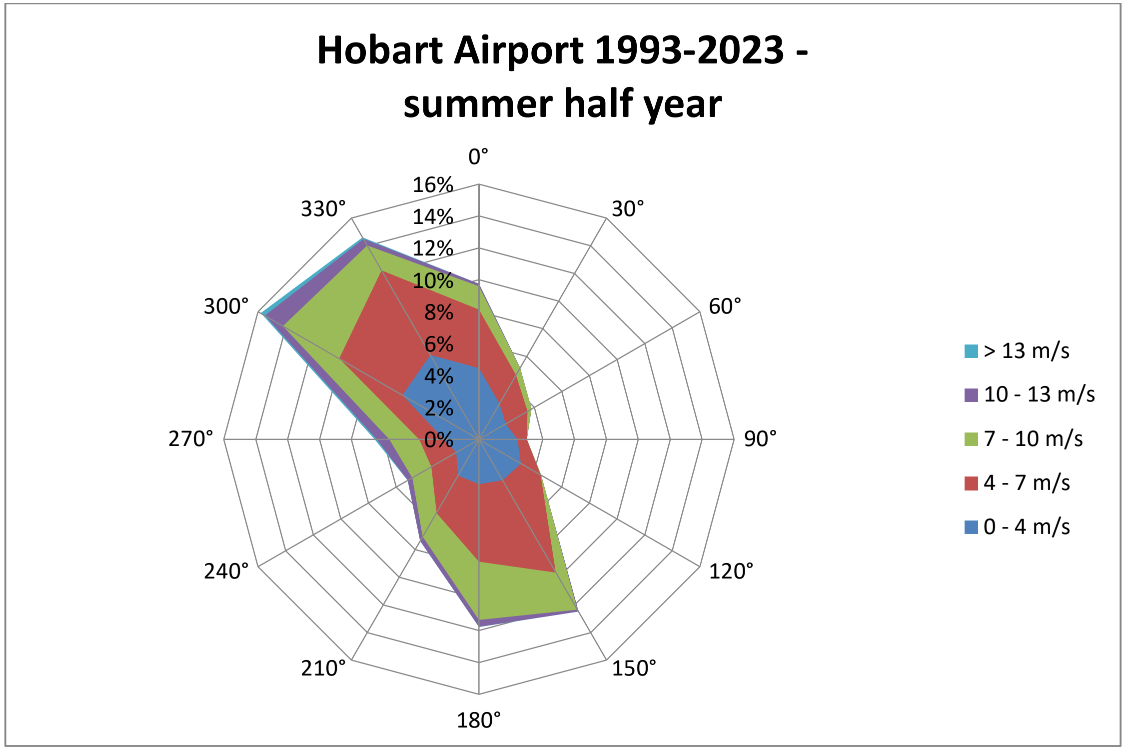

Fig. 4.3: Wind climate for Hobart Airport, **summer** half year (October to March)

