



WIND MICROCLIMATE ASSESSMENT REPORT

39 Deansgate, Manchester

16 December 2019

GIA No: 0961

Working in partnership with:



Foreword

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1 INTRODUCTION & SUMMARY

This report outlines the results of a wind microclimate analysis of the proposed development at 39 Deansgate in Manchester, UK.

1.1 SUMMARY

The impact of the proposed development at 39 Deansgate, Manchester on pedestrian wind comfort and safety was assessed in both existing and cumulative surrounds.

The proposed development makes conditions a category windier around the corner of Deansgate and St Mary's Gate, but still suitable for their intended usage. This is a moderate adverse wind effect but does not require any wind mitigation.

For either existing or cumulative surrounds there was a substantial adverse wind effect in the service courtyard to the east of the development, if wind mitigation is not included.

For either existing or cumulative surrounds there was a moderate adverse wind effect by the service entrance to the east of the development.

For either existing or cumulative surrounds there was a moderate adverse wind effect by the north west entrance, if the recess at this entrance was not accounted for.

When the wind mitigation measure of a wall at the southern end of the bin store region was included, and the model fidelity was increased to account for the recess at the north west entrance, the conditions were rendered suitable for their intended usage. Residual effects in the service courtyard are negligible, and residual effects by the building entrances are moderate beneficial.

2 GUIDANCE

This section outlines relevant legislation and policy related to pedestrian wind comfort.

The assessment was performed using the LDDC variant of the Lawson Comfort Criteria. The Lawson Criteria are well-established in the UK for quantifying wind conditions in relation to build developments and, although not a UK 'standard', the criteria are recognised by local authorities as a suitable benchmark for wind assessments. The Lawson Criteria have been adopted for this assessment.

Planning Practice Guidance 6th March 2014. The Department for Communities and Local Government (DCLG) web based Planning Practice Guidance resource includes a section on design and sets out how a building's size and shape can affect the wind microclimate. The section addressing Design - How should buildings and the spaces between them be considered? 'Consider scale' Paragraph O26, states that: *"Account should be taken of local climatic conditions, including daylight and sunlight, wind, temperature and frost pockets."*

The National Design Guidance, published October 2019, by The Ministry of Housing, Communities & Local Government, paragraph 70, states that, *"proposals for tall buildings (and other buildings with a significantly larger scale or bulk than their surroundings) require special consideration. This includes their location and siting; relationship to context; impact on local character, views and sight lines; composition - how they meet the ground and the sky; and environmental impacts, such as sunlight, daylight, overshadowing and wind. These need to be resolved satisfactorily in relation to the context and local character."*

3 METHOD

To identify the likely effect of the proposed development on the pedestrian level wind environment, a 3D CFD model of the development and surrounding site was created. This section describes the methodology for the creation of this model and the inputs used.

3.1 ASSESSMENT METHODOLOGY

The assessment was performed using Wirth Research's high-resolution Computational Fluid Dynamics (CFD) modelling.

CFD is a computer based modelling technique, which simulates the effect of wind on the built environment. The air is divided into hundreds of millions of "cells", within which the equations of motion are solved. Wirth Research use a high-performance supercomputer, 500 times faster than a standard desktop, to achieve market leading accuracy. The CFD modelling delivers a detailed assessment of wind conditions in and around a site for all wind directions in terms of pedestrian comfort and strong winds.

Wirth Research use an in-house method to account for gusts, which has been correlated against world leading wind tunnels, which ensures that the effect of gusts is predicted.

A full description of the test methodology is included in Appendix A.

3.2 ESTABLISHING BASELINE CONDITIONS

Baseline conditions were established using a high resolution CFD model, extending 400m radius from the Site.

The model was built using 3D CAD, provided by GIA between 05/11/19 and 05/12/19.

A model of the Development was included within the CFD model and tested to determine the conditions at and around the Site. The model used is shown in Figure 1 to Figure 4.

The model was run at full scale from 18 wind angles, spaced using 10° or 30° increments such that no sector contributes more than 10% of the annual wind. The wind angles which were run are indicated in Appendix A.

Wind speeds were measured at 1.5m above any surfaces expected to be used for pedestrian activity.

On-site and local wind speeds were combined with 30 years-worth of weather data for Manchester airport, corrected for terrain local to the airport and the Site, to obtain annual and seasonal frequency and magnitude of wind speeds across the model. This allows the 'grading' of the pedestrian level winds according to the Lawson Comfort Criteria, which are explained later in this chapter.

Seasonal wind roses for the airport are shown in Appendix A. The dominant wind direction is from the south.

The correction factors between the airport (measured 10m above ground) and the Site (at a reference height of 120m) are shown in Table 1. It should be noted that the terrain analysis has been performed using sectors of 30°, which is presented here.

Table 01: Site Wind Correction Factors

DIRECTION (°N)	0°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°
Corr. Factor	1.43	1.44	1.43	1.45	1.38	1.39	1.37	1.39	1.43	1.45	1.45	1.40

The wind microclimate effects are assessed annually and for the winter months (December, January and February). Winter conditions are reported as this is the season when the strongest winds are expected.

Any areas which show up as either unsafe (annually) or uncomfortable (for winter) will require mitigation, unless they are in locations where pedestrian access can be controlled in the event of strong winds. This applies to all thoroughfares (for pedestrians) and roads (for cyclists) around the Development.

3.3 TARGET CONDITIONS

For a mixed-use urban area within which the Site is located, the desired wind microclimate would typically need to have areas acceptable for sitting, standing (including at entrances of buildings) and walking use. A description of the comfort categories to classify wind conditions in accordance with is given below.

The areas immediately outside any building entrances should be suitable for standing use during winter to provide a “buffer” between the still conditions in interior spaces and the general thoroughfare.

