MINISTERO
DELLE INFRASTRUTTURE E DEI TRASPORTI

E.N.A.C
ENTE NAZIONALE per L'AVIAZIONE CIVILE

Committente Principale

AEROPORTO INTERNAZIONALE DI FIRENZE AMERIGO VESPUCCI

Opera

PROJECT REVIEW – PIANO DI SVILUPPO AEROPORTUALE AL 2035

Titolo Documento

NUOVO TERMINAL PASSEGGERI
Wind Comfort degli Spazi Esterni Coperti a livello Pedonale

Livello di Progetto

SCHEDE DI APPROFONDIMENTO PROGETTUALE

A LIVELLO MINIMO DI PROGETTO DI FATTIBILITÀ TECNICA ED ECONOMICA

LIV	REV	DATA EMISSIONE	SCALA	CODICE FILE
PSA	00	MARZO 2024	N/A	FLR-MPL-PSA-TRM2-008-WS-RT_Wind Pedestrian Comfort
				TITOLO RIDOTTO Wind Pedestrian Comfort

02	03/2024	EMISSIONE PER PROCEDURA VIA-VAS	J. Wacker	D. PERRI	L. TENERANI
REV	DATA	DESCRIZIONE	REDATTO	VERIFICATO	APPROVATO

COMMITTENTE PRINCIPALE	GRUPPO DI PROGETTAZIONE	SUPPORTI SPECIALISTICI
ACCOUNTABLE MANAGER Dott. Vittorio Fanti	**DIRETTORE TECNICO** Ing. Lorenzo Tenerani Ordine degli Ingegneri di Massa Carrara n°631	PROGETTAZIONE SPECIALISTICA Arch. David Perri Ordine degli Architetti di Lucca n 1157
POST HOLDER PROGETTAZIONE Ing. Lorenzo Tenerani **POST HOLDER MANUTENZIONE** Ing. Nicola D'Ippolito **POST HOLDER AREA DI MOVIMENTO** Geom. Luca Ermini	**RESPONSABILE INTEGRAZIONE PRESTAZIONI SPECIALISTICHE** Arch. David Perri Ordine degli Architetti di Lucca n 1157	SUPPORTI SPECIALISTICI **ACI ENGINEERING S.A.** RAFAEL VIÑOLY ARCHITECTS PC WACKER INGENIEURE WIND ENGINEERING

Intro

Il presente documento costituisce lo studio del Wind Comfort degli Spazi Esterni Coperti a livello Pedonale. Questo è da considerarsi parte integrante della Project Review del Piano di Sviluppo Aeroportuale (o Masterplan) al 2035 dell'aeroporto di Firenze, qui sviluppata e dettagliata ad un livello tecnico ritenuto congruo con le finalità della presente fase procedurale, comunque non inferiore a quello del progetto di fattibilità tecnica ed economica di cui all'art. 41 del D. Lgs. n. 36/2023.

Il citato approfondimento tecnico viene previsto ad integrazione della Sezione Generale della Project Review del Piano di Sviluppo Aeroportuale al 2035, predisposta in aderenza alle normative e/o regolamenti specifici del settore aeronautico, rispetto alla quale si pone l'obiettivo di elaborare ulteriori elementi tecnici di studio, dettaglio, analisi e progettazione, ritenuti necessari ai fini del compiuto espletamento dei procedimenti amministrativi (di compatibilità ambientale e di autorizzazione) ai quali risulta per legge assoggettato lo strumento del Piano di Sviluppo Aeroportuale, così integrato in modo da rafforzarne la valenza e la funzione progettuale, strettamente interconnessa con quella pianificatoria e programmatica di investimento.

Le informazioni di seguito riportate vanno, pertanto, analizzate in stretta correlazione rispetto ai più ampi ed estesi aspetti tecnico-economici trattati all'interno dei documenti afferenti alla Sezione Generale del Masterplan, con i quali esse si relazionano secondo un processo capillare di progressivo approfondimento e dettaglio, ritenuto utile per una più completa, consapevole e piena visione dell'insieme delle previsioni di trasformazione dello scalo aeroportuale e delle aree circostanti, e per una più esauriente analisi e comprensione della Project Review del Piano di Sviluppo Aeroportuale.

La citata Project Review costituisce la nuova formulazione tecnica delle previsioni progettuali e di investimento che ENAC prevede di attuare, nel medio-lungo periodo (orizzonte 2035, coerente con quello del Piano Nazionale degli Aeroporti in fase di aggiornamento), relativamente all'infrastruttura aeroportuale di Firenze, redatta dal Gestore aeroportuale di intesa con l'Ente regolatore in attuazione degli obblighi di miglioramento, ottimizzazione e sviluppo dell'aeroporto insiti nel contratto di concessione che lega lo stesso Gestore alle Istituzioni dello Stato (Ministero delle Infrastrutture e ENAC) per la gestione totale dell'infrastruttura aeroportuale (bene dello Stato). Ne consegue che l'insieme documentale di cui la presente relazione costituisce parte integrante deve essere visto e analizzato nella propria autonomia e indipendenza sostanziale, per quanto inevitabilmente consequenziale rispetto al precedente Masterplan 2014-2029 col quale risultano ancora sussistenti più elementi di dialogo che, tuttavia, ci si pone l'obiettivo di non assurgere a valenza prodromica e a funzionalità necessaria per una completa illustrazione, definizione e comprensione del nuovo Piano di Sviluppo Aeroportuale 2035.

Toscana Aeroporti Engineering S.r.l.
Via del Termine, 11 – 50127 Firenze – tel.: 055.3061300 – fax: 055.3061355 – www.toscana-aeroporti.com
R.E.A. FI 634743 - Capitale Sociale Euro 80.000,00 i.v. P.IVA e Codice Fiscale: 06521990488

Si auspica, infine, di aver esaurientemente e correttamente tradotto e trasferito, all'interno della documentazione di cui al nuovo Masterplan 2035, quel prezioso bagaglio di esperienza e quell'insieme di utili risultanze derivanti dal dialogo costruttivo e dialettico che, nell'ultimo decennio, ha visto in più momenti la partecipazione di ENAC, del Gestore aeroportuale, degli Enti/Amministrazioni interessati, delle Istituzioni nazionali e regionali, dei vari stakeholders e della cittadinanza attiva intorno ai temi relativi al trasporto aereo, alla multimodalità della mobilità, al ruolo della rete aeroportuale territoriale toscana e al futuro dello scalo aeroportuale di Firenze, che ENAC vede sempre più strategico, integrato e funzionale alla rete nazionale ed europea dei trasporti.

