CIVIL AND ENVIRONMENTAL ENGINEERING REPORTS

E-ISSN 2450-8594

CEER 2025; 35 (4): 0025-0037
DOI: 10.59440/ceer/210049
Original Research Article

INFLUENCE OF VENTILATION PATTERNS IN DIFFERENT URBAN MORPHOLOGIES ON WIND AND THERMAL COMFORT

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A b s t r a c t

Wind comfort plays an important role in selected urban spaces, influencing safety, well-being and the quality of use of outdoor spaces, therefore its consideration is crucial in assessing the quality of the built environment. The aim of this article is to comparatively analyse the impact o on the plot atf three common building typologies – detached (DD), block perimeter (BD) and organic (OD) on wind and thermal comfort on a plot at ul. Racula 5 in Zielona Góra, which was used to build models in Autodesk Forma. Additional models were also prepared with an additional structure introduced in the form of small architecture and greenery to examine their impact on the obtained simulation results. A total of 30 variants were built (10 for each type of building) and subjected to simulations. Wind comfort was analysed taking into account the westerly wind and a speed of up to 10 m/s, as well as thermal comfort according to the (UTCI) scale. WCI that allowed for the ordering and averaging of the obtained results, respectively: Wind Comfort Index (WCI) and Thermal Comfort Index (TCI). In the case of WCI, the best result was achieved by block perimeter development (BD) and the worst by detached development (DD). In the case of TCI, the best result was achieved by organic development (OD), while detached development (DD) again came out the worst. Adding elements in the form of greenery and low-rise development in the examples with the worst results improved them. The obtained results also allowed for the creation of design guidelines for these typologies.

Keywords: spatial shaping, ventilation, city, wind comfort, thermal comfort

1. INTRODUCTION

Shaping a healthy and comfortable urban environment is one of the key challenges of contemporary urban planning. In the context of progressive urbanization, urban density and climate change, ensuring appropriate air quality and thermal comfort of residents is becoming particularly important. One of the important factors influencing the microclimate of cities is natural ventilation, i.e. the process of air exchange driven by wind forces and temperature differences. Appropriate ventilation of urbanized areas

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can contribute to the dispersion of pollutants, which has a direct impact on air quality (Barclay, Kang & Sharples, 2012), reduction of the urban heat island effect (UHI) and improvement of the quality of life of residents, which has been confirmed by the example of the benefits of planning ventilation corridors in Beijing (Zheng, Ren, G. Gao & Yang, 2022).

Previous research on urban ventilation has often focused on the role of green infrastructure in ventilation and optimization. The impact of green roofs and tree plantings on microclimate and air quality has been analyzed (Ciacci et al., 2023), the impact of green walls on ventilation and heat removal from street canyons has been studied (Li et al., 2022), and the impact of street trees on the spread of pollutants and canyon ventilation has been assessed (Fellini et al., 2022). These solutions are considered key in planning sustainable cities. It is also worth mentioning that field measurements in Polish single-family housing already show that the efficiency of natural ventilation can drop dramatically when external conditions deviate from the design assumptions (Antczak-Jarząbska and Krzaczek 2016).

In parallel, other studies have addressed the issue of the influence of urban geometry on airflow. For example, they have analyzed the influence of the distance between buildings and their height on indoor ventilation in idealized layouts (Chen, Rong, & Zhang, 2021) or assessed ventilation paths depending on the street orientation and its aspect ratio in specific urban locations (Yin, Qingming, & Tayyab, 2021). They have also investigated the influence of architectural elements, such as protruding eaves, on turbulence structures in street canyons (Alwi et al., 2023) and the general influence of building density on the potential of natural ventilation (Xie, Luo, Grimmond, & Sun, 2023).