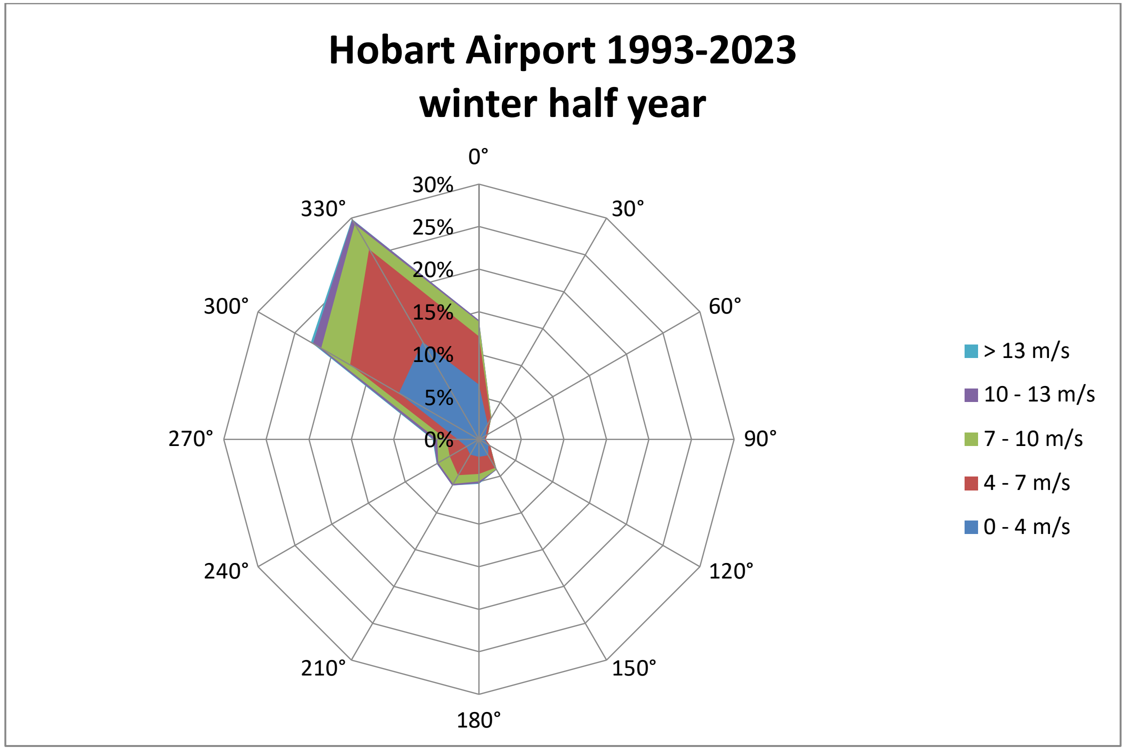

Fig. 4.4: Wind climate for Hobart Airport – **winter** half year (April to September)

5. ANALYSIS OF WIND COMFORT

Wind comfort is analyzed in terms of exceedance probabilities of wind speeds. Therefore, information of regional wind climate and local accelerations and decelerations of the wind velocities due to buildings are combined.

For the estimation of the local wind velocities under the influence of buildings in relation to the undisturbed case without buildings, a velocity factor X_i was introduced by Gandemer and Guyot (1976):

$$X_i = \frac{(\overline{U} + \gamma \cdot \sigma)_{built-up}}{(\overline{U} + \gamma \cdot \sigma)_{undist.}}$$

where $\overline{U}$: means wind speed; σ: standard deviations of wind velocity fluctuations and γ: peak factor. The factor X_i is the ratio of the local wind speed influenced by the building (Index: built-up) to the undisturbed wind speed without the structure at the same height (Index: “undist.”). Both velocities are determined in the wind tunnel. $X_i < 1$ means a reduction of the local wind speed due to buildings; $X_i > 1$ an increase. Values of the peak factor γ are given by several authors and vary between 1 and 4 (e.g. Gandemer, 1982).

The velocity factors are determined from wind tunnel simulations as a function of wind direction. The factors are combined with the probability of occurrence of the local wind velocities (wind climate). Wind speeds exceeding selected probabilities are then predicted. The full-scale predictions are then compared with the criteria for pedestrian wind comfort. The conversion from wind climate data to pedestrian heights is performed based on regulations given in relevant wind standards.

6. WIND COMFORT CRITERIA

The wind study will assess the pedestrian comfort for outdoor areas. Outdoor areas are public spaces and always need to be accessible for pedestrians. The applied criteria for assessing the pedestrian comfort are explained as follows.

Pedestrian comfort in outdoor areas: Different demands are made on the pedestrian comfort, depending on the intended use. At grandstand areas, e.g. a long stay (sitting) should be possible and, thus, low wind speeds are required. In areas that are solely used for traffic higher wind speeds are less of an issue. Based on different academic studies and on our longstanding experience in pedestrian comfort studies, the comfort criteria, listed in Tab. 6.1 evolved. With these criteria it is possible to assess the pedestrian comfort for different activities. The criteria include the requirements of different standards and regulations. To overcome the shortcomings of criteria given in some standards with respect to the fluctuation of the wind speed (gustiness) additional criteria were introduced based on academic studies.

With respect to the typical activities inside and outside the Stadium, according to this classification a comfort class 1 is desirable e.g. for the sitting areas at the grandstand, while for queueing areas in front of a ticket station a comfort class of 2 or 3 should be achieved. It should be noted that the assessment of the pedestrian comfort is a subjective feeling. However, the criteria meet the perception of the majority of the pedestrians.

The classification of the pedestrian comfort is evaluated separately for summer and winter seasons.

In addition to the wind comfort, the study also considers safety criterion (Class 6). This safety classification is an instrument to estimate wind danger and to predict if unacceptable wind conditions may arise. According to the safety criterion mean speeds of >15 m/s should occur in less than 0.3% of the annual hours (this corresponds to approximately 26 hours per year), or a gust wind speed of >25 m/s in less than 0.1% of the annual hours (approximately 9 hours per year). In this context an unacceptable condition occurs when winds are of sufficient strength to blow people over. In areas classified as Class 6, this potential risk is unacceptably high and wind protection measures are strictly necessary. For the analysis of safety criteria, the period of an entire year is considered.