Toscana Aeroporti Engineering S.r.l.
Via del Termine, 11 – 50127 Firenze – tel.: 055.3061300 – fax: 055.3061355 – www.toscana-aeroporti.com
R.E.A. FI 634743 - Capitale Sociale Euro 80.000,00 i.v. P.IVA e Codice Fiscale: 06521990488

Florence International Airport

(Florence, Italy)

Wind Engineering Services (CFD simulation):

Wind comfort at pedestrian level (drop-off/pick-up area breezeway, breezeway between baggage terminal building and parking area)

Client: Toscana Aeroporti S.p.A.

Project Engineer: Dr.-Ing. A. Richter

Birkenfeld, 14.11.2023

Prof. Dipl.-Ing. J. Wacker
Wacker Ingenieure

Wacker Ingenieure GmbH
Gewerbestr. 2 | 75217 Birkenfeld
Geschäftsführer: Prof. Dipl.-Ing. Jürgen Wacker, Dipl.-Ing. Tobias Wacker
Amtsgericht Mannheim HRB 728224 | USt-Id-Nr: DE 312877167

Bankverbindung: Sparkasse Pforzheim Calw
IBAN: DE28 6665 0085 0008 9593 90 | SWIFT/BIC: PZHSDE66XXX
Tel. +49 (0)7082 94443-0 | Fax +49 (0)7082 94443-19
www.wacker-ingenieure.de | info@wacker-ingenieure.de

SUMMARY

In this report, a forecast of the future wind comfort situation for pedestrians in the outdoor areas at the drop-off/pick-up and parking areas at the new terminal of the International Airport in Florence, Italy, is given. On the basis of meteorological climate data and numerical flow simulations (CFD), taking into account the planned development situation, the investigated outdoor areas are classified into comfort classes, which are assigned to certain usage requirements. In addition, potential uncomfortable areas and possible hazard locations are investigated.

The main results of the investigations after applying the comfort criteria can be summarized as follows:

- There are wind flow accelerations within the two passages. In large parts, the pedestrian comfort is suitable for a short drop-off/pick-up or a parking area. If any outdoor waiting areas are planned (e.g. bus stop), improvement measures are recommended.

- Within a small part of the drop-off/pick-up area, the pedestrian comfort is only moderately suitable for entrance zones. Improvement measures are recommended.

TABLE OF CONTENTS

1 Introduction

At the Florence International Airport (see Fig. 1.1) in Florence, Italy, a new airport terminal building is planned. In this context, wind engineering services are requested. The location of the planned project is shown in Fig. 1.2.

Wacker Ingenieure Consulting Wind Engineers, Germany, were commissioned to investigate the following wind engineering aspects by means of numerical flow simulations (CFD):

- Wind comfort at pedestrian level (drop-off/pick-up area breezeway, breezeway between baggage terminal building and parking area)
- Impact of airport building on wind characteristics above runway (existing and new one)

In the present report the **results of the first aspect (pedestrian comfort)** are documented.

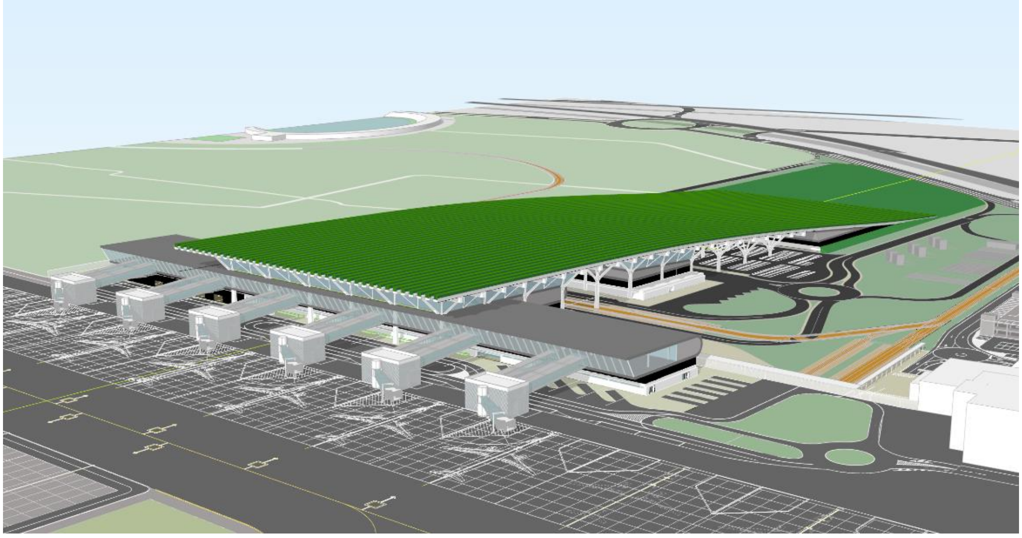


Fig. 1.1: Visualization of Florence International Airport in Florence, Italy (from RVA, 2023)