Table 02: Lawson Comfort Criteria (LDDC variant)

KEY	COMFORT CATEGORY	MEAN WIND SPEED (5% EXCEEDANCE)	DESCRIPTION
	Sitting	4 m/s	Acceptable for outdoor sitting use (e.g. cafés, benches, balconies)
	Standing	6 m/s	Acceptable for main building entrances, pick-up/drop-off points and bus stops
	Walking (leisure)	8 m/s	Acceptable for strolling
	Walking (business)	10 m/s	Acceptable for external pavements, walking purposefully without lingering
	Uncomfortable	>10 m/s	Not comfortable for regular pedestrian access

Table 03: Lawson Comfort Criteria (LDDC variant)

KEY	SAFETY CATEGORY	MEAN WIND SPEED (0.022% EXCEEDANCE)	DESCRIPTION
	No Safety Exceedance	<15 m/s	
	S15 (Distress)	>15 m/s	Unsafe for frail individuals, or cyclists
	S20 (Safety)	>20m/s	Wind conditions considered unsafe for all users

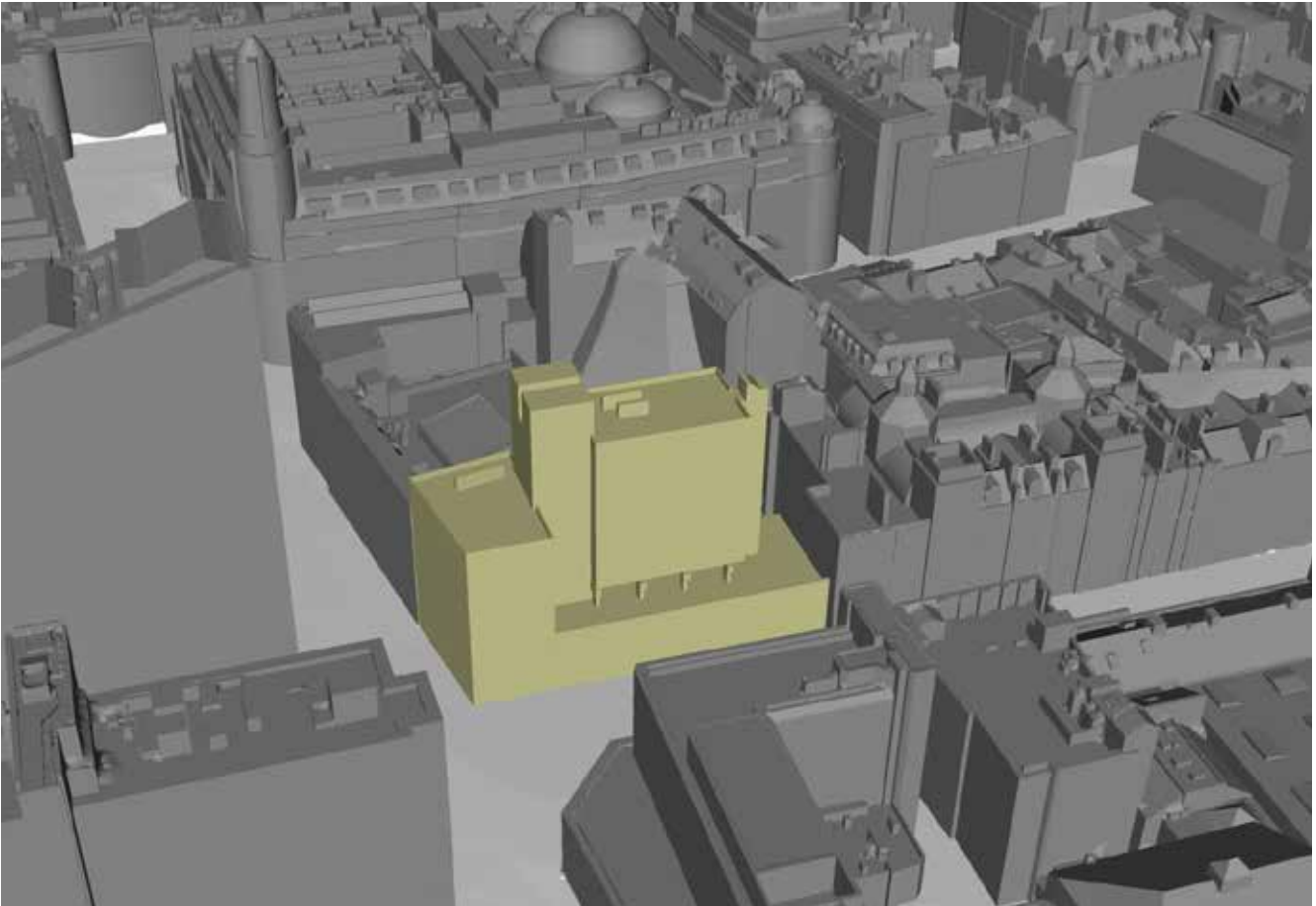


Fig. 01: Existing Site

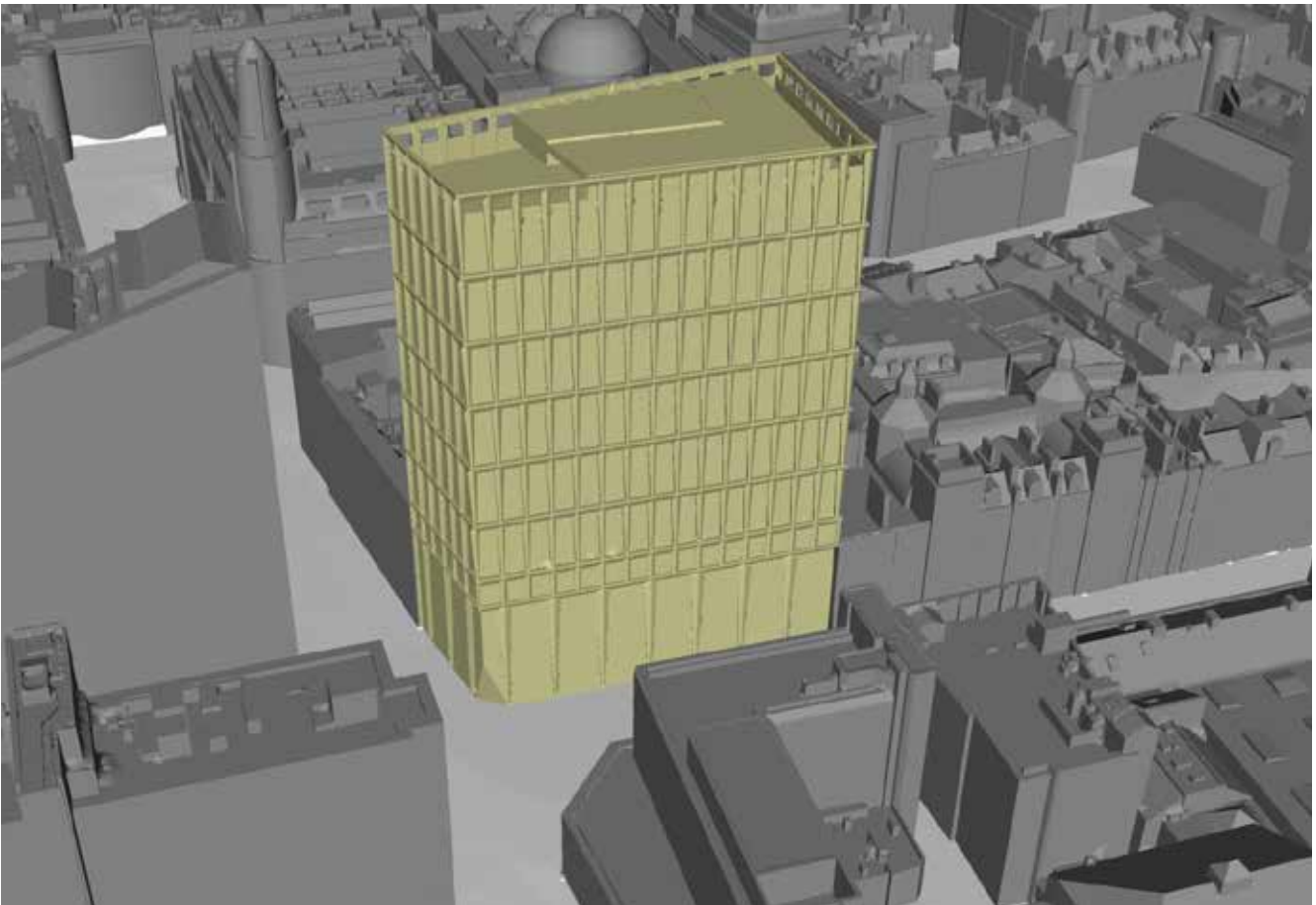


Fig. 02: Site with Proposed Development



Fig. 03: Surrounding Context (existing buildings)



Fig. 04: Surrounding Context (existing plus cumulative buildings)

3.4 TEST SCENARIOS

The purpose of these tests was to ensure that target conditions could be achieved whether the proposed development is operational with its current surroundings or with cumulative consented schemes.

The following 5 scenarios were tested:

- Existing Site, Existing Surrounds: The site (as existing) with the baseline conditions surrounding the site.
- Proposed Site, Existing Surrounds: The completed and operational development with the baseline conditions surrounding the site.
- Proposed Site, Cumulative Surrounds: The completed and operational development with the baseline and cumulative schemes.
- Proposed Site, Existing Surrounds with Mitigation: The completed and operational development with mitigation measures included and the baseline conditions surrounding the site.
- Proposed Site, Cumulative Surrounds with Mitigation: The completed and operational development with mitigation measures included and the baseline and cumulative schemes.

It should be noted that the “existing surrounds” tested here include any buildings which are already built, plus any consented schemes for which works have started on site pursuant to the building works to continue thereafter. The existing surrounds represent the expected surrounds as of December 2019..

3.5 SIGNIFICANCE CRITERIA

The significance of any wind effects will determine whether the wind effects require mitigation. The method outlined below for determining significance is in accordance with current industry best practice.

The significance of on-site wind effects is defined by comparing the wind comfort/safety levels with the intended pedestrian activity. This is shown in Table 4.

The significance of off-site wind effects is defined by both comparing the wind comfort levels with the intended pedestrian activity, and also comparing the condition to those experienced prior to the introduction of the proposed development. This is shown in Table 5.

All effects for the completed and operational development are considered long term and local.

Table 04: Significance Criteria for On-Site Wind Effects

SIGNIFICANCE	TRIGGER	MITIGATION REQUIRED
Substantial Adverse	Conditions are "unsafe"	Yes
Moderate Adverse	Conditions are "unsuitable" (in terms of comfort) for the intended pedestrian use	Yes
Negligible	Conditions are "suitable" for the intended pedestrian use	No
Moderate Beneficial	Conditions are calmer than required for the intended pedestrian use (by at least one comfort category)	No