It should be noted that the perceived wind comfort depends on the wind conditions and the activity as well as other parameters, such as the temperature, humidity, solar radiation, or clothing. These factors are not considered in the investigation.

Windcomfort criteria						Example for possible usage
Wind velocity [m/s]	Probability of exceedence [% - hours per year]	Quality Class	Activity			
			Traversing	Strolling	Sitting	
U_{mean} = 5 m/s	< 2.5	1	Good	Good	Good	cafes, seating areas
$U_{gust,eff}$ = 6 m/s	< 5.0					
U_{mean} = 5 m/s	2.5 - 5.0	2	Good	Good	Moderate	waiting areas, parks
$U_{gust,eff}$ = 6 m/s	5.0 - 10.0					
U_{mean} = 5 m/s	5.0 - 10.0	3	Good	Moderate	Poor	shopping areas, entrance areas
$U_{gust,eff}$ = 6 m/s	10.0 - 20.0					
U_{mean} = 5 m/s	10.0 - 20.0	4	Moderate	Poor	Poor	side walks
$U_{gust,eff}$ = 6 m/s	> 20.0					
U_{mean} = 5 m/s	> 20.0	5	Poor	Poor	Poor	wind shelter recommended
U_{mean} = 15 m/s	> 0.05					
$U_{gust,eff}$ = 13 m/s	> 1.0					
Safety criteria						
U_{mean} = 15 m/s	> 0.3	6	potential risk			wind shelter necessary
$U_{gust,peak}$ = 25 m/s	> 0.1					

Tab. 6.1: Wind comfort criteria for ground level areas (according to Gandemer and Guyot 1976, Hunt 1976, Williams et al. 1990, Ratcliff and Peterka 1990, NEN 8100, ASCE)

Based on the initial concept plans it appears the Project will be able to satisfy the wind comfort criteria set out at Table 6.1. However, it will be important to ensure that, as detailed design progresses, this is confirmed.

Accordingly, any approval of the Project should include a condition requiring that during the detailed design stage, testing of wind effect occurs, to ensure that the Project satisfies the wind comfort criteria for ground level areas set out in Table 6.1 (according to Gandemer and Guyot 1976, Hunt 1976, Williams et al. 1990, Ratcliff and Peterka 1990, NEN 8100, ASCE).

7. WIND SPEED MEASUREMENTS: PROPOSED LOCATIONS

It is intended to carry out wind velocity measurements in the wind tunnel at about 40 different positions at the bowl, the concourse, and the precinct around the Stadium to provide appropriate level of analysis to assist in minimising and managing the wind effect. A map of proposed measurement locations is shown in Fig. 7.1.

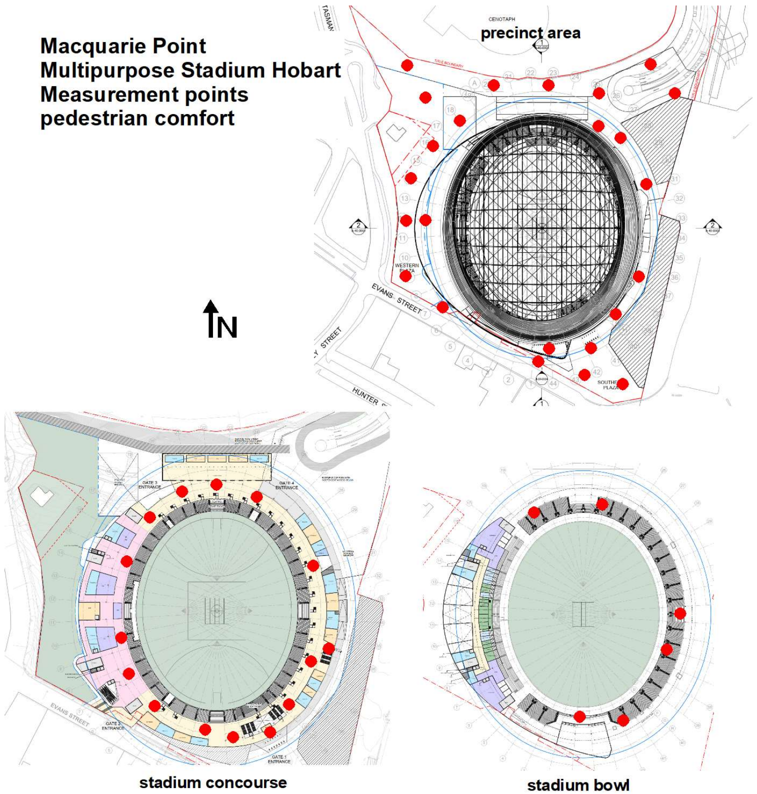

Fig. 7.1: Location of the measurement points for the pedestrian comfort study

8. REFERENCES

ASCE 7-10: “Minimum Design Loads for Buildings and Other Structures”. American Society of Civil Engineers, 2012.