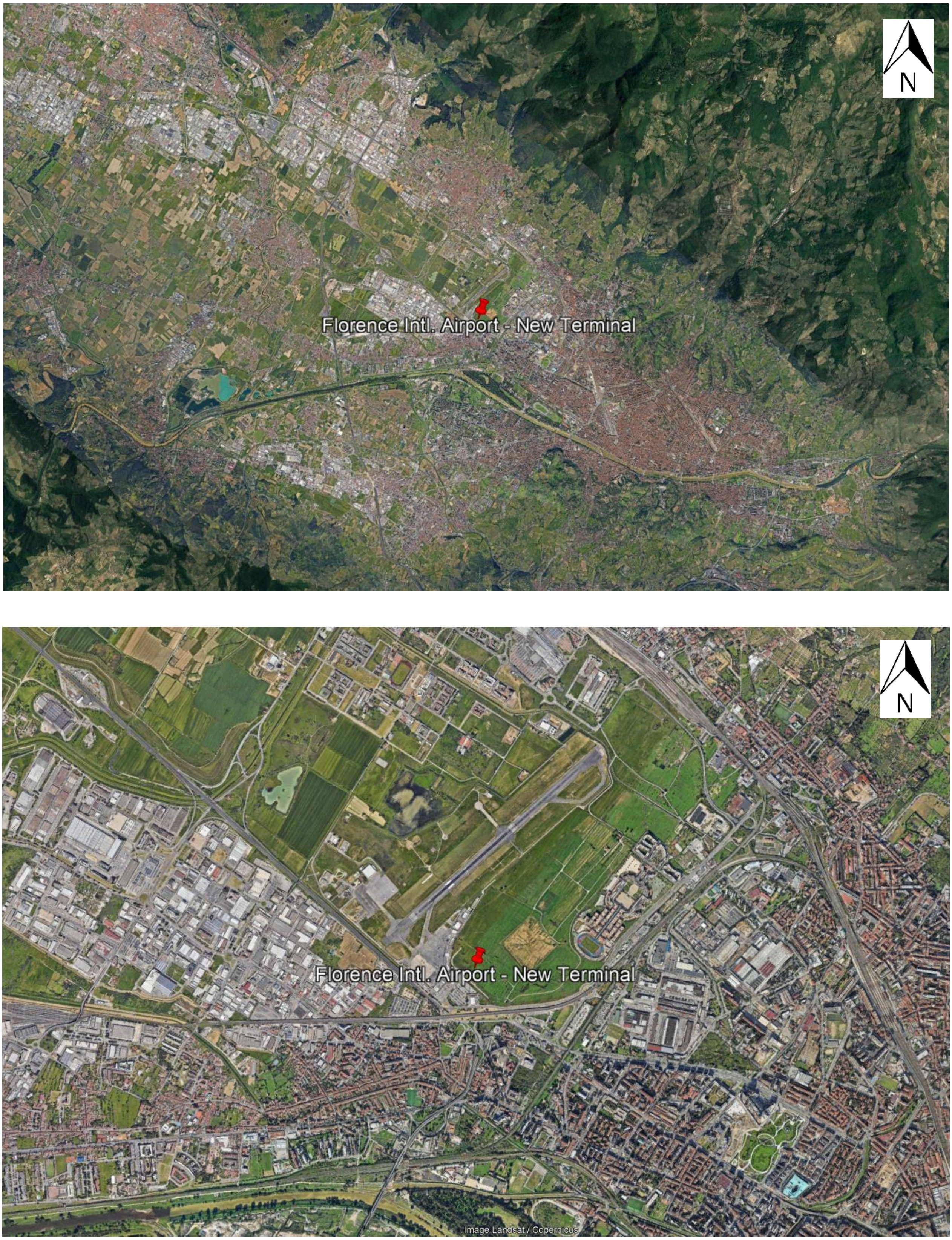


Fig. 1.2: Location of the planned project in Florence, Italy (Google Earth, 2023)

2 Procedure, Methodology

For a quantitative prognosis of the wind comfort or wind discomfort in the exterior areas of buildings, the local wind speeds for different wind directions have to be determined, statistically processed and evaluated.

For the present investigation, the existing terminal buildings as well as the new planned buildings were considered.

2.1 Boundary conditions

The new terminal is planned south-east of the existing runway (s. Fig. 2.1). Underneath the roof of the new terminal, there exist two passages where a parking and drop-off/pick-up area is planned (s. Fig. 2.2).

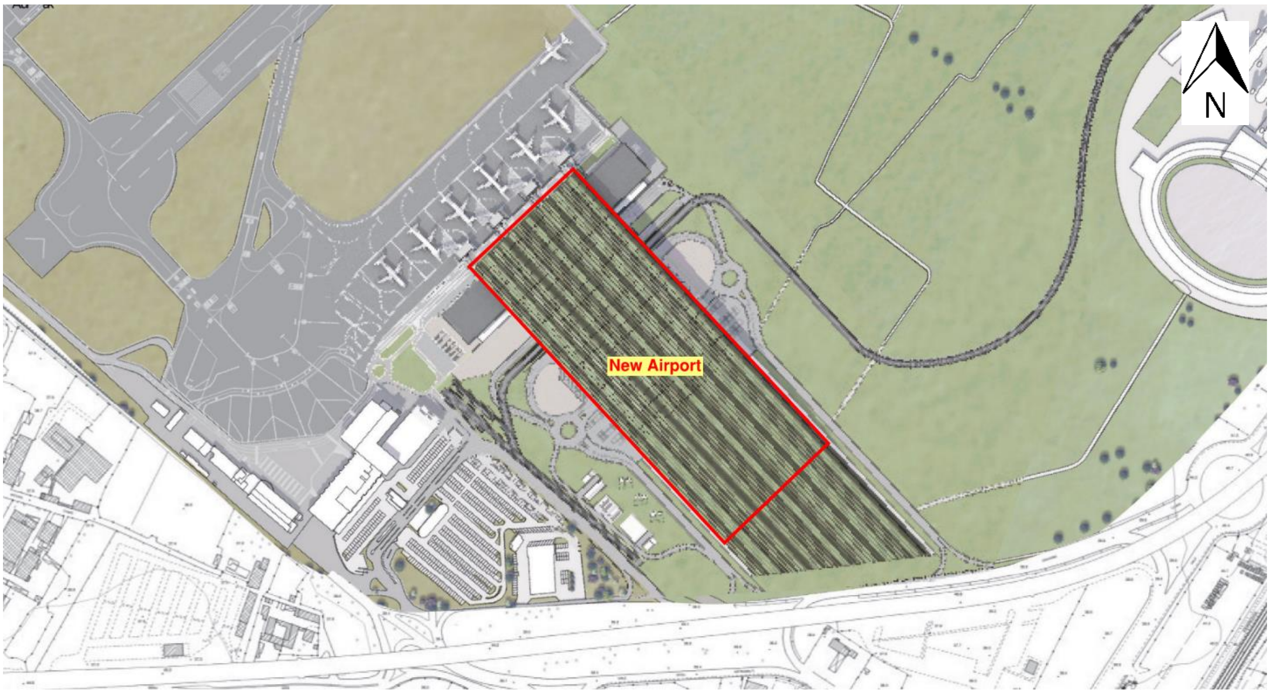


Fig. 2.1: Top view of the planned new Airport Terminal (via RVA, 2023)