Significance Criteria for On-Site Wind Effects

SIGNIFICANCE	TRIGGER	MITIGATION REQUIRED
Substantial Adverse	Conditions that were "safe" in the baseline scenario become "unsafe" as a result of the proposed development OR Conditions that were "suitable" in terms of comfort become "unsuitable" as a result of the proposed development OR Conditions that were "unsafe" in the baseline scenario are made worse as a result of the proposed development.	Yes
Moderate Adverse	Conditions that were "suitable" in terms of comfort in the baseline scenario are made windier (by at least one comfort category) as a result of the proposed development, but remain "suitable" for the intended pedestrian activity.	No
Negligible	Conditions remain the same in the baseline scenario.	No
Moderate Beneficial	Conditions that were "unsuitable" in terms of comfort in the baseline scenario become "suitable" as a result of the proposed development OR Conditions that were "unsafe" in the baseline scenario are made better as a result of the proposed development (but not so as to make them "safe")	No
Substantial Beneficial	Conditions that were "unsafe" in the baseline scenario become "safe" as a result of the proposed development.	No

LIMITATIONS AND ASSUMPTIONS

The accuracy of the results are dependent upon the accuracy of the CAD used to construct the model.

There is an inherent assumption that on-site wind speeds will scale linearly with the measured wind speeds at the airport.

There is an inherent assumption that the wind speed statistics for the past 30 years will remain applicable for the foreseeable future.

It should be noted that the above assumptions would also be true of a wind tunnel based assessment.

4 RESULTS

Conditions for existing site with existing surrounds

Annual safety and winter comfort for the baseline model (existing site with existing surrounds) are shown in Figure 5.

There are no safety exceedances, and winter comfort is suitable for a mixture of sitting and standing.

Conditions for proposed site with existing surrounds

Annual safety and winter comfort for the proposed development with existing surrounds are shown in Figure 6.

The general winter comfort conditions are suitable for a mixture of sitting, standing and leisure walking. There are regions (particularly around the corner of Deansgate and St Mary's Gate) which are a category windier than for the baseline model, which is a moderate adverse wind effect, but will not require any wind mitigation.

There is an S15 safety exceedance for 5 hours per year in the service courtyard to the east of the development. This is a substantial adverse wind effect and requires mitigation.

There are regions which are suitable for leisure walking adjacent to both the north-western entrance (on the corner of Deansgate and St Mary's Gate) and the eastern service entrance. These are both moderate adverse wind effects, which require mitigation.

Conditions for proposed site with cumulative surrounds

Annual safety and winter comfort for the proposed development with cumulative surrounds are shown in Figure 7.

The general winter comfort conditions are suitable for a mixture of sitting, standing and leisure walking. There are regions (particularly around the corner of Deansgate and St Mary's Gate) which are a category windier than for the baseline model, which is a moderate adverse wind effect, but will not require any wind mitigation.

There is an S15 safety exceedance for 5 hours per year in the service courtyard to the east of the development. This is a substantial adverse wind effect and requires mitigation.