ASCE 49-12, 2012: "Wind Tunnel Testing for Buildings And Other Structures", American Society of Civil Engineers, 2012.

ASCE, 2003: “Outdoor Human Comfort And Its Assessment – State of the art”. American Society of Civil Engineers, USA.

AWES-QUAM-1-2019: “Quality Assurance Manual: Wind Engineering studies of buildings”. Australian Wind Engineering Society.

Cox, 2024: “Drawings concerning the Macquarie Point Multipurpose Stadium Hobart, Tasmania, Australia”, Cox Architecture, Melbourne, Australia.

EN 1991-1-4: "Eurocode 1: Actions on structures — Part 1-4: General actions — Wind actions”. European Standard.

Gandemer, J., Guyot, A., 1976: „Intégration du phénomène vent dans la conception du milieu bati“. La Documentation Française, Paris.

Gandemer, J., 1982: „Simulation and Measurement of the Local Wind Environment“. In: T.A. Reinhold (ed), Wind Tunnel Modelling for Civil Engineering Applications, Cambridge University Press.

Lawson, T. V., 1973: „The wind environment of buildings: a logical approach to the establishment of criteria“. University of Bristol, Dept. of Aeronautical Engineering, Report No. TVL 7321.

NEN 8100:2006: “Nederlandse Norm: Windhinder en windgevaar in de gebouwde omgeving“, Nederlands Normalisatie-instituut.

Plate, E.J., 1982: "Wind tunnel modelling of wind effects in engineering". In E.J. Plate (ed.), Engineering Meteorology, Chapter 13, Elsevier, Amsterdam-Oxford-New York, pp. 573-639.

WTG 2023: "Wind tunnel tests for building aerodynamics", in German, Windtechnologische Gesellschaft, 2023.

Curriculum Vitae

Prof. Dipl.-Ing. Jürgen Wacker
Owner & Managing Director

born in 1959

ACADEMIC EDUCATION

1979 - 1986	**University of Karlsruhe, Germany**
	⅄ Studies in Civil Engineering, Flow Mechanics

PROFESSIONAL BACKGROUND

1986 – 1991	**Scientific Employee at University of Karlsruhe, Germany**
	⅄ Wind Engineering Division – Special Research Group "SFB 210": "Wind related design criteria for buildings"
1992	**Manager of SFB 210 at University of Karlsruhe, Germany**
1992	**Founding of Wacker Ingenieure - Wind Engineering in Birkenfeld, Germany**
2008	**Erection of new company building**
	⅄ New offices, wind tunnel laboratory and model fabrication shop
Since 2009	**University of Applied Science, Frankfurt/Main, Germany**
	⅄ Teaching position for "Sustainable Structures" course
Since 2012	**University of Applied Science, Frankfurt/Main, Germany**
	⅄ Honorary Professorship

REFERENCE PROJECTS "STADIUMS"

- Olympiastadion, Berlin, Germany
- Fenerbahce Stadium, Istanbul, Turkey
- Stadium Valencia, Spain
- Wanda Metropolitano, Madrid, Spain
- Dubai Sports City, UAE
- Stadium Klagenfurt, Austria
- Dolphins Stadium, Miami, USA
- Stadium Foshan, China
- Sheikh Khalifa Stadium, Al Ain, UAE
- Main Bowl Complex, Abuja, Nigeria
- Soccer City, Johannesburg, South Africa
- Maracana, Rio de Janeiro, Brazil
- Commerzbank Arena, Frankfurt, Germany
- Stadium Limoges, France
- Mercedes Benz Arena, Stuttgart, Germany
- National Stadium, Warsaw, Poland

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Memorandum

Attention	Mark Smith	File No.	Memo_TPC Response on Wind
Company	Macquarie Point Development Corporation	Date	4-Mar-2025

Memorandum No.	Item
Memo_TPC Response on Wind	**TPC Response on Wind**

1.0 Summary

The purpose of this Notice of Advice (NOA) is to provide a response to the TPC query:

Evidence or analysis should be provided on wind effects and pedestrian comfort levels associated with the proposed building design, or any measures to minimise or manage wind effects (section 8.1 of the Guidelines).