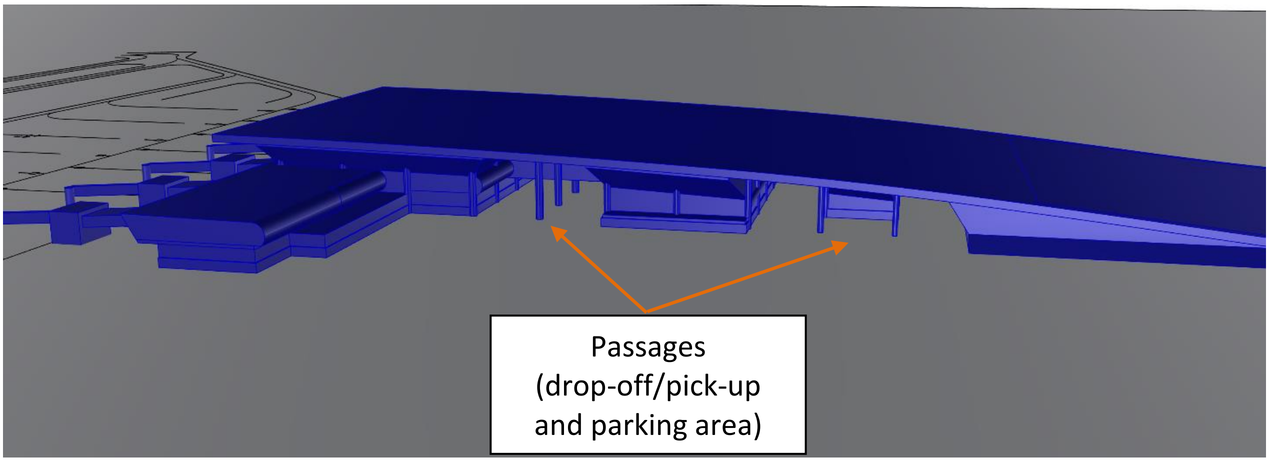


Fig. 2.2: Screenshot of the 3D-model with the two passages

2.2 Numerical flow simulations

Numerical flow simulations were performed to determine the wind speeds using the open source program OpenFOAM (Open Source Field Operation an Manipulation).

For the numerical solution of the conservation equations, a suitable computational grid must be generated. In the simulations performed here, only structured computational grids were used. During the grid generation, the relevant areas were resolved more finely, this means a local refinement near the wall and the floor. A computational grid with approx. 12 million grid cells was generated. This was based on the 3D-model provided by the architects (RVA, 2023). The surrounding development was taken into account in a radius of approx. 400 m. The 3D model used for the simulation is shown in Fig. 2.3.

In total, 8 wind directions were simulated. The evaluation of wind comfort was performed about 1.5 m above ground level. The simulations were performed in accordance with VDI 3787 part 4.

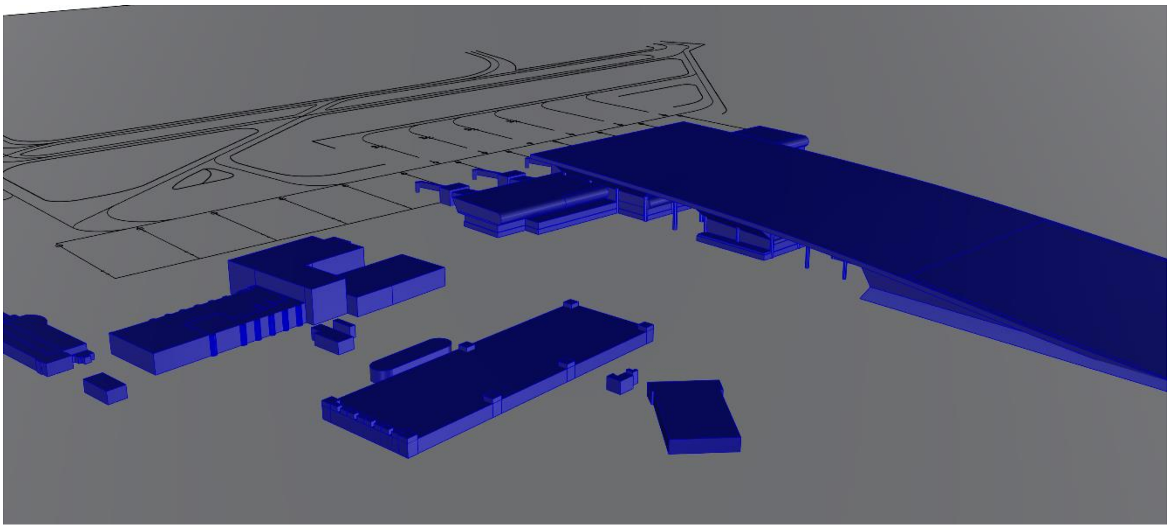
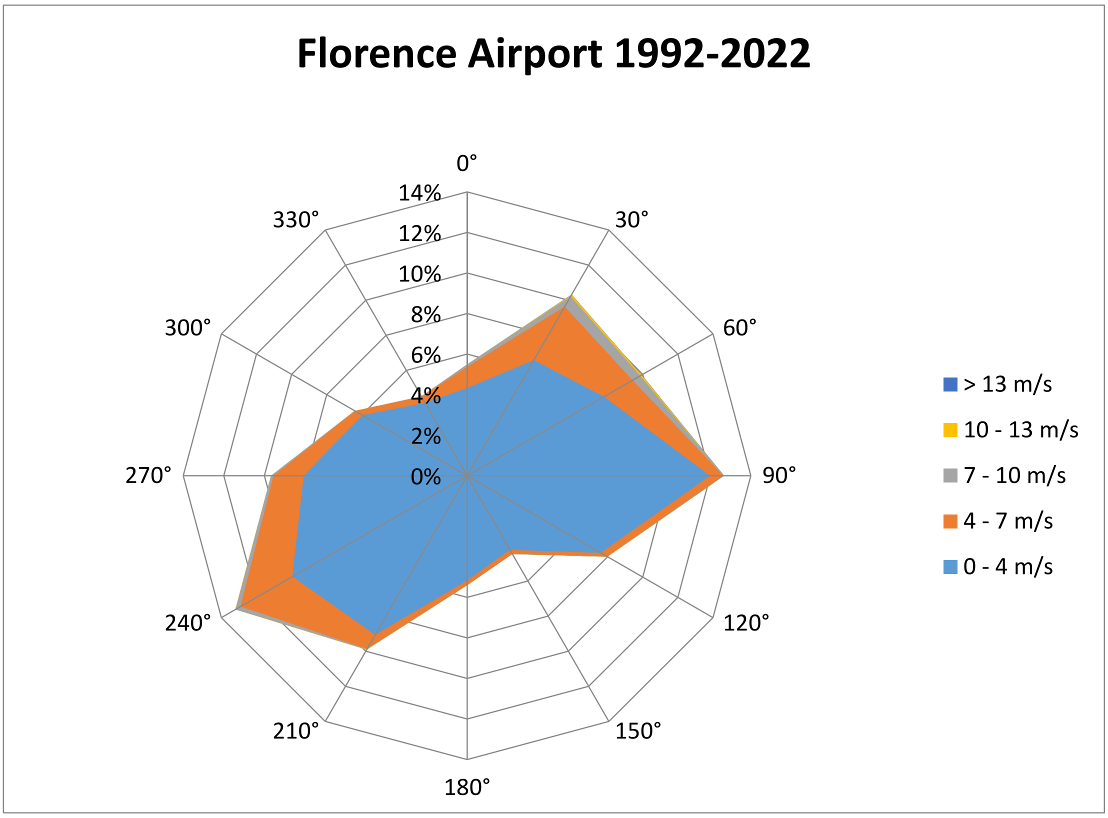


Fig. 2.3: 3D model of the new terminal and existing buildings provided by RVA, 2023

2.3 Wind climate at site

Long-term wind climate data from the nearest weather station at Florence Intl. Airport were used to evaluate wind comfort and wind safety. Specific frequency distributions of wind speeds were generated from the climate data (Fig. 2.4). These are average frequency distributions. It should therefore be noted that deviations from the average may occur in individual years.