There are regions which are suitable for leisure walking adjacent to both the north-western entrance (on the corner of Deansgate and St Mary's Gate) and the eastern service entrance. These are both moderate adverse wind effects, which require mitigation.

There is also a region which is suitable for leisure walking along St Mary's Gate, to the north of the development. This region is located in the highway, away from any building entrances, so is suitable for the intended purpose.



Annual Wind Safety



Winter Wind Comfort

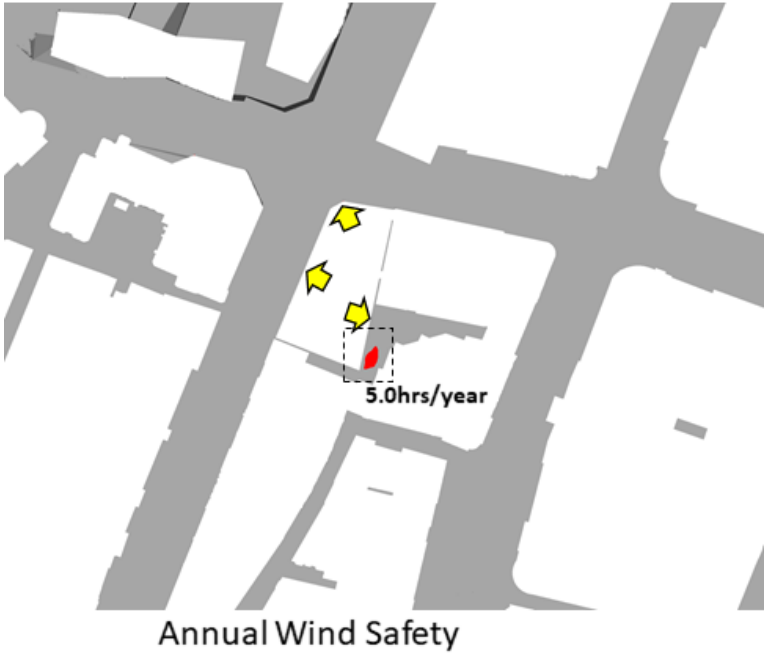
Comfort Category	Colour	Entrances	
Sitting	Green	Safety Category	Colour
Standing	Blue	No Safety Exceedance	Grey
Leisure Walking	Yellow	S15 (distress)	Red
Business Walking	Magenta	S20 (safety)	Black
Uncomfortable	Red		

Fig. 05: Existing Site with Existing Surrounds



Comfort Category	Colour	Entrances	Safety Category	Colour
Sitting	Green	Yellow arrow	No Safety Exceedance	Grey
Standing	Blue		S15 (distress)	Red
Leisure Walking	Yellow		S20 (safety)	Black
Business Walking	Magenta			
Uncomfortable	Red			

Fig. 06: Proposed Site with Existing Surrounds



Comfort Category	Colour	Entrances	
Sitting	Green	Safety Category	Colour
Standing	Blue		
Leisure Walking	Yellow		
Business Walking	Magenta		
Uncomfortable	Red		
		No Safety Exceedance	Grey
		S15 (distress)	Red
		S20 (safety)	Black

Fig. 07: Proposed Site with Cumulative Surrounds

5 ANALYSIS AND MITIGATION

The adverse wind effects in the service courtyard occur when the wind is from between 170° and 260°. The critical wind angle is 220°.

Figure 8 shows the flow features which are contributing to the raised wind speeds in the service courtyard, when the wind is from 220°.

It is apparent that the critical flow feature is downwash from the southern face of the proposed development, which is then accelerated through the gap adjacent to the bin store.

The proposed mitigation for this feature is to include a wall across the southern edge of the bin store region, as shown in Figure 9

With regards to the adverse wind effects by the north-western entrance, it should be noted that this entrance is due to be recessed rather than flush to the adjacent thoroughfare. This recess was added to the "with mitigation" runs and is shown in Figure 10.

