

BeStPLW – A Benchmark Study on Pedestrian Level Winds

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SUMMARY

As new urban schemes increasingly prioritise outdoor recreational spaces, designers and developers are often required to incorporate wind microclimate considerations early in the design process so that wind-responsive strategies can be systematically integrated within the architectural expression of the project. This process ensures that such spaces remain comfortable and functional, whilst any negative impacts on the surrounding environment are minimised. Despite widespread adoption of wind microclimate guidelines by local authorities globally, differences persist in the outcome of pedestrian level wind assessments, even when wind consultants follow the same guidelines. This paper presents the preliminary findings of a benchmark study on pedestrian level winds coordinated by the UK Wind Engineering Society. The study aims to critically evaluate the fidelity of computational simulations, to compare their outputs against measurements obtained in a boundary layer wind tunnel facility, and to provide an overview of the current state of practice within the industry.

Keywords: *Pedestrian Level Winds, Wind Microclimate, Computational Fluid Dynamics, Wind Tunnel Testing*

1. INTRODUCTION

The way wind interacts with the built environment can influence people's activities within the urban fabric of a city. Despite the recent publication of wind microclimate guidelines across several cities globally (City of London, 2019; Leeds City Council, 2021; and the City of Toronto, 2022), differences in the outcome of pedestrian level wind studies using computational fluid dynamics (CFD) remain. A blind benchmark study was carried out under the direction of a sub-committee of UK WES, the UK Wind Engineering Society (www.windengineering.org.uk) to understand the degree of variability in the output of CFD simulations conducted by wind consultants / researchers; to establish how such output compares against measurements taken in a boundary layer wind tunnel facility; and to provide a snapshot of the state of the industry. This project is called 'BeStPLW' (short for 'Benchmark Study on Pedestrian Level Winds'). The prospect of conducting a benchmark study on pedestrian level winds was first introduced at the '14th UK Conference on Wind Engineering' which was held at the University of Southampton in September 2024 (Vita et al., 2024). The 'BeStPLW' project was then officially launched in June 2025 with an open invitation to the wider community of computational wind engineering practitioners and researchers. A 3D geometry of a realistic urban environment together with a pre-defined layout of sampling points, target in-flow boundary conditions and a detailed test matrix were shared with all participants at the end of July 2025. A total of 21 submissions were received before the closing date (end of October 2025). The Department of Aeronautics and Astronautics at the University of

Southampton (UK) played a vital role in ensuring that all data submission and data handling remained anonymous. The 'BeStPLW' project will also benefit from a wind tunnel testing campaign that will be conducted in the closed-loop boundary layer facility at TU/e (Eindhoven University of Technology, The Netherlands) in December 2025: this work is part of the transnational access project “ERIES – WES”, supported by the Engineering Research Infrastructures for European Synergies (ERIES) project (www.eries.eu), which has received funding from the European Union’s Horizon Europe Framework Programme under Grant Agreement No. 101058684. This is ERIES publication number C109.

2. BACKGROUND

A substantial amount of work has been dedicated to standardising the assessment of wind effects in the built environment over the course of the last few decades. The Architectural Institute of Japan (AIJ, 2016) produced a series of benchmark studies for validating CFD simulations establishing canonical geometries accompanied by wind tunnel datasets. In recent years, along with the AIJ guidelines (Tominaga et al., 2008) these benchmark cases have been widely used to validate numerical methodologies. However, when compared to the broad range of urban environments typically assessed as part of planning applications, these canonical geometries tend to lack complexity. To the knowledge of the authors of this paper, no benchmark studies have been conducted to date in the space of pedestrian level winds for a realistic urban setting.