However, despite these valuable studies on individual geometric factors and greenery-based solutions, the literature still lacks comparative analyses that would assess the integrated impact of commonly used urban typologies (such as detached, block or organic development) on the simultaneous shaping of wind and thermal comfort in urban spaces. There is also often a lack of translation of simulation or experimental research results into specific, practical guidelines for planners and architects, going beyond general recommendations on the importance of ventilation or greenery. Understanding how overall spatial arrangements, and not just individual parameters, modify wind flow and affect temperature distribution is essential for consciously shaping urban structures that are resistant to the negative effects of climate change and provide a high quality of life.

In response to this need noticed during the research, the aim of this article is to conduct a comparative analysis of the impact of three selected building layouts – detached, block and organic – on wind and thermal comfort (assessed by the UTCI index), and then to assess the introduction of model small architecture and greenery layouts into the urban structure data using the example of an area located in Zielona Góra. Computer simulation methods in Autodesk Forma software were used for the analysis.

2. METHOD AND DATA

The research tool used to conduct the research is the Autodesk Forma 2024 computer program. This program was used to configure a geolocated project with real context data and model complex 3D projects and perform analyses such as: Wind analysis and Microclimate analysis.

Two analyses were selected for the research: Wind Analysis and Microclimate Analysis because the comparison of the results from these two analyses gave sufficient and reliable results for the examples studied.

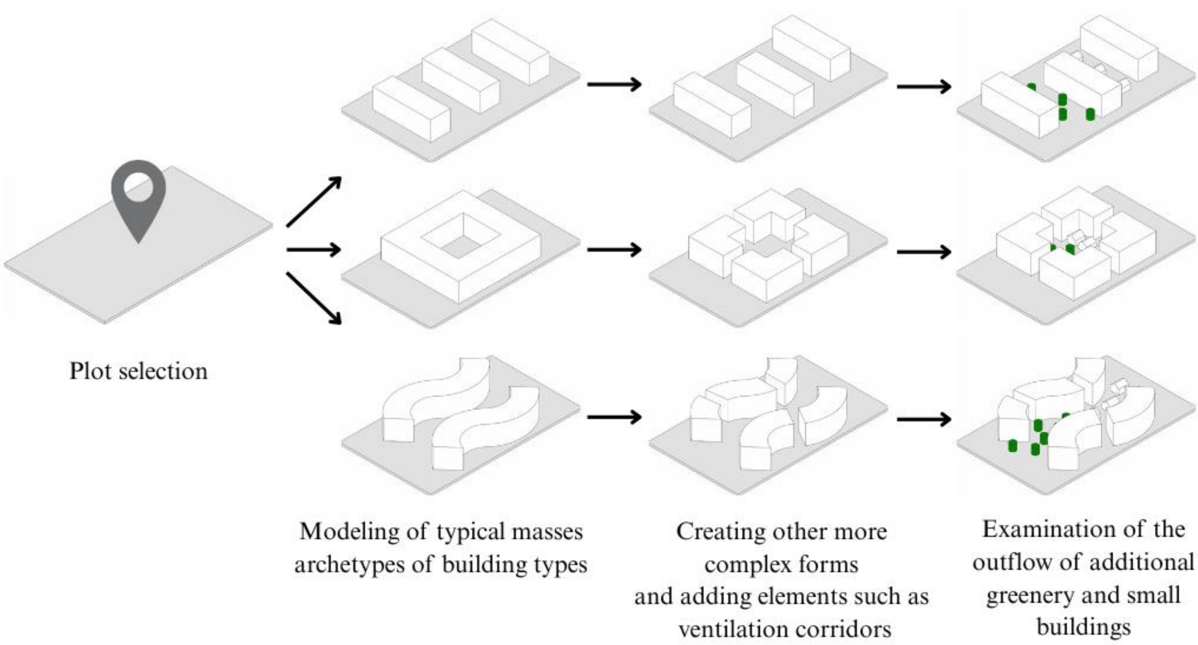

Fig. 1. Diagram of executive models in Autodesk Forma program. Source: K. Bajor, 2025

The study consisted of creating the most popular and slightly less standard forms of urban development such as: detached development, block perimeter development or organic development in the form of 3D models, on a plot at Racula Street 5 in Zielona Góra in Autodesk Forma. Then, on selected models, Wind Analysis and Microclimate Analysis were created.