For the application of the statistics, the influence of the different ground roughness of measuring station and project site according to EN 1991-1-4 (2010) was taken into account.



wind direction	Exceedance frequency of certain wind speeds											
	0 m/s	1 m/s	2 m/s	3 m/s	4 m/s	5 m/s	6 m/s	7 m/s	8 m/s	9 m/s	10 m/s	13 m/s
0°	5.5%	3.6%	2.7%	1.8%	1.2%	0.4%	0.3%	0.1%	0.0%	0.0%	0.0%	0.0%
30°	10.3%	7.3%	5.8%	4.7%	3.7%	1.9%	1.4%	0.7%	0.3%	0.2%	0.1%	0.0%
60°	10.0%	6.6%	4.4%	2.8%	2.2%	1.2%	0.9%	0.5%	0.3%	0.2%	0.1%	0.0%
90°	12.7%	8.4%	5.3%	1.7%	0.7%	0.2%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%
120°	8.0%	5.3%	3.3%	1.1%	0.4%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%
150°	4.5%	2.8%	1.6%	0.5%	0.3%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
180°	5.4%	3.4%	1.9%	0.6%	0.2%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
210°	9.9%	6.6%	4.4%	1.9%	0.8%	0.2%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%
240°	13.2%	9.4%	7.1%	4.8%	3.2%	1.2%	0.7%	0.3%	0.1%	0.0%	0.0%	0.0%
270°	9.7%	6.6%	4.7%	2.8%	1.6%	0.5%	0.3%	0.1%	0.0%	0.0%	0.0%	0.0%
300°	6.4%	4.0%	2.5%	1.1%	0.4%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%
330°	4.5%	2.7%	1.7%	0.8%	0.4%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%
total:	**100.00%**	**66.79%**	**45.38%**	**24.63%**	**15.08%**	**5.97%**	**4.13%**	**1.91%**	**0.89%**	**0.44%**	**0.21%**	**0.03%**

Fig. 2.4: Sum frequency in [%] for different mean wind speeds and wind directions of the weather station at the Florence International Airport

2.4 Quantitative determination of the pedestrian comfort

The pedestrian comfort is usually quantified in the literature - as also in the VDI guideline 3787 part 4 - via the frequency of certain wind speeds at the study site. Therefore, the assessment must take into account the regional wind climate as well as local acceleration and shadowing effects caused by surrounding buildings and the wind flow around the building itself.

To quantify the pedestrian comfort, Gandemer and Guyot (1976) developed the velocity factor X_i:

$$X_i = \frac{(\overline{U} + \gamma \cdot \sigma)_{wB}}{(\overline{U} + \gamma \cdot \sigma)_{w/oB}}$$

with $\overline{U}$: mean wind speed;
σ: standard deviation of the wind speed fluctuations
γ: weighting factor.

X_i is the quotient of the local wind speed influenced by the development (index "wB") and the undisturbed reference speed without development (index "w/oB") at the same location on pedestrian level (about 1.5 m above ground). Via the standard deviation σ and the weighting factor γ, the gustiness of the wind can be taken into account. In the literature, the values for the weighting factor γ vary between 1 and 4 (e.g. Gandemer, 1982). For the assessment of wind comfort, weighting factors between 0 and 1.5 are usually chosen, for the assessment of wind safety values between 3 and 3.5.

Velocity factors $X_i < 1$ mean that a reduction in wind speeds occurs due to development; velocity factors $X_i > 1$ were determined to increase local wind speeds relative to the wind situation without development. The X_i factors are determined using the results of the numerical flow simulations.

Subsequently, the velocity factors are coupled with the wind climate at the site. The wind climate is determined on the basis of a statistical evaluation of long-term measurement series (e.g. from airports). From this, statements can be made about how often a certain speed is exceeded at the measuring point.

This procedure is also described analogously in VDI Guideline 3787 Part 4 and is thus consistent with the procedure recommended there.

2.5 Pedestrian comfort criteria (according to VDI 3787 Part 4)

With regard to comfort impairment in stronger winds, VDI Guideline 3787 Part 4 (Section 7.2) makes the following statements:

“Various outdoor activities can be impaired by intense wind effects. Depending on the activity, therefore, there exist criteria for assessing whether adverse effects can be expected. These criteria rely on the concept of critical speeds and the associated exceedance probabilities. If hourly means of the wind speed are used as critical speeds, the local wind climate can be divided as shown in Fig. 2.5 into four wind comfort zones A (very high wind comfort) to D (very low wind comfort).

Various human activities are assigned to these four zones (see Tab. 2.1), since the degree of wind nuisance depends on the relevant activity. The activities are classified under “Prolonged sitting or standing” (the most demanding challenge for wind comfort), “Brief sitting or standing”, “Slow strolling, sauntering”, and “Brisk walking” (the least demanding challenge for wind comfort).

The critical wind speeds of zones A – D as hourly averaged wind speeds can be represented as distributions as shown in Equation (1):

$$u_{Grenz}(p) = 0{,}103 \cdot c \cdot (-\ln p)^{1/k} \cdot u_{Grenz}(p = 0{,}01) \qquad (1)$$

where the Weibull parameters c and k are assumed to have the values: $c = 4$; $k = 2{,}5$; p in %.

Tab. 2.1 lists critical speeds $u_{Grenz}(p)$ for the different wind comfort zones A – D.

For an investigation point, there does not necessarily have to be a distribution as shown in Fig. 2.5.

Therefore, it is advisable to determine either the critical speed for at least four exceedance probabilities distributed across the total range, or the exceedance probabilities for at least four speeds distributed across the total range.

When conducting the assessment, the least favourable obtained wind comfort zone shall be selected.”