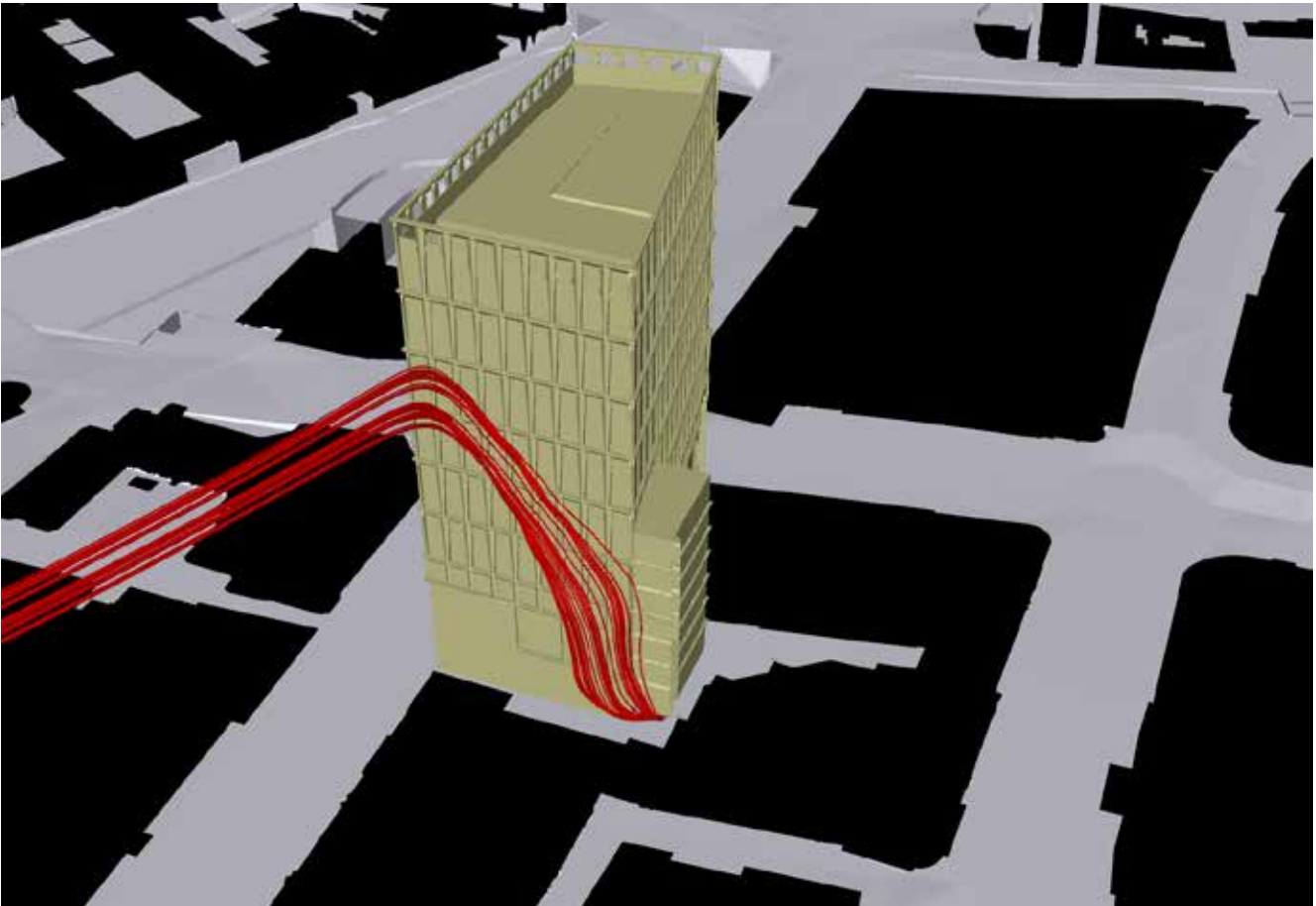


Fig. 08: Airflow into the Service Courtyard (wind from 220deg)



Fig. 09: Wall Added as Wind Mitigation

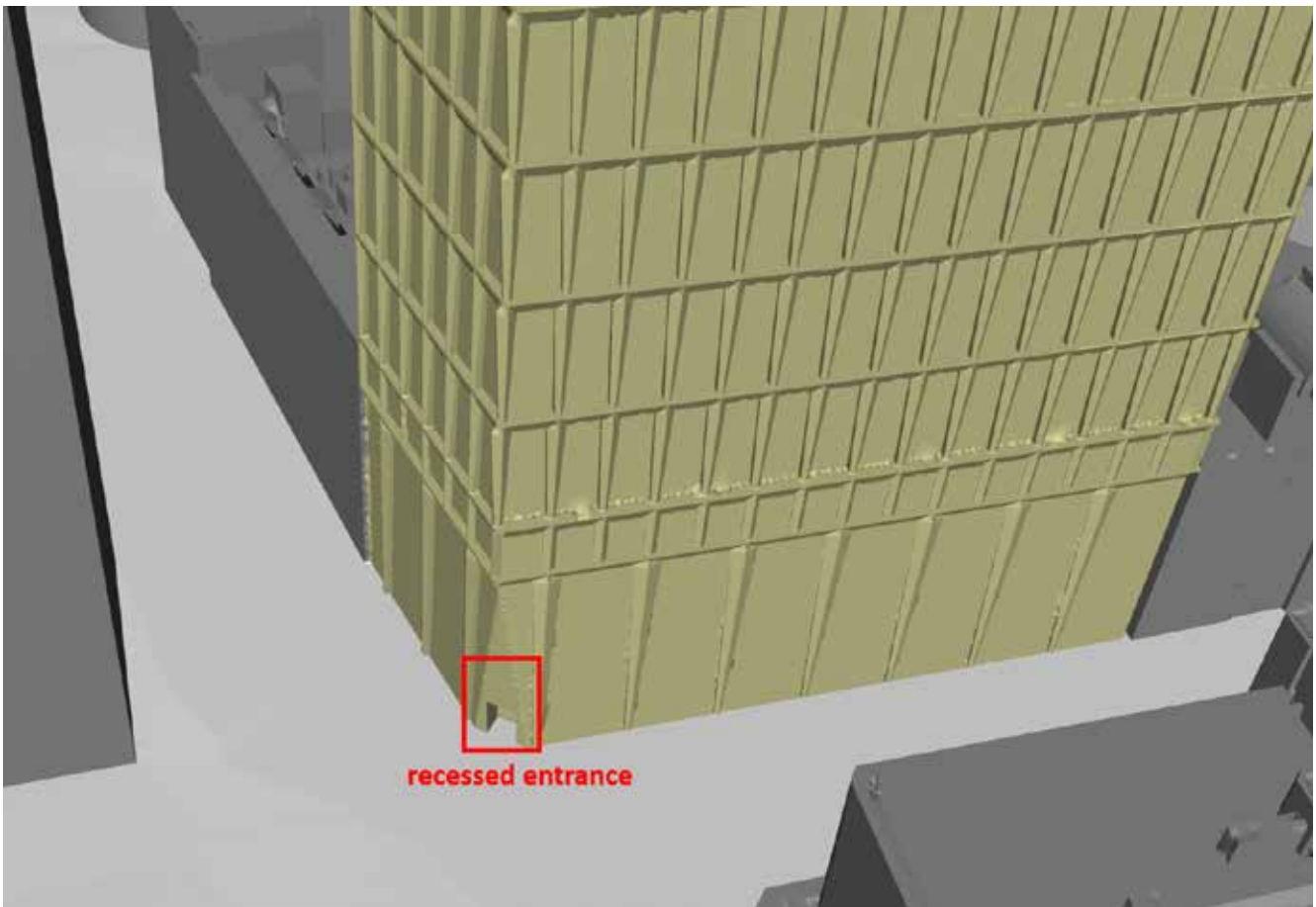


Fig. 10: Recessed Entrance at North West Corner

6 RESULTS – WITH WIND MITIGATION

Conditions for proposed site with existing surrounds and wind mitigation

Annual safety and winter comfort for the proposed development with wind mitigation measures included and existing surrounds are shown in Figure 11.

The S15 exceedances in the service courtyard are no longer apparent. This area is now suitable for the intended use and residual wind effects are negligible.

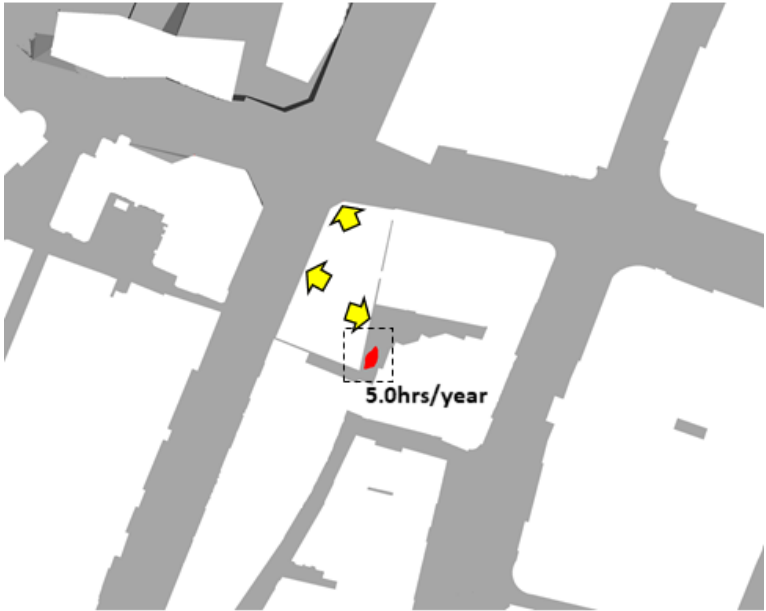
Conditions immediately adjacent to each entrance are now suitable for sitting in winter conditions. This is one category calmer than required, and the residual wind effects can be considered moderate beneficial.