During the Wind Analysis, an air flow simulation was created up to a maximum speed of 10m/s. It was assumed that wherever the wind exceeds 5m/s, these are places that are uncomfortable for humans. Data for the analysis were taken from the Global Wind Atlas 3.0 database, measurements were also taken at a height of 1.75m above ground level, a westerly wind, which is the most common in a given region, and a coefficient of 0.25 for roughness.

Then, the microclimate analysis was simulated, which presents an index assessing human thermal comfort in outdoor conditions, based on the equivalent air temperature (Universal Thermal Climate Index, UTCI), Figure 3, taking into account key meteorological factors such as: air temperature, relative humidity, thermal radiation, wind speed.

UTCI allows for determining the impact of weather conditions on subjective heat sensations and health risks, making it a particularly useful tool in meteorology, urban planning and climate change assessment. UTCI values are expressed in °C and classified on a scale from extremely cold to extremely hot, indicating comfort or potential thermal hazards.

The UTCI index allowed us to assess thermal comfort and analyze the impact of climate on health and quality of life, which is important for developing resilience to climate change, including the effects of extreme weather events such as heat waves or frost. The UTCI scale includes categories from comfortable conditions (9–26°C) to extreme thermal hazards (< -40°C or > 38°C), which allows for a holistic approach to designing spaces that are friendly to residents.

The analysis assumed that insufficient ventilation occurs at temperatures above 25°C and wind speeds below 3 m/s. The temperatures were measured in the warmest month, August, and the wind direction was also from the west.

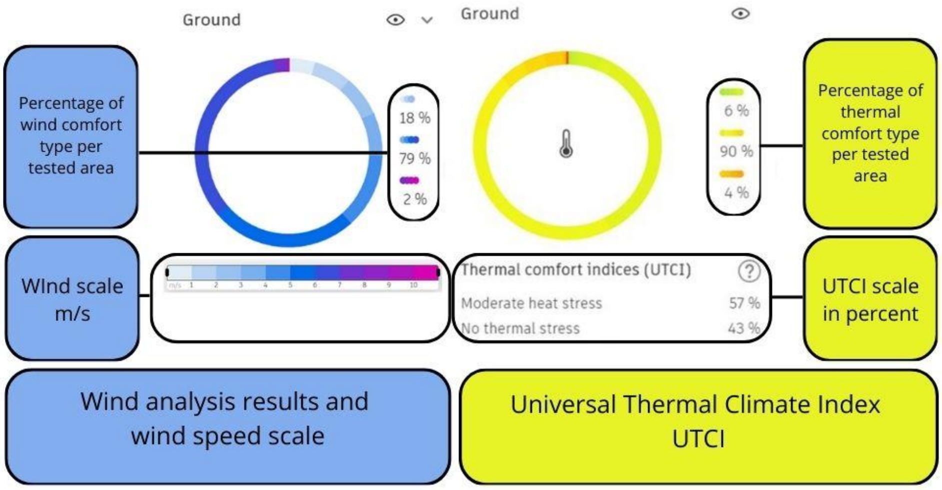

Fig. 2. Wind and Universal Thermal Climate Index, UTCI analysis results. Source: K. Bajor, 2025

3. STEP 1 MODEL BUILDING

Analyzed how the inherent ventilation patterns of three building morphologies – detached, block perimeter and organic, 10 examples from each group, on wind comfort and thermal comfort, measured using the Universal Thermal Climate Index (UTCI) was analyzed. The selection of three extreme building morphologies on the same plot allows for achieving accurate results in a controlled manner. This development was selected due to the universality of solutions for Poland and other places in the world. (Deng et al. 2023) He compared this type of development as typical archetypes of residential development, while (Matallah et al. 2021) analyzed three historical tissue shapes, compact, semi-compact and organic, respectively.