To which assessment of the wind effects and pedestrian comfort at the project site is based on an analysis of the regional wind climate at the nearest meteorological station at Hobart City, Ellerslie Rd (WMO 949700) only about 1.3 km southwest from the Stadium and a detailed study of wind velocity changes due to the influence of the surrounding buildings. The latter is investigated through a wind tunnel study in a boundary layer wind tunnel using a model of the proposed Stadium and its surroundings.

The result of the assessment will address the wind effect requirements outlined in the Wind Comfort Assessment for Visitors and the Precinct Area Report prepared by Wacker Ingenieure Wind Engineering Consultants, dated 21 August 2024.

The preliminary findings from the assessment work so far can be summarised as follows:

<u>Safety criterion</u>

- The safety criterion is satisfied at each measuring point inside and outside the Stadium. The proposed buildings within the project area provide a general sheltering effect, resulting in similar or improved pedestrian comfort conditions compared to the scenario without the new buildings. Thus, a potential wind-induced risk according to the defined criterion is not likely to occur.

<u>Pedestrian comfort outside the Stadium</u>

- At all investigated locations, pedestrian comfort is at least suitable for sidewalks and potential wind-induced risk according to the defined criterion is not likely to occur. The comfort level would be further enhanced by incorporating shelter elements such as plantings, shade structures, and similar features into the landscape.

<u>Pedestrian comfort inside the Stadium</u>

- No significant wind comfort issues are expected at the lower and upper tiers.
- On the Level 1 concourse, wind speeds are slightly higher compared to the tiers. However, most measurement locations do not indicate significant wind comfort issues. Only at the northeastern edge do higher wind conditions occur occasionally, but the assessed wind comfort remains suitable for waiting areas.

2.0 Wind Tunnel Testing

The assessment of the pedestrian comfort at the project site is based on an analysis of the regional wind climate at the nearest meteorological station at Hobart City, Ellerslie Rd (WMO 949700) only about 1.3 km southwest from the Stadium and a detailed study of wind velocity changes due to the influence of the surrounding buildings. The latter is investigated through a wind tunnel study in a boundary layer wind tunnel using a model of the proposed Stadium and its surroundings performed in accordance with standard procedure for wind tunnel testing as described in codes and standards including American Society of Civil Engineers (ASCE) standards ASCE 7-16, ASCE 49-12, WtG 1996, EN 1991-1-4 2005 and Australian Wind Engineering Society AWES-QUAM-1-2019.

To measure the flow velocities, a 1:300 scale rigid model of the Stadium, and its surroundings (Figure 1) is built based on the current design drawings.