Conditions for proposed site with cumulative surrounds and wind mitigation

Annual safety and winter comfort for the proposed development with wind mitigation measures included and cumulative surrounds are shown in Figure 12.

The S15 exceedances in the service courtyard are no longer apparent. This area is now suitable for the intended use and residual wind effects are negligible.

Conditions immediately adjacent to each entrance are now suitable for sitting in winter conditions. This is one category calmer than required, and the residual wind effects can be considered moderate beneficial.



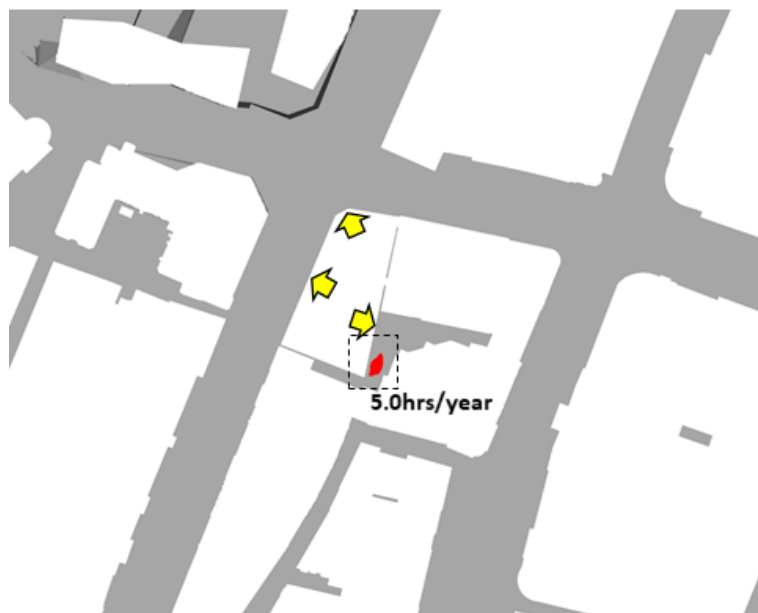
Annual Wind Safety



Winter Wind Comfort

Comfort Category	Colour	Entrances	Safety Category	Colour
Sitting	Green	↖ ↗ ↘ ↙	No Safety Exceedance	Grey
Standing	Blue		S15 (distress)	Red
Leisure Walking	Yellow		S20 (safety)	Black
Business Walking	Magenta			
Uncomfortable	Red			

Fig. 11: Proposed Site with Wind Mitigation and Existing Surrounds



Annual Wind Safety



Winter Wind Comfort

Comfort Category	Colour	Entrances	Safety Category	Colour
Sitting	Green	Yellow arrow	No Safety Exceedance	Grey
Standing	Blue		S15 (distress)	Red
Leisure Walking	Yellow		S20 (safety)	Black
Business Walking	Magenta			
Uncomfortable	Red			

Fig. 12: Proposed Site with Wind Mitigation and Cumulative Surrounds

7 CONCLUSIONS

The impact of the proposed development at 39 Deansgate, Manchester on pedestrian wind comfort and safety was assessed in both existing and cumulative surrounds.

The proposed development makes conditions a category windier around the corner of Deansgate and St Mary's Gate, but still suitable for their intended usage. This is a moderate adverse wind effect but does not require any wind mitigation.

For either existing or cumulative surrounds there was a substantial adverse wind effect in the service courtyard to the east of the development, if wind mitigation is not included.

For either existing or cumulative surrounds there was a moderate adverse wind effect by the service entrance to the east of the development.

For either existing or cumulative surrounds there was a moderate adverse wind effect by the north west entrance, if the recess at this entrance was not accounted for.

When the wind mitigation measure of a wall at the southern end of the bin store region was included, and the model fidelity was increased to account for the recess at the north west entrance, the conditions were rendered suitable for their intended usage. Residual effects in the service courtyard are negligible, and residual effects by the building entrances are moderate beneficial.

APPENDIX 01

DETAILED METHODOLOGY

CFD METHODOLOGY

The CFD was performed using Ansys Fluent.

Meshed using a hybrid mesh of hexahedral, tetrahedral and prismatic elements:

- On site building edge length:
0.05m - 0.3m
- Surrounding context edge length:
0.3m - 1m

The total mesh size was between 208 and 230 million cells. Mesh detail is shown in Figure 13.

Buildings within 400m of the site were included.

The domain was 3420m x 1800m, with a blockage ratio of 0.9%

The blockage ratio uses the height of the tallest building on site (70m) and the diameter of the in which buildings are modelled (800m).

Run using the industry standard Realisable k-epsilon turbulence model with non-equilibrium wall functions.

The simulations were steady state and isothermal.