To isolate the effect of ventilation characteristics on the microclimate, the research began with modeling three basic development scenarios reflecting popular urban typologies. The reference point was a regular and, in the case of organic development, an irregular, layout of buildings with a height of 4 storeys because this is the average height of buildings in Zielona Góra and the height of multi-family buildings surrounding the studied plot. The distances from the plot boundary and between buildings were changed depending on the studied layout, but they were in accordance with the technical conditions.

Scenario 1: Detached Development:

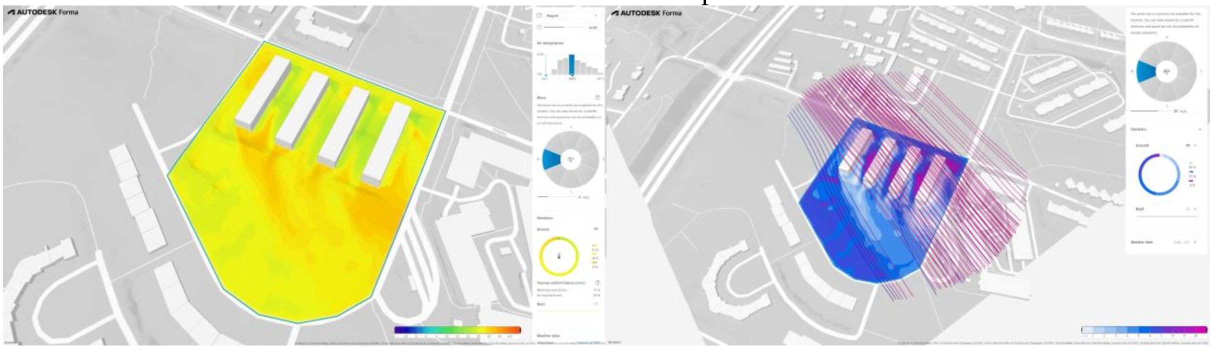

Fig. 3. An example model of detached multi-family housing development. Source: K. Bajor, 2025

Scenario 2: Block perimeter development:

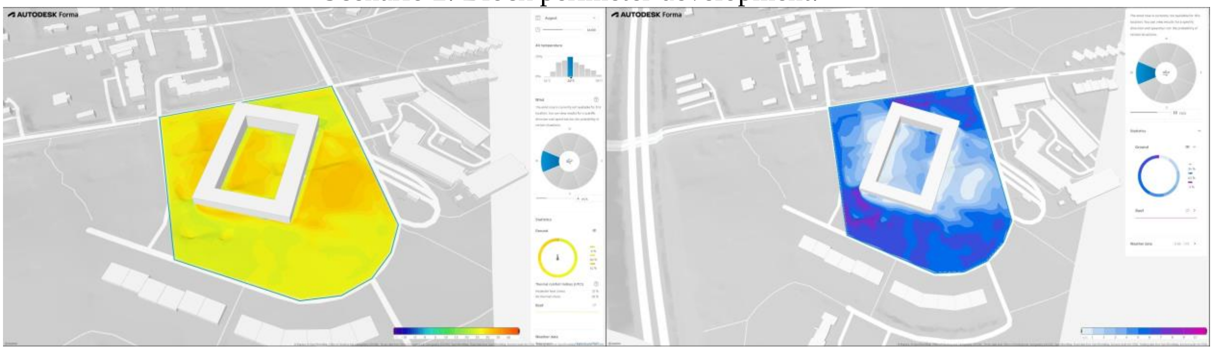

Fig. 4. An example model of block perimeter development multi-family housing development. Source: K. Bajor 2025

Scenario 3: Organic Development:

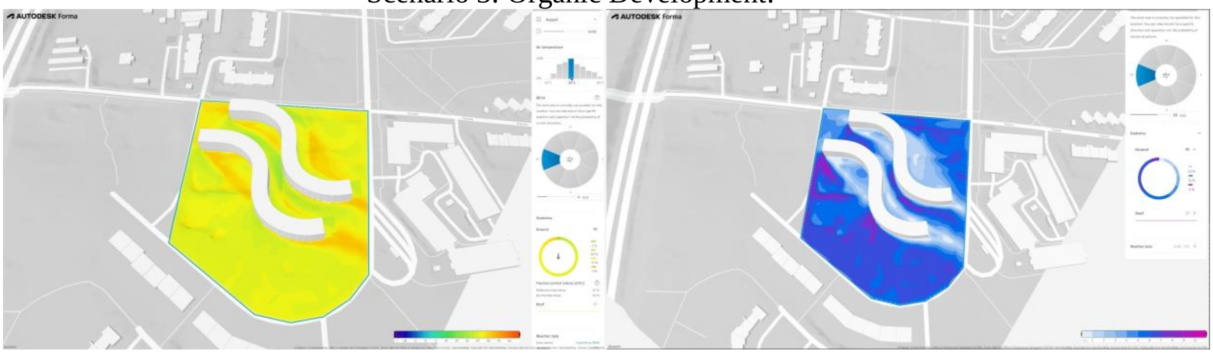

Fig. 5. An example model of organic multi-family housing development. Source: K. Bajor, 2025

3.1. Step 2 wind comfort index definition

By analysing the created model examples for selected types of development to obtain the final average wind comfort results, the Wind Comfort Index (WCI) was defined. It is based solely on the percentage shares of the terrain surface, in this case the model plot, in the individual speed categories, the results of which we obtained from the simulation.

We define the Wind Comfort Index (WCI):

$$\mathrm{WCI} = (PL, PI, PH) \tag{3.1}$$

where:

- PL: Percentage of land area with low wind speed (0≤v<3 m/s).
- PI: Percentage of land area with moderate wind speed (3≤v≤5 m/s).
- PH: Percentage of land area with high wind speed (v>5 m/s).

$$PL + PI + PH = 100\% \tag{3.2}$$

The average Wind Comfort Index for a building type, e.g. DD, denoted as $\overline{WCI_{\mathrm{DD}}}$, is a vector (set) of average percentage values for each category:

$$\overline{\mathrm{WCI_{DD}}} = (\overline{PL_{\mathrm{DD}}}, \overline{PI_{\mathrm{DD}}}, \overline{PH_{\mathrm{DD}}}) \tag{3.3}$$

Where the building typology designation is used:

- DD - Detached Development
- BD - Block perimeter Development
- OD - Organic Development

Now, the average percentage shares of the model plot area for each type of development are calculated as follows:

1. Average percentage of area with Low wind speed (PL_{ZW})**:** We sum up the percentage of the area PL from all variants (A…Z) belonging to the selected development type (DD) and divide it by the number of these variants (N_{IKW}).

$$\overline{PL_{\mathrm{DD}}} = \frac{1}{N_{\mathrm{WCI}}} \sum_{i=1}^{N_{\mathrm{WCI}}} PL, si \tag{3.4}$$

2. Average percentage of area with Moderate wind speed (PI_{ZW}): We sum up the PI percentages of all variants (A…Z) belonging to the selected development type (DD) and divide by the number of these variants (N_{WCI}).

$$\overline{PI_{\mathrm{DD}}} = \frac{1}{N_{\mathrm{WCI}}} \sum_{i=1}^{N_{\mathrm{WCI}}} PI, si \tag{3.5}$$

Average percentage of area with High wind speed (PH_{DD}): We sum up the percentage of PL from all variants (A…Z) belonging to the selected development type DD and divide by the number of these variants (N_{WCI}).

$$\overline{PH_{\mathrm{DD}}} = \frac{1}{N_{\mathrm{WCI}}} \sum_{i=1}^{N_{\mathrm{WCI}}} PH, si \tag{3.6}$$

Where:

N_{WCI}=3

$si = development\ variant\ in\ a\ specific\ development\ group$

Table 1. Average Wind Comfort Index for detached development. (DD) . Source: K. Bajor, 2025

$\mathbf{DD}, \boldsymbol{si}$	$\overline{\boldsymbol{PL}_{\mathbf{DD}}}$	$\overline{\boldsymbol{PI}_{\mathbf{DD}}}$	$\overline{\boldsymbol{PH}_{\mathbf{DD}}}$
$\mathbf{DD} - \boldsymbol{A}$	24	58	18
$\mathbf{DD} - \boldsymbol{B}$	18	76	6
$\mathbf{DD} - \boldsymbol{C}$	25	70	5
$\mathbf{DD} - \boldsymbol{D}$	23	72	5
$\mathbf{DD} - \boldsymbol{E}$	27	68	6
$\mathbf{DD} - \boldsymbol{F}$	23	73	4
$\mathbf{DD} - \boldsymbol{G}$	16	79	5
$\mathbf{DD} - \boldsymbol{H}$	11	84	5
$\mathbf{DD} - \boldsymbol{I}$	8	75	16
$\mathbf{DD} - \boldsymbol{J}$	14	74	12
$\overline{\boldsymbol{WCI}_{\boldsymbol{ZW}}} \approx$	19	73	8

Table 2. Average Wind Comfort Index for a block perimeter of the building. (BD) . Source: K. Bajor, 2025

$\mathbf{BD}, \boldsymbol{si}$	$\overline{\boldsymbol{PL}_{\boldsymbol{BD}}}$	$\overline{\boldsymbol{PI}_{\boldsymbol{BD}}}$	$\overline{\boldsymbol{PH}_{\boldsymbol{BD}}}$
$\mathbf{BD} - \boldsymbol{A}$	17	79	4
$\mathbf{BD} - \boldsymbol{B}$	34	63	3
$\mathbf{BD} - \boldsymbol{C}$	23	70	7
$\mathbf{BD} - \boldsymbol{D}$	20	76	4
$\mathbf{BD} - \boldsymbol{E}$	33	64	3
$\mathbf{BD} - \boldsymbol{F}$	16	81	2
$\mathbf{BD} - \boldsymbol{G}$	37	61	3
$\mathbf{BD} - \boldsymbol{H}$	21	76	2
$\mathbf{BD} - \boldsymbol{I}$	20	78	2
$\mathbf{BD} - \boldsymbol{J}$	18	79	3
$\overline{\boldsymbol{WCI}_{\boldsymbol{BD}}} \approx$	24	73	3

Table 3. Average Wind Comfort Index for organic buildings. (OD) . Source: K. Bajor, 2025

$\mathbf{OD}, si$	$\overline{PL_{OD}}$	$\overline{PI_{OD}}$	$\overline{PH_{OD}}$
$\mathbf{OD}-\boldsymbol{A}$	23	71	6
$\mathbf{OD}-\boldsymbol{B}$	18	76	7
$\mathbf{OD}-\boldsymbol{C}$	23	72	4
$\mathbf{OD}-\boldsymbol{D}$	21	72	7
$\mathbf{OD}-\boldsymbol{E}$	44	52	4
$\mathbf{OD}-\boldsymbol{F}$	20	69	11
$\mathbf{OD}-\boldsymbol{G}$	25	66	9
$\mathbf{OD}-\boldsymbol{H}$	11	74	16
$\mathbf{OD}-\boldsymbol{I}$	29	68	3
$\mathbf{OD}-\boldsymbol{J}$	28	67	5
$\overline{\boldsymbol{WCI_{OD}}} \approx$	24	69	7

3.2. Step 3 thermal comfort index definition

In this step, the Thermal Comfort Index (TCI) was defined to calculate the average percentage thermal comfort according to the UTCI index in order to obtain the results from the simulations performed.