In the present study, the exceedance frequencies were calculated for 5 different limiting speeds covering the relevant low and high wind speed ranges. The mean velocities in the study area determined on the basis of the numerical simulation were taken into account. The associated limiting probabilities for the classification into the wind comfort zones were determined according to Fig. 2.5.

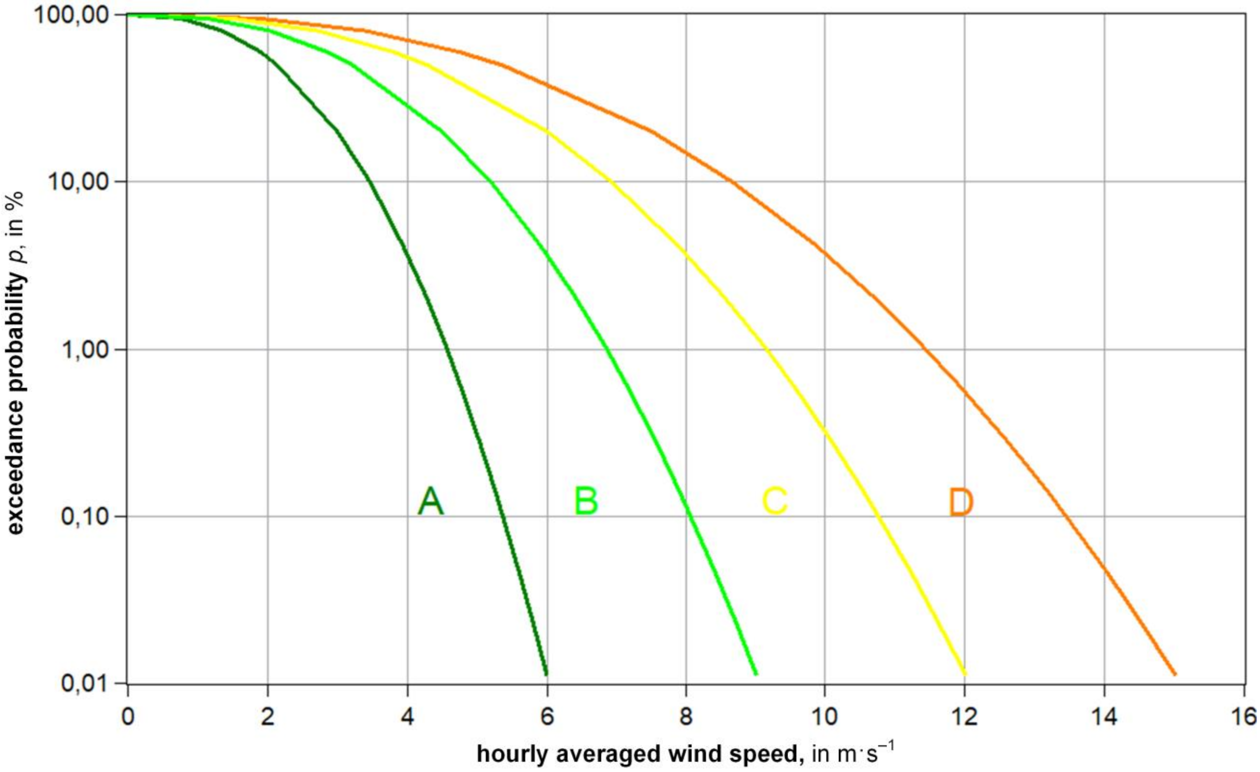


Fig. 2.5: Classification of wind comfort zones under strong winds, wind speed at the moving and resting height, based on investigations by various authors (VDI 3787 Part 4-2020)

Wind comfort zone	Activity class			
	Prolonged sitting or standing (e.g. parks, marketplaces, street cafés, beer gardens, playgrounds, rest areas)	**Brief sitting or standing** (e.g. train or bus platforms, other outdoor waiting areas)	**Slow strolling, sauntering** (e.g. along shopfronts, entrance zones)	**Brisk walking** (e.g. shopping arcades, car parks)
A	suitable	suitable	suitable	suitable
B	moderately suitable	suitable	suitable	suitable
C	unsuitable	moderately suitable	suitable	suitable
D	unsuitable	unsuitable	moderately suitable	just suitable

Tab. 2.1: Criteria for assessing the local wind climate for wind nuisance (VDI 3787 Part 4 – 2020)

Critical speed u_{Grenz} **(**p **= 0,01%)**	**Zone A:** **6 m·s⁻¹**	**Zone B:** **9 m·s⁻¹**	**Zone C:** **12 m·s⁻¹**	**Zone D:** **15 m·s⁻¹**
Exceedance probability p in %	**Critical speed** in m·s⁻¹			
100	0,00	0,00	0,00	0,00
95	0,75	1,13	1,50	1,88
80	1,35	2,03	2,71	3,39
60	1,89	2,83	3,77	4,72
50	2,13	3,20	4,26	5,33
20	2,99	4,48	5,97	7,47
10	3,45	5,17	6,89	8,62
5	3,83	5,74	7,66	9,57
2	4,26	6,39	8,52	10,65
1	4,55	6,82	9,09	11,37
0,5	4,81	7,21	9,62	12,02
0,2	5,13	7,69	10,25	12,82
0,1	5,35	8,02	10,70	13,37
0,05	5,56	8,33	11,11	13,89
0,02	5,82	8,72	11,63	14,54
0,01	6,00	9,00	12,00	15,00

Tab. 2.2: Critical wind speeds $u_{Grenz}(p)$ for the different wind comfort zones A – D (VDI 3787

3 Results of the pedestrian comfort study

3.1 Pedestrian comfort at site as reference

The wind data from the available weather station show that the most frequent and largest wind speeds are to be expected from northeasterly and southwesterly wind directions. In order to be able to assess the following results, the wind comfort at pedestrian height h = 1.5 m in a completely undeveloped environment (without project building and local surrounding development) was first evaluated. For this purpose, the wind statistics of the weather station are adapted to the project site (according to EN 1991-1-4, 2010) and a constant increase factor $X_i = 1$ from all wind directions is assumed.

Based on the wind climate alone, wind comfort class B is achieved at the site in an open area without the direct influence of buildings (but taking into account the wider urban environment) according to the criteria in chapter 2.4. The location would therefore be suitable for short-term stays (sitting or standing), such as in waiting areas.

3.2 Pedestrian comfort in the ground-level outdoor area

For the investigated outdoor area, the speed-up factors X_i can be determined depending on the wind direction. These indicate by how much the velocity changes as a result of the development compared to an undisturbed area. For example, increase factors of 1.2 mean that the velocities are 20% higher than in undeveloped terrain, factors of 0.8 mean a velocity reduction of 20%.

