Introducing BeStPLW: A Benchmark Study on Pedestrian Level Winds

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1 INTRODUCTION

The interaction between wind and the built environment can significantly alter the experience of pedestrians within the urban fabric of a city [1]. With a growing focus on incorporating recreational outdoor spaces into new developments, designers and developers are often tasked with "shaping" the wind microclimate to ensure the suitability of these spaces whilst minimising impacts on surrounding areas. In this context, high-rise buildings receive special attention from planning authorities due to their potential to detrimentally modify the wind conditions around them. As a result, planners are increasingly becoming aware of the need for early considerations of the expected wind microclimate as part of design proposals and, in the UK, mandate comprehensive wind assessments and design measures to mitigate any identified and significant wind effects [2].

In the UK, despite the introduction of the 'Wind Microclimate Guidelines' by the City of London Corporation back in 2019 [3], a certain degree of interpretation in the execution of pedestrian level wind studies still exists. To gain a better insight into the quality and consistency of wind microclimate studies conducted both experimentally and computationally by wind engineering practitioners, a benchmark study (BeStPLW, short for 'Benchmark Study on Pedestrian Level Winds') led by a sub-committee of WES - the UK Wind Engineering Society [4], will be undertaken. The experimental component of BeStPLW will benefit from funding provided by ERIES - the Engineering Research Infrastructures for European Synergies [5].

The main goal of BeStPLW is to provide a snapshot of the state-of-the-art in the industry. More specifically, BeStPLW will be aimed at: i) providing guidelines on the minimum level of details of the building of interest and of its surroundings; ii) providing guidance on the most suitable layout of surface-mounted wind sensors; iii) providing guidelines on the minimum number of wind directions; iv) quantifying the impact of different post-processing methods used in the industry to obtain 'gust' wind speeds; v) investigating experimental and computational modelling techniques for wind mitigation solutions.

This technical paper represents the first introduction of BeStPLW; it will provide an update on its current status, including details on up-coming engagements with the industry; and it will present a timeline for the delivery of its different 'work packages'.

2 BESTPLW CASE STUDY

One of the trickiest aspects of setting up a benchmark is that a real case study needs to be chosen which is generalisable for practical applications throughout the possible variability of the urban fabric of a city. The city of Manchester represents an appropriate area of study which can arguably be representative of a typical urban area in the UK, i.e. featuring a mix of high-rise and low-rise buildings, open parkland and roadworks. Both clusters of tall buildings, as well as more isolated and exposed buildings of large footprints have in fact the potential to introduce complex adverse wind effects that can cause uncomfortable or even unsafe conditions for pedestrians and the Deansgate area of Manchester provides an opportunity to test all of these aspects.

Figure 1 shows the area taken as a reference, with the Hilton hotel at its centre. We anticipate that at least three (3) surround configurations will be studied (existing scenario, cumulative scenario and existing scenario with the geometry of the Hilton hotel to be replaced by a much more challenging but realistic geometry). We also anticipate that the assessments will be initially conducted in the absence of mitigation solutions and that eventual wind mitigation measures will be studied separately either numerically or experimentally.