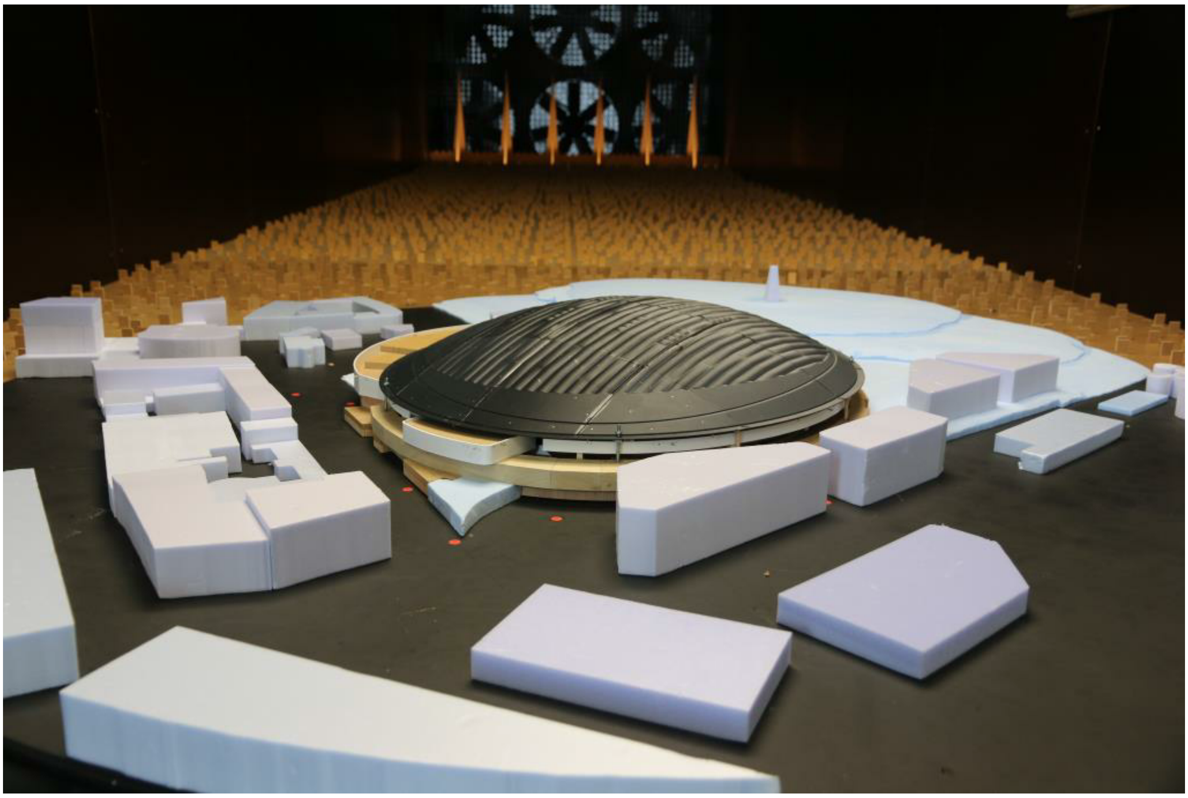

Figure 1 - Wind Tunnel Model of the Stadium with Surroundings (scale 1:300)

The tests are conducted in a low-speed, open-circuit boundary layer wind tunnel with a test section measuring 12m (L), 2.5m (W), and 1.85m (H). To simulate the atmospheric boundary layer flow at the project site, vortex generators are placed at the entrance of the test section, and roughness elements are added to the tunnel floor.

The model is positioned on a turntable with a large inertial mass, enabling the simulation of any wind direction by rotating the model to the desired angle within the wind tunnel. This setup allows for exposure to 24 different wind directions, spaced at 15-degree intervals (from 0° to 345°).

Wind velocity measurements were taken at various locations on the ground within the precinct, as well as at the concourse level and seating areas. Irwin probes and hot wire sensors were utilised for these measurements. Refer figures 2, 3 and 4 below.