In total 8 wind directions were investigated. Exemplarily, the X_i-factors for the two main wind directions (north-east and south-west) are shown in Fig. 3.1. For those two wind directions, flow accelerations are observed within the narrow passages underneath the canopy of the new terminal (drop-off/pick-up area, parking area).

From the coupling of the wind direction-dependent speed-up factors with the wind statistics, the frequencies are determined with which certain limit speeds are exceeded.

The determined wind comfort classes for the situation with the new terminal are shown in Fig. 3.2. The comfort classes were evaluated 1.5 m above ground level.

The terminal building results in a reduction of wind speed and an improvement of the pedestrian comfort classes outside the narrow passages and at the edge regions of the passages (comfort class A). Inside the passages comfort class C is reached in most parts. This is suitable for slow strolling, e.g. at entrance zones or for getting in and out of the car. It is only moderately suitable for a brief sitting or standing, e.g. at a bus stop, if any are planned there.

In the north-western part (drop-off/pick-up area) within a small area comfort class D is reached or even exceeded. This is where the free height of the passage is reduced by a planned connecting bridge between the two parts of the building (s. Fig. 3.3). Comfort class D is only moderately suitable for entrance areas. Therefore, improvement measures are recommended.

One option is to enlarge the cross section underneath the connecting bridge in order to reduce the acceleration effects within the bottleneck. Since high X_i-factors arise for winds coming from the sector north to east, another possibility would be to prevent the wind from blowing unhindered into the narrow passage from this side. This could be achieved, for example, by planting trees and shrubs north-eastern of the passage.

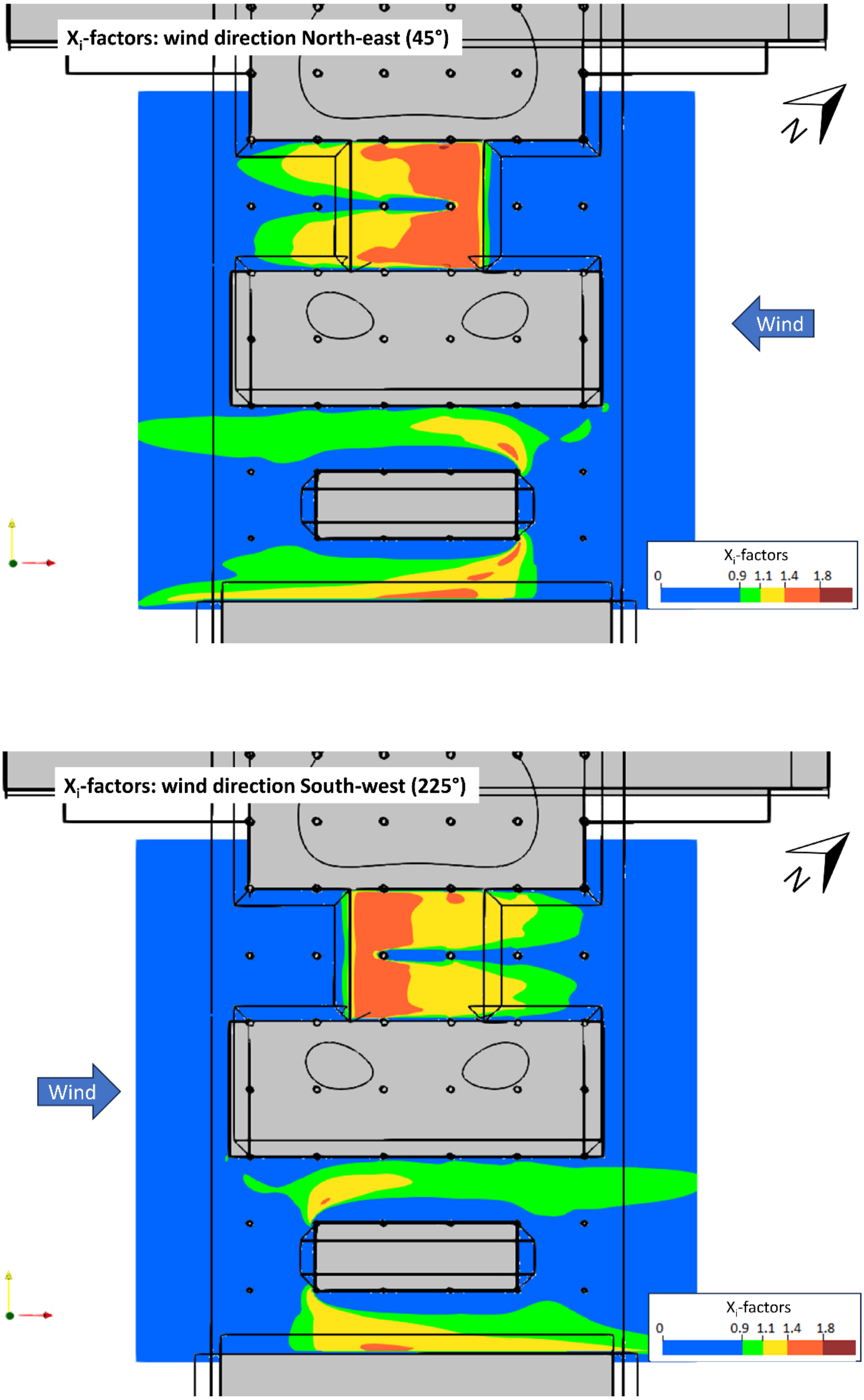
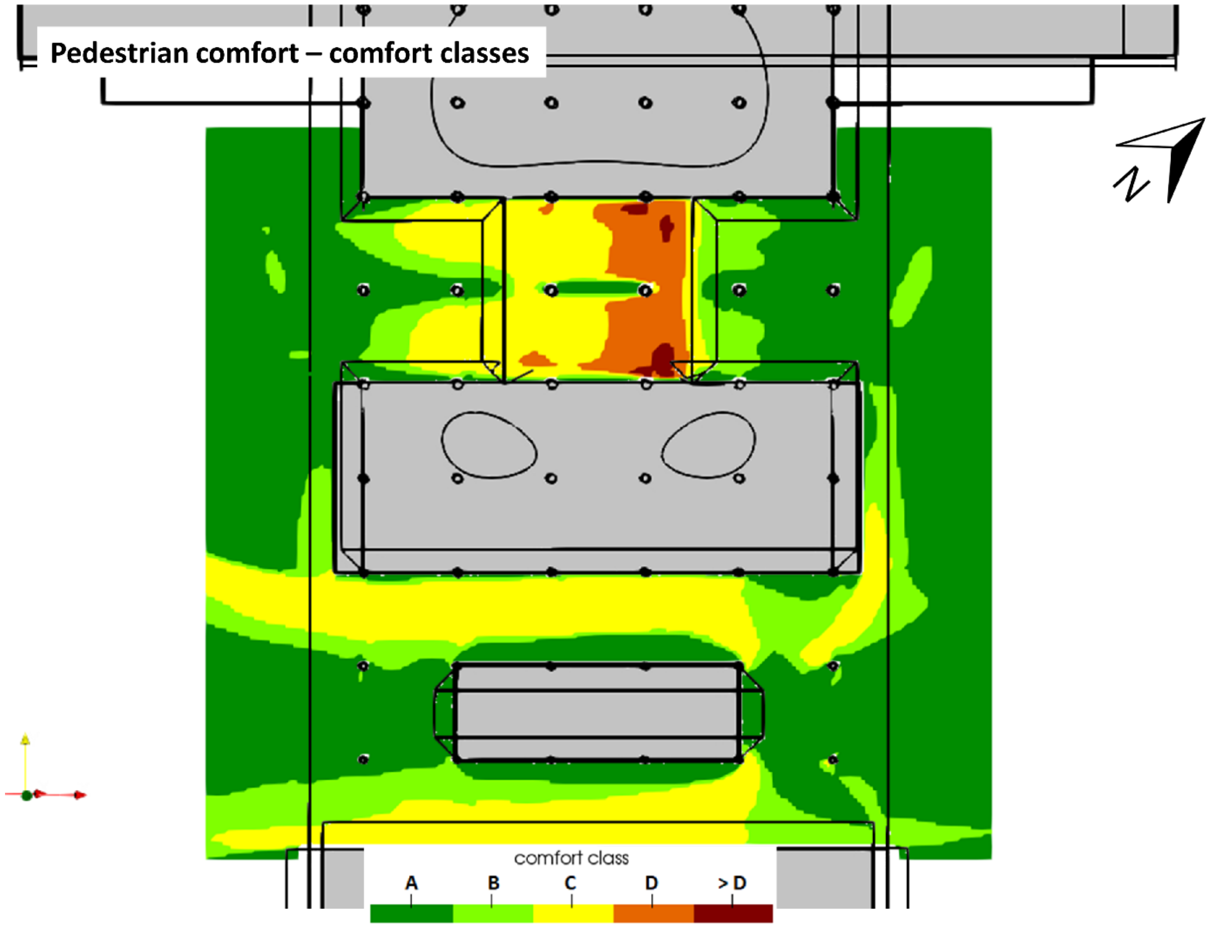