3. APPROACH & METHODOLOGY

3.1. Computational approach

Participants in the 'BeStPLW' project received a 3D geometry (see Figure 1) that is identical to the one to be tested in the wind tunnel facility at TU/e. The geometry represents a realistic urban environment, comprising an idealised ‘building of interest’ and its surrounding buildings within a 500m radius. The model also includes elevated levels representing train and tram tracks, as well as lowered topography akin to rivers and canals. The test matrix with seven scenarios shown in Table 1 was also provided to all participants. The first two scenarios were mandatory for CFD submissions; the others were optional. ‘Scenario 1’ required 36 wind directions in 10° increments covering 0°-350°, while ‘Scenario 1a’ (optional) extended this to 72 directions in 5° increments. Subsequent scenarios used a reduced range of wind directions (170°-280° in 10° increments, inclusive). Scenarios were chosen to reflect common wind mitigation measures employed in practice, including the use of perforated screens, solid canopies, trees, and façade treatments such as vertical fins. One scenario incorporated an irregular building shape to ‘stress-test’ computational mesh quality. Participants were provided with in-flow profiles of velocity and turbulence intensity (longitudinal component) and were asked to match these by following their standard methodology for defining the atmospheric boundary layer. Experimental data on the 2D pressure drop across porous screens was also provided. Results were requested in the form of normalised velocity (U/U_{ref}) at a pre-defined set of approximately 116,000 sampling points. Participants were also asked to provide ‘gust-equivalent mean’ (GEM) wind speeds and the computed turbulent kinetic energy. Whilst optional, participants were encouraged to provide details of their computational setup, including domain size, boundary conditions, wall functions, discretization schemes, convergence criteria, mesh characteristics, and a sampled profile in an empty domain.

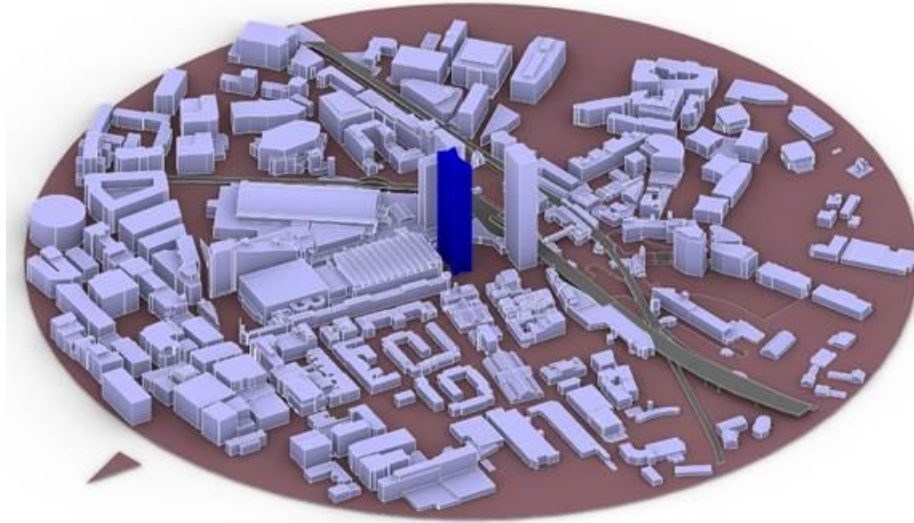


Figure 1: The 3D geometry of 'Scenario 1', to be numerically studied and wind tunnel tested.

Table 1: Test matrix.

Scenario	Description	Number of wind directions	CFD simulations	Wind tunnel testing
1	Basic run.	36	✓	✓
2	As per "Scenario 1" but with perforated screens at street level.	12	✓	✓
3	As per "Scenario 1" but with a solid canopy at the base of the building of interest.	12	Optional	✓
4	As per "Scenario 1" but with trees at street level.	12	Optional	✓
5	Alternative geometry for the building of interest.	12	Optional	✓
6	As per "Scenario 1" but with the envelope of the building of interest featuring solid vertical fins.	12	Optional	✓
7	As per "Scenario 1" but with an alternative arrangement of the surface-mounted physical probes.	12	Not required	✓
1a	As per "Scenario 1" but with wind speed data sampled / measured at 5° increments.	72	Optional	✓

3.2. Experimental approach

The wind tunnel tests will use a 1:400 scale physical model (blockage lower than 5%). Measurements will be taken using 128 surface-mounted Irwin probes covering the same spatial envelope as the CFD sampling points, enabling direct comparison between computational and experimental data. An additional scenario (Scenario 7) will include a denser layout of Irwin probes to assess the potential impact of flow interference.

4. INITIAL FINDINGS

Upon receipt of the 21 anonymised submissions, an initial quality check was carried out, which highlighted potential discrepancies with the normalisation of the velocity results between submissions. Participants were therefore asked to confirm their normalisation approach to ensure consistency across all submissions. This raises the potential issue of horizontal inhomogeneity in the CFD simulations (Blocken et al., 2007) whereby vertical profiles of mean wind speed, turbulent