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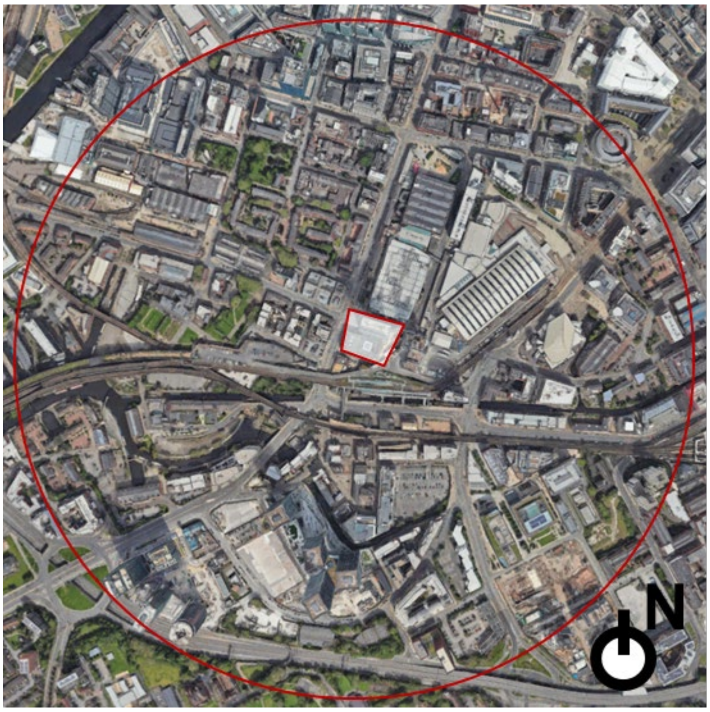

Figure 1. Google Earth aerial view of the study area.

A close-up view of the 3D model of the selected built environment (existing scenario) is shown in Figure 2, providing an appropriate composition of low-, medium- and high-rise buildings as well as complex street canyons. This unique composition has the potential to exhibit complex urban flow phenomena such as downwash from high-rise buildings, flow acceleration from sharp building corners, funnelling between building interference.

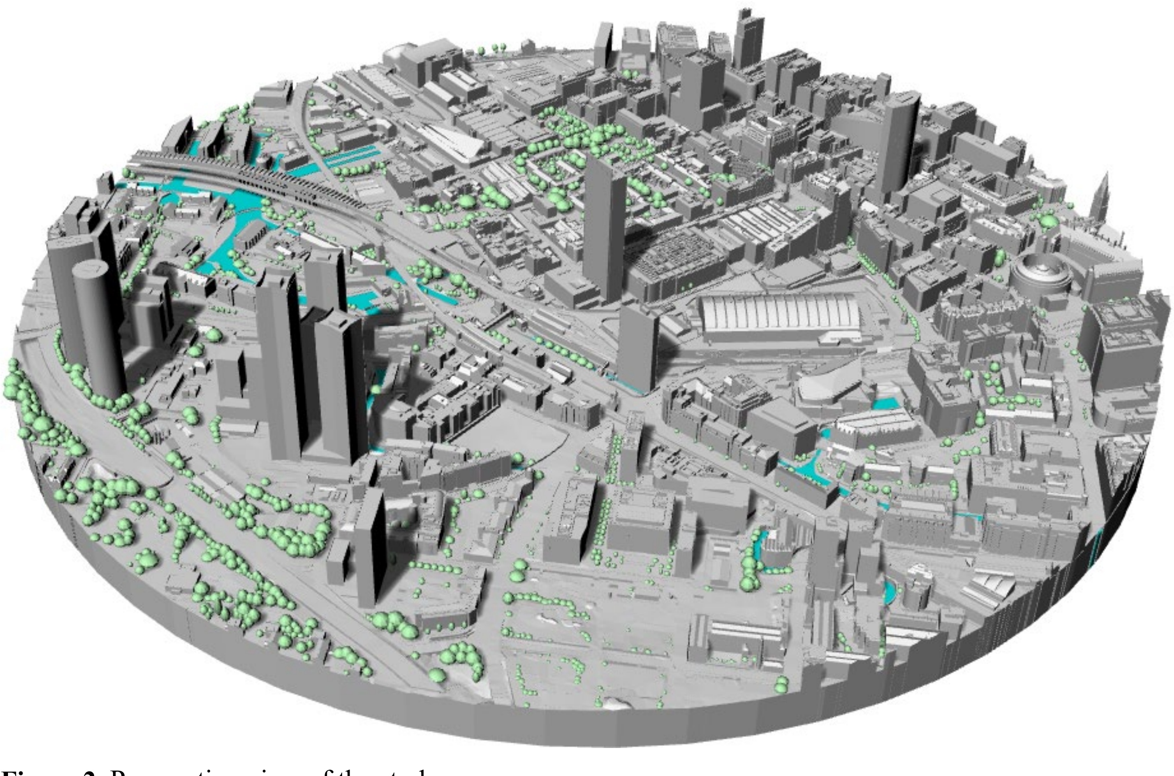

Figure 2. Perspective view of the study area.