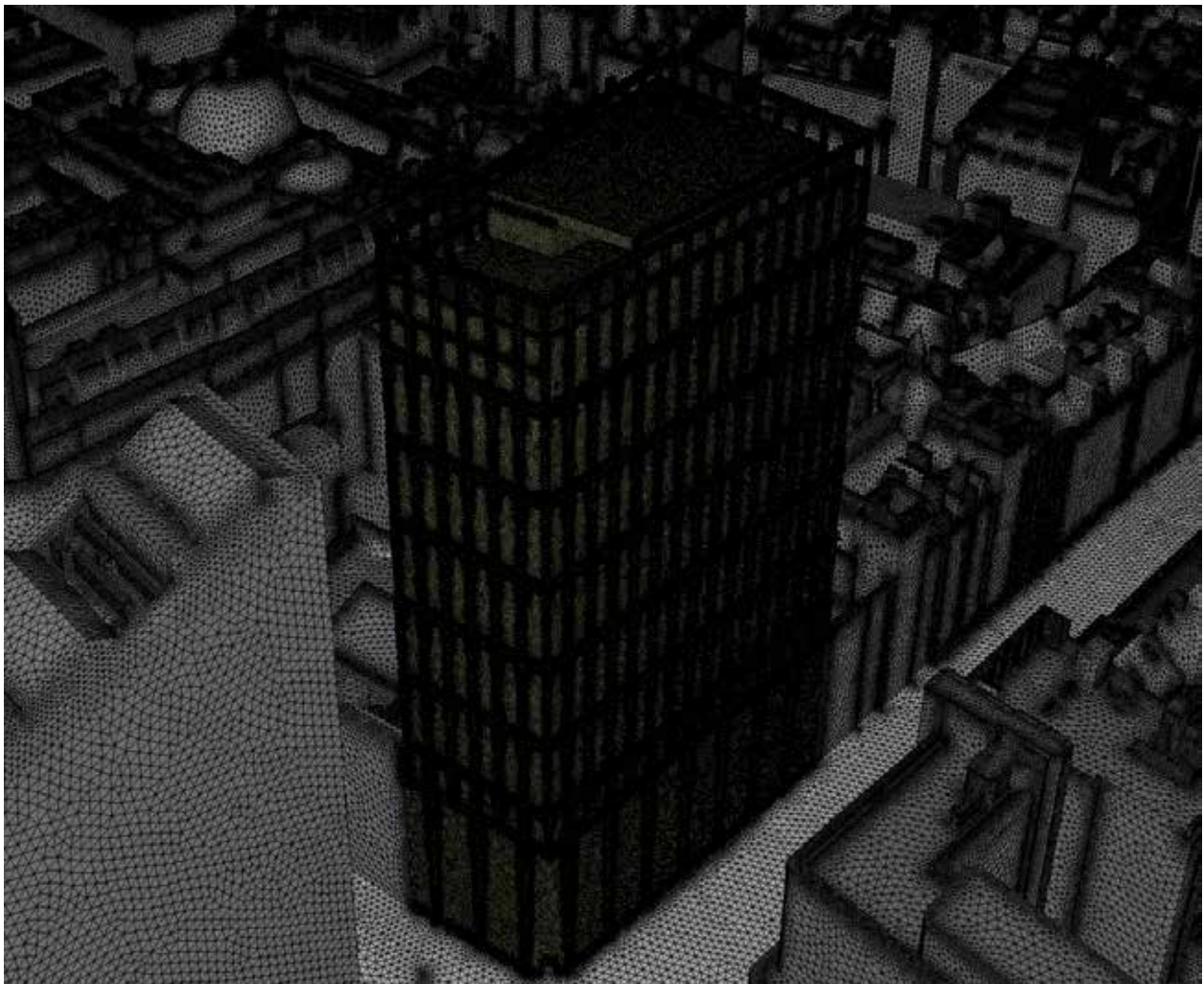


Fig. 13: Mesh Detail on Site Buildings

A combination of 2nd and 3rd order discretisation schemes was used.

Convergence was measured as the residuals of the continuity, x-velocity, y-velocity, z-velocity, k and epsilon equations all falling by at least 2 orders of magnitude, and by measured static pressure on the site buildings varying by less than 1% over the final 100 iterations.

The wind speed is corrected into a “gust-equivalent” mean. Which is calculated using a proprietary method which uses the Turbulent Kinetic Energy (TKE) field and the velocity field from the CFD to estimate the gust velocity across the domain.

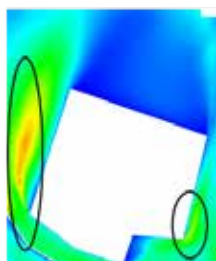
The use of TKE has been questioned due to the known limitations of RANS in predicting absolute TKE values, but for the purposes of generating GEM only the additional TKE generated by the flow structures within the domain is relevant.

There is published literature which demonstrates that discrepancies between mean velocities from CFD and GEM from wind tunnels are only marked when concerned with the gustiness associated with flow accelerations around the corners of buildings.

As can be seen on the left of Figure 14, the TKE field generated shows a clear increase in TKE in the region of corner accelerations.

The WR method has been correlated against wind tunnel data. The studies used for this are confidential, but an anonymised section is shown to the right of Figure 14 to demonstrate the benefits from changing from mean velocity to GEM.

TKE field around typical building corner



Clear increases of TKE are visible for corner accelerations

Using GEM improved correlation for the circled probes

A comparison of WT (dots) and CFD (continuous field) using:
CFD mean velocity CFD GEM (v & TKE combined)

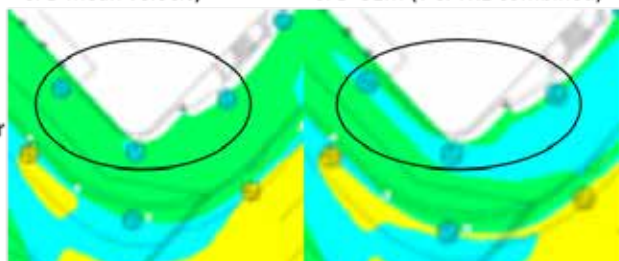


Fig. 14: TKE and GEM using WR method

WIND CLIMATE METHODOLOGY

The simulations were performed from 18 wind directions, spaced such that no single direction contributed more than 10% of the annual winds.

The directions simulated were 0°, 30°, 60°, 90°, 120°, 150°, 170°, 180°, 190°, 200°, 210°, 220°, 240°, 260°, 270°, 280°, 300°, 330°.

30 years of wind data was obtained for Manchester airport, seasonal wind roses for this data are shown in Figure 15.

Target wind profiles for the site, from each wind direction, were generated using sectoral analysis of the terrain surrounding the site and the local weather station (Manchester-Bradford airport), with ESDU 2010 Item01008 'Computer program for wind speeds and turbulent properties: flat or hilly sites in terrain with roughness changes'. The target wind profiles, compared to the wind speeds measured from the CFD model are shown in Figure 16.