Fig. 3.1: X_i-factors for the wind directions north-east and south-west in a height of 1.5 m at the drop-off/pick-up area and the parking area of the planned terminal.



Wind comfort zone	Activity class			
	Prolonged sitting or standing (e.g. parks, marketplaces, street cafés, beer gardens, playgrounds, rest areas)	**Brief sitting or standing** (e.g. train or bus platforms, other outdoor waiting areas)	**Slow strolling, sauntering** (e.g. along shopfronts, entrance zones)	**Brisk Walking** (e.g. shopping arcades, car parks)
A	suitable	suitable	suitable	suitable
B	moderately suitable	suitable	suitable	suitable
C	unsuitable	moderately suitable	suitable	suitable
D	unsuitable	unsuitable	moderately suitable	just suitable
> D	comfort class D not satisfied			

Fig. 3.2: Forecast of comfort classes or uses in the drop-off/pick-up area and parking area near ground level based on climate data at the site and numerical flow simulations.

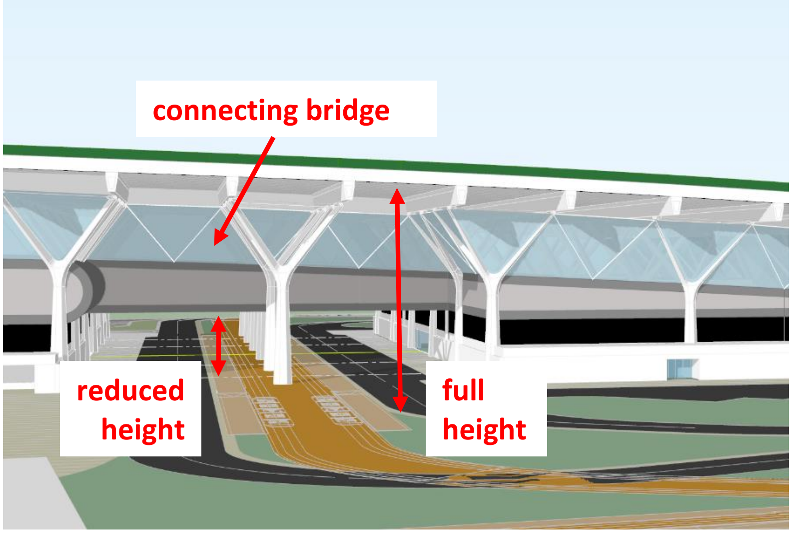


Fig. 3.3: Visualization of the drop-off/pick-up area with connecting bridge

4 Notes

When applying the results, it should be noted that the classification into the various comfort classes was made on the basis of statistical evaluations of long-term wind climate time series, i.e., the statements made above regarding frequency are representative of an average year. In individual years, there may be deviations from the average. Likewise, individual events may deviate from this.

In addition to the wind speed, the comfort of people depends on many other parameters, including the outside temperature. For example, prolonged use of seating areas is not comfortable when air temperatures are low, even when there is no wind.

If there are outward-opening swing doors planned in areas where comfort level D is reached near the façade or the comfort criteria are no longer met, it should be examined whether these doors should be equipped with drives (wind effect on the door leaves).

5 Documents

EN 1991-1-4, 2010: Eurocode 1: Actions on structures – Part 1-4: General actions – Wind actions.

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.

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

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.

RVA 2023: „Planning documents, information, communication on the new Terminal at Florence Airport, Italy", Rafael Vinoly Architects, New York, United States.

VDI 3787 Part 4, 2020: "Environmental meteorology – Methods for describing and evaluating strong and weak winds in built-up areas", VDI/DIN-Kommission Reinhaltung der Luft (KRdL) – Normenausschuss - Fachbereich Umweltmeteorologie (Commission on air pollution prevention of VDI and DIN).