Thermal Comfort Index Definition (TCI):

$$TCI=(PM,PN) \tag{3.7}$$

Where The following values for temperature and wind speed were assumed:

- M (Moderate Heat Stress): Areas with moderate heat stress (temperature > 25°C and wind speed < 3 m/s).
- N (No Thermal Stress): Areas without heat stress (all other conditions, i.e. temperature ≤ 25°C or wind speed ≥ 3 m/s).

Variables - for each simulation scenario:

- PM: Percentage of the terrain surface covered by "Moderate Heat Stress (M)" conditions.
- PN: The percentage of the land area where the conditions occur "No Thermal Stress (N).

$$PM + PN = 100\% \tag{3.8}$$

The average Wind Comfort Index for a building type, e.g., denoted as $\overline{TCI_{DD}}$, similarly to formula (3), is a vector (set) of average percentage values of the land area for each building category:

$$\overline{TCI_{DD}} = (\overline{PM_{DD}}, \overline{PN_{DD}}) \tag{3.9}$$

Where:

DD - Detached Development

BD - Block perimeter Development

OD - Organic Development

Now, the average percentage shares for the type of development, e.g. DD, are calculated as follows:

1. Average percentage of area with high thermal stress (PM_{DD}): The sum of the percentage of PM from all variants (A…Z) belonging to the DD type and divided by the number of these variants (N_{WCI}).

$$\overline{PM_{DD}} = \frac{1}{N_{TCI}} \sum_{i=1}^{N_{TCI}} PM, si \tag{3.10}$$

2. Average percentage of area with low thermal stress (PN_{DD}): We sum up the percentages of PN from all variants (A…Z) belonging to type DD and divide by the number of these variants (N_{TCI}).

$$\overline{PN_{\mathrm{DD}}} = \frac{1}{N_{TCI}} \sum_{i=1}^{N_{TCI}} PN, si \tag{3.11}$$

Table 4. Average Wind Comfort Index for Detached development. (DD) . Source: K. Bajor, 2025

$\mathbf{DD}, \boldsymbol{si}$	$\overline{\boldsymbol{PM_{DD}}}$	$\overline{\boldsymbol{PN_{DD}}}$
$\mathbf{DD}-\boldsymbol{A}$	77	23
$\mathbf{DD}-\boldsymbol{B}$	71	29
$\mathbf{DD}-\boldsymbol{C}$	75	25
$\mathbf{DD}-\boldsymbol{D}$	72	28
$\mathbf{DD}-\boldsymbol{E}$	70	30
$\mathbf{DD}-\boldsymbol{F}$	64	36
$\mathbf{DD}-\boldsymbol{G}$	65	35
$\mathbf{DD}-\boldsymbol{H}$	67	33
$\mathbf{DD}-\boldsymbol{I}$	39	61
$\mathbf{DD}-\boldsymbol{J}$	60	40
$\overline{\boldsymbol{TCI_{DD}}} \approx$	66	34

Table 5. Average Wind Comfort Index for a block perimeter of the building. (BD) . Source: K. Bajor, 2025

$\mathbf{BD}, \boldsymbol{si}$	$\overline{\boldsymbol{PM_{BD}}}$	$\overline{\boldsymbol{PN_{BD}}}$
$\mathbf{BD}-\boldsymbol{A}$	59	41
$\mathbf{BD}-\boldsymbol{B}$	72	28
$\mathbf{BD}-\boldsymbol{C}$	40	60
$\mathbf{BD}-\boldsymbol{D}$	67	33
$\mathbf{BD}-\boldsymbol{E}$	72	28
$\mathbf{BD}-\boldsymbol{F}$	73	27
$\mathbf{BD}-\boldsymbol{G}$	66	34
$\mathbf{BD}-\boldsymbol{H}$	66	34
$\mathbf{BD}-\boldsymbol{I}$	65	35
$\mathbf{BD}-\boldsymbol{J}$	65	35
$\overline{\boldsymbol{TCI_{BD}}} \approx$	64	36