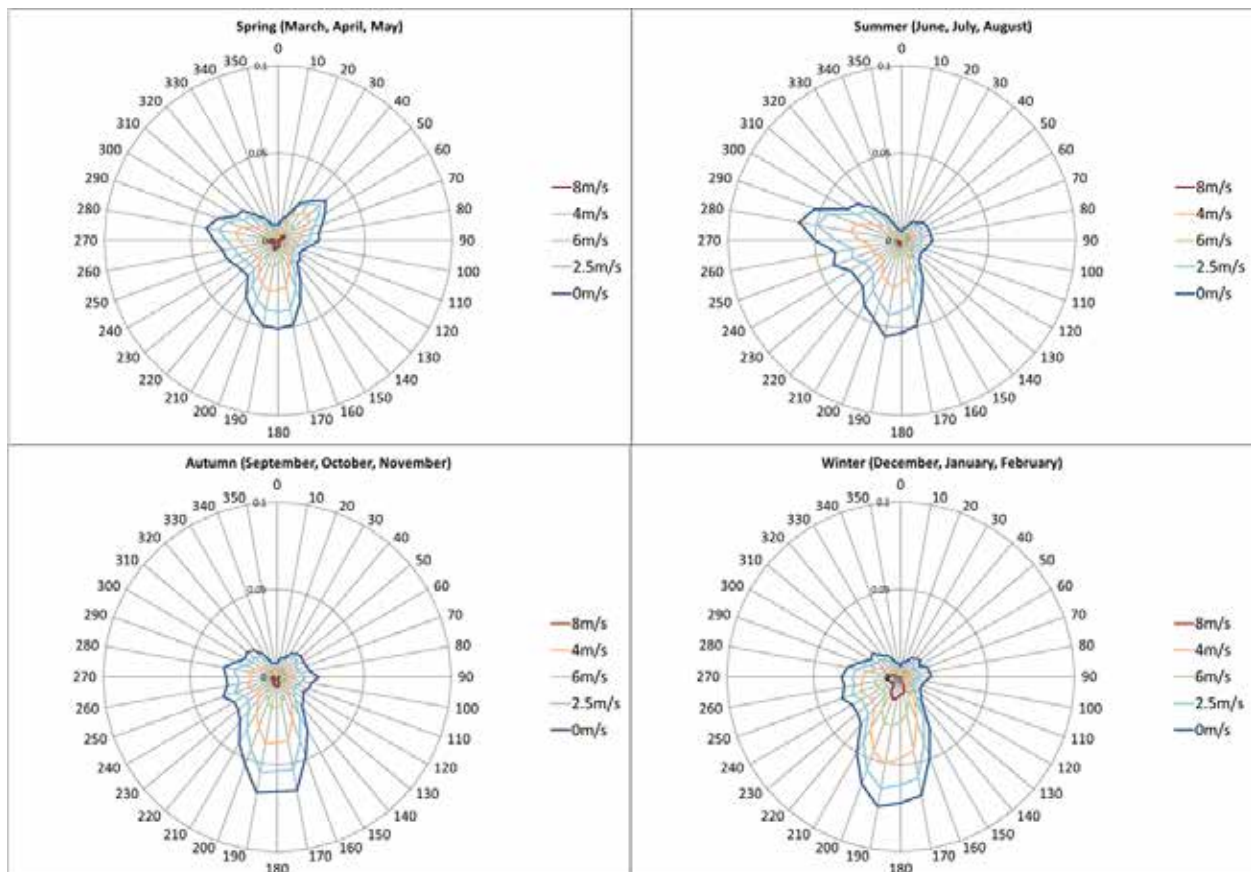


Fig. 15: Seasonal Wind Roses for Manchester Airport

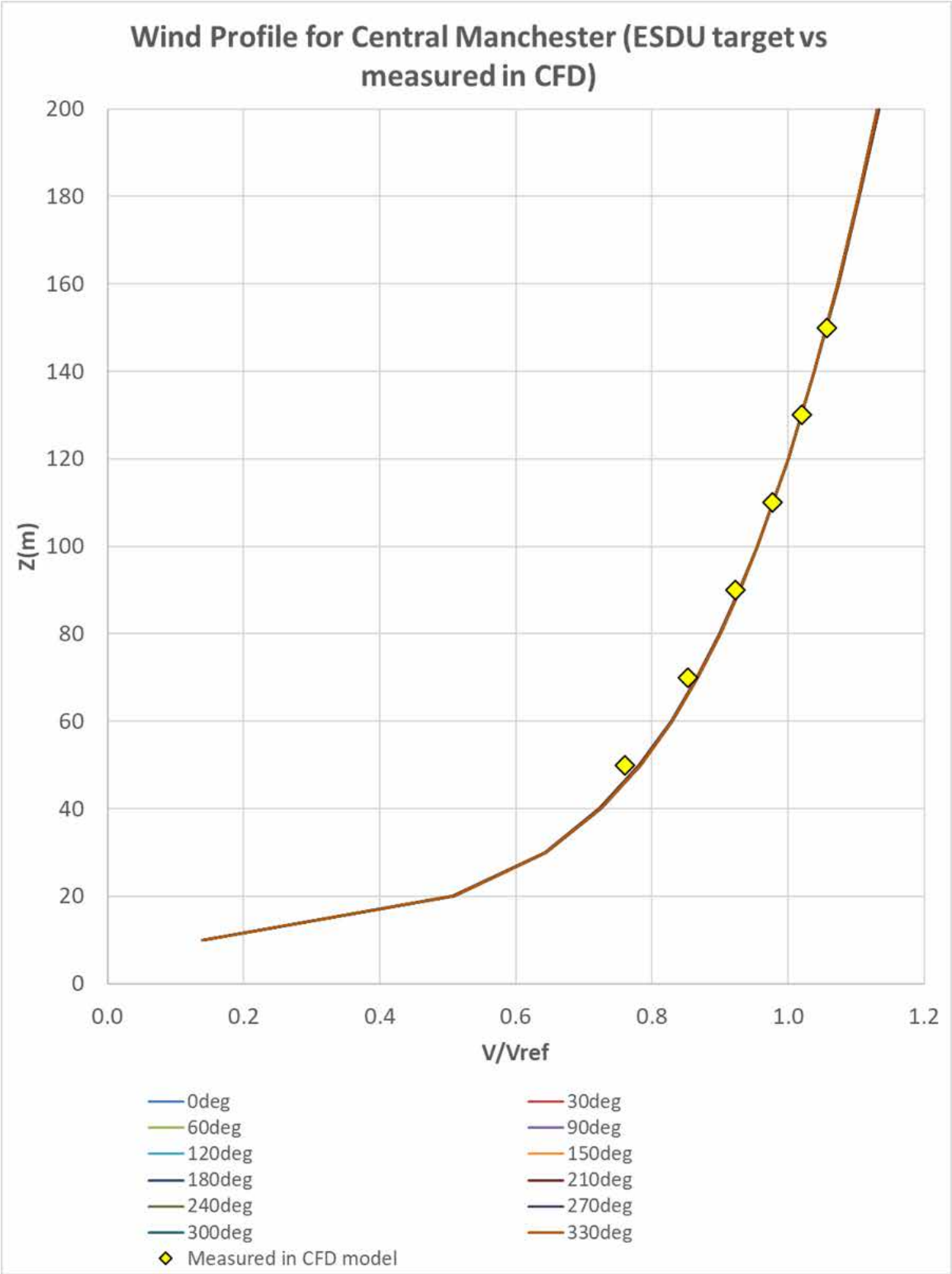


Fig. 16: Wind Profile for Broadway

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