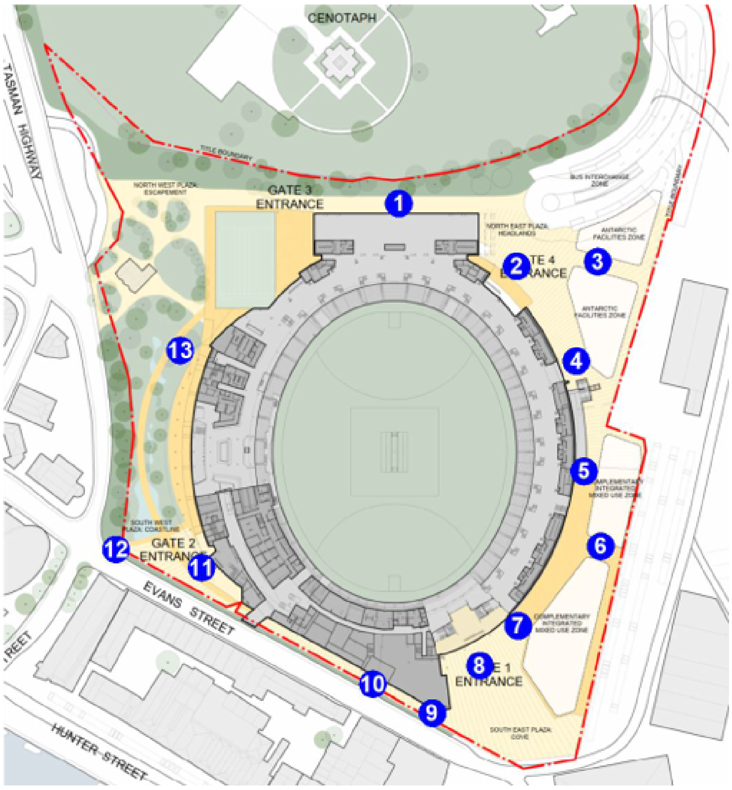

Figure 2 - Locations of measuring points - Outer Precinct

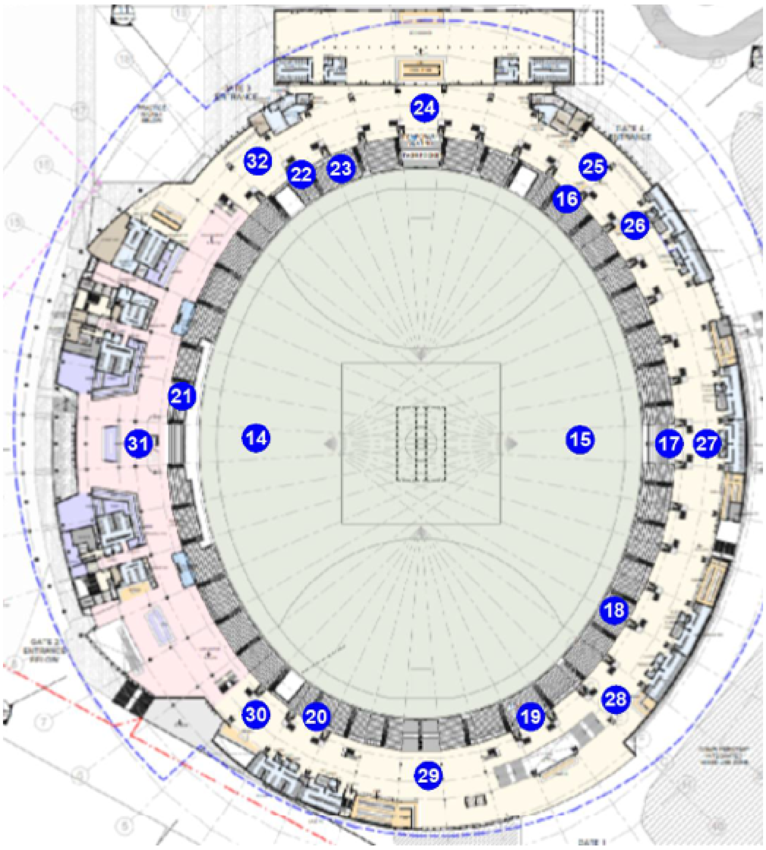

Figure 3 - Locations of measuring points - Lower Tier and Concourse Level 1

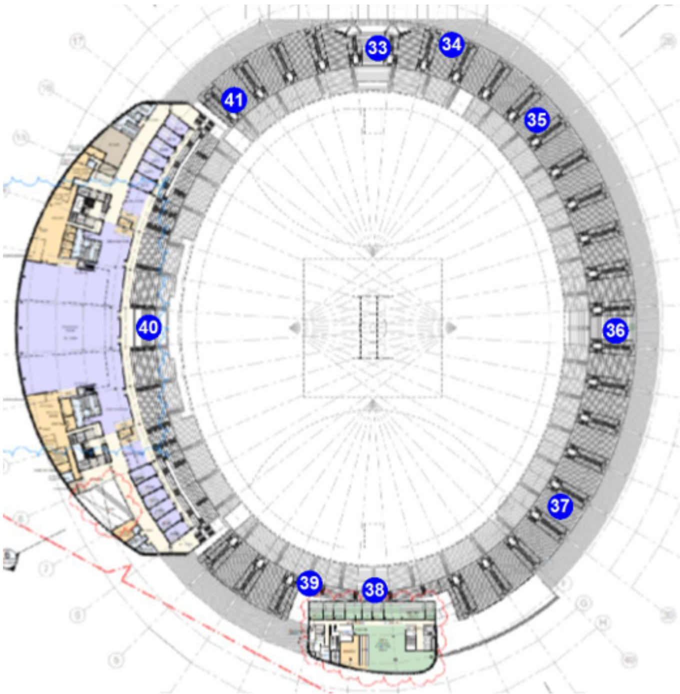

Figure 4 - Locations of measuring points - Upper Tier

Consequently, wind speeds with specific probabilities of exceedance, representative of various locations of interest, are obtained. These results are then evaluated using standard wind comfort criteria to predict the wind comfort level for the study site outlined in the Wind Comfort Assessment for Visitors and the Precinct Area Report prepared by Wacker Ingenieure Wind Engineering Consultants.

3.0 Wind Comfort Analysis

Pedestrian comfort is assessed separately for the summer and winter seasons. Besides evaluating wind comfort, the study also considers safety criteria. This safety classification helps estimate wind danger and predict if unacceptable wind conditions might occur. In this context, an unacceptable condition is defined as winds strong enough to knock people over.