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3 APPROACH AND METHODOLOGY

The benchmark is composed of three work packages: (1) wind tunnel testing; (2) computational fluid dynamics (CFD) simulations; and (3) a digital platform for data exchange and management.

3.1 Wind Tunnel Tests

Wind tunnel testing represents a core request in planning applications, both at preliminary and definitive levels of the design. The wind tunnel tests planned for this benchmark study will involve benchmark testing in the atmospheric boundary layer wind tunnel of the Technical University of Eindhoven in the Netherlands.. Discussions with another facility are currently on-going and, if successful, this would give us the opportunity of gathering two independent sets of experimental data.

An urban scaled model, at a geometrical scale of 1:400, will be designed and manufactured to represent the ground geometry and the geometry of the buildings to a suitable level of details which is representative of significant flow structures affecting the pedestrian comfort and safety. It is anticipated that one single exposure will be used in the experiments. Also, if a second wind tunnel facility is engaged, we anticipate that the same physical wind tunnel model will be shipped between the two laboratories to minimise sources of discrepancies.

The pedestrian level wind speed will be measured using the industry-standard Irwin probes placed at multiple locations [5,6].

Multiple wind directions (up to 36 with 10° intervals) will be tested. Data from the Irwin probes will be collected for a sufficient sample time, depending on sampling frequency (typically above 500Hz), to obtain proper statistics for estimating the peak velocities, which will shed light on significant wind gusts affecting pedestrian comfort and safety.

The full set of measurements obtained from the wind tunnel testing campaign will be made publicly available and will also be studied and compared by a sub-committee of WES against the outcome of the CFD simulations.

3.2 CFD Simulations

The geometry and configurations of the wind tunnel model and tests will be replicated numerically to ascertain the limitations of both technologies and most importantly to better understand how they complement each other.

The CFD simulations will primarily focus on identifying best numerical practice and equip planning authorities and third-party reviewers with a defined roadmap to evaluate the work of practitioners proposing a sole numerical test to assess pedestrian safety and comfort, which is allowed for smaller buildings.

A suitable validation procedure could also be scoped in to address the validity of numerical results obtained using low-fidelity CFD methods (such as RANS) in assessing the gust wind speed. Also, a thorough comparison of the results obtained is expected to help WES to come up with suitable minimal quality requirements for CFD simulations in the built environment.

Ultimately the scope of the work is to set out a systematic study on a variety of key parameters to establish best practice or minimal quality requirements for both numerical and experimental tools. The outcome of the work would be a set of CFD results that are accurate for pedestrian wind assessment purposes.

3.3 A Comprehensive Digital Platform

The main ambition of the project is the vision of establishing a digital platform to provide a blind-test benchmarking for industry practitioners who would like to contribute to the wind microclimate assessment market. The main aim of the platform is not to inhibit the growing competition in this field, but to minimise risks associated with poorly planned and poorly executed wind tunnel tests and CFD simulations.

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4 CURRENT PROGRESS AND PLANNED FUTURE WORK

BeStPLW has already been granted funding through the ERIES Projects (Ref: 101058684, Call: HORIZON-INFRA-2021-SERV-01-07).

A contact has been made with the host facility of the "Venturi Lab" at the Technical University of Eindhoven in the Netherlands to plan the work ahead. The wind tunnel testing campaign is expected to start early in 2025. The CFD work has also commenced in terms of choice of the geometry and setting up of the models.

Initial steps have been made towards defining a robust framework for data gathering and data storing but this needs to be finalised in due course. Also, the first steps in advertising this initiative across the industry will commence soon after the 2024 WES Conference and are expected to make use of well-established channels such as LinkedIn.

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