The standard wind comfort criteria used to predict the wind comfort level for the Stadium is shown below in Table 1.

Windcomfort criteria						Example for possible usage
Wind velocity [m/s]	Probability of exceedence [% - hours per year]	Quality Class	Activity			
			Traversing	Strolling	Sitting	
U_{mean} = 5 m/s	< 2.5	1	Good	Good	Good	cafes, seating areas
$U_{gust,eff}$ = 6 m/s	< 5.0					
U_{mean} = 5 m/s	2.5 - 5.0	2	Good	Good	Moderate	waiting areas, parks
$U_{gust,eff}$ = 6 m/s	5.0 - 10.0					
U_{mean} = 5 m/s	5.0 - 10.0	3	Good	Moderate	Poor	shopping areas, entrance areas
$U_{gust,eff}$ = 6 m/s	10.0 - 20.0					
U_{mean} = 5 m/s	10.0 - 20.0	4	Moderate	Poor	Poor	side walks
$U_{gust,eff}$ = 6 m/s	> 20.0					
U_{mean} = 5 m/s	> 20.0	5	Poor	Poor	Poor	wind shelter recommended
U_{mean} = 15 m/s	> 0.05					
$U_{gust,eff}$ = 13 m/s	> 1.0					
Safety criteria						
U_{mean} = 15 m/s	> 0.3	6	potential risk			wind shelter necessary
$U_{gust,peak}$ = 25 m/s	> 0.1					

Table 1 - Wind Comfort Criteria

4.0 Preliminary Findings

The wind comfort measurements were carried out at 41 measuring points of which measuring points 1-13 are located outside at the precinct, points 14 and 15 on the playing field, points 16-23 on the lower tier, points 24-32 on the concourse in Level 1 and points 33-41 on the upper tier. The locations of the measuring points are shown in Figures 2, 3 and 4.

4.1 Results for the Project Site without Buildings

For reference, the wind comfort is assessed for the vacant condition at the project site, assuming the buildings do not affect the airflow (while considering the general roughness around the site). Consequently, the wind comfort level was classified as comfort class 4 for both the summer and winter halves of the year, according to the pedestrian comfort classification (refer Table 1).

This indicates that, without the influence of nearby buildings and the Stadium, the wind comfort at the project site is moderately suitable for walking in both seasons, with uncomfortable wind speeds occurring slightly more frequently during the summer.

4.2 Pedestrian Comfort Outside and Inside the Stadium

Pedestrian comfort was assessed separately for the summer season (October to March) and the winter season (April to September). In most locations, the predicted wind comfort class for the summer is similar to or slightly worse than that for the winter.

<u>Pedestrian comfort outside the Stadium</u>

The pedestrian comfort classes observed in the outer precinct area range from class 2 to 4 in both seasons. This indicates that, in most cases, the proposed buildings within the project area provide a general sheltering effect, resulting in similar or improved pedestrian comfort conditions compared to the scenario without the new buildings.

At all investigated locations, pedestrian comfort is at least suitable for sidewalks. The comfort level would be further enhanced by incorporating shelter elements such as plantings, shade structures, and similar features into the landscape as follows:

- The northeastern areas near the planned Antarctic Facilities Zone are the windiest (comfort class 4).
- Wind comfort classes between 2 and 3 were assessed at the entrance areas. Generally, this is considered satisfactory; however, the southwestern Gate 2 is the windiest (comfort class 3).

<u>Pedestrian comfort inside the Stadium</u>

Inside the stadium, wind speeds are noticeably lower compared to outside. Both the lower and upper tiers achieved the highest comfort class 1 at all measuring points, indicating no significant wind comfort issues.

On the Level 1 concourse, wind speeds are slightly higher than in the tiers, but most locations still do not show wind comfort problems. Only at the northeastern edge do higher wind conditions occasionally occur, but the assessed wind comfort remains acceptable for waiting areas.

4.3 Conclusions and Recommendations

The safety criterion is satisfied at each measuring point inside and outside the Stadium. The proposed buildings within the project area provide a general sheltering effect, resulting in similar or improved pedestrian comfort conditions compared to the scenario without the new buildings. Thus, a potential wind-induced risk according to the defined criterion is not likely to occur.

At all investigated locations outside the Stadium, pedestrian comfort is at least suitable for sidewalks. The comfort level would be further enhanced by incorporating shelter elements such as plantings, shade structures, and similar features into the landscape.