Table 6. Average Wind Comfort Index for organic buildings. (OD) . Source: K. Bajor, 2025

$\mathbf{OD}, si$	$\overline{PM_{OD}}$	$\overline{PN_{OD}}$
$\mathbf{OD}-\boldsymbol{A}$	45	55
$\mathbf{OD}-\boldsymbol{B}$	57	43
$\mathbf{OD}-\boldsymbol{C}$	57	43
$\mathbf{OD}-\boldsymbol{D}$	61	39
$\mathbf{OD}-\boldsymbol{E}$	53	47
$\mathbf{OD}-\boldsymbol{F}$	48	52
$\mathbf{OD}-\boldsymbol{G}$	54	46
$\mathbf{OD}-\boldsymbol{H}$	39	61
$\mathbf{OD}-\boldsymbol{I}$	60	40
$\mathbf{OD}-\boldsymbol{J}$	59	41
$\overline{TCI_{OD}} \approx$	53	47

3.3. Step 4 greenery and small architecture introduction

In this step, the influence of small buildings and greenery on the index results from tables from Tab.1 to Tab.6 was studied. 3 examples of buildings with the worst results were selected from the pool of 30 examples that were studied in previous steps, 1 from each type of building (DD, BD, OD). Trees and buildings were placed in places with high thermal stress and high wind speed. Trees 5 m high and with an average spacing of 5 m and two-storey buildings 5x9 m with a spacing of 10-15 m.

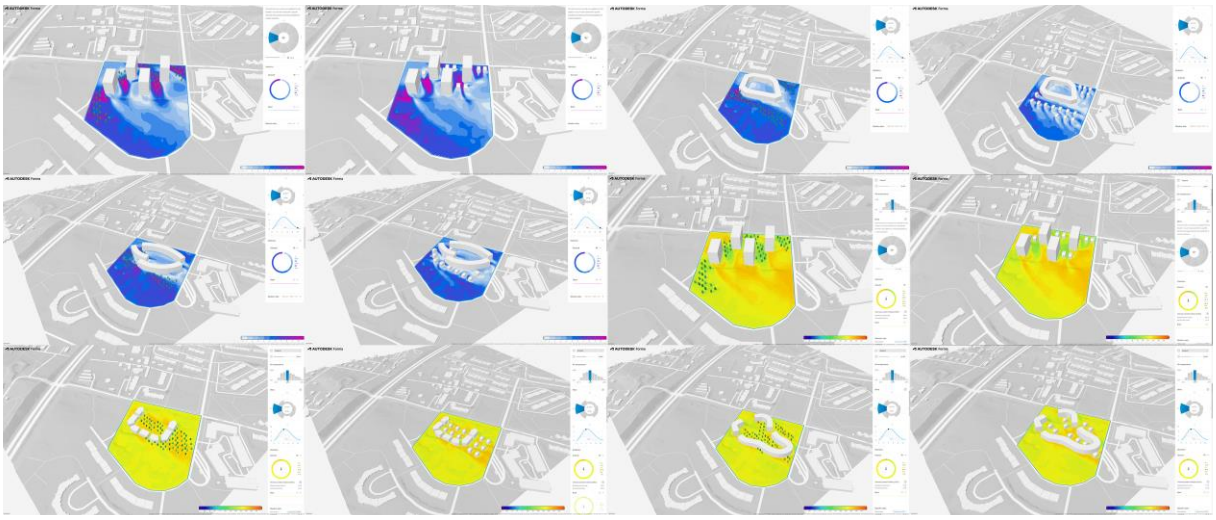

Fig. 6. Selected examples of development with the worst WCI and TCI results for research with greenery and small architecture. Source: K. Bajor, 2025

Table 7. Average Wind Comfort Index after adding greenery and buildings. . Source: K. Bajor, 2025

	BUILDING			BUILDING + GREENERY			BUILDING + BUILDINGS		
$\overline{WCI_{si}}$	$\overline{PL}$	$\overline{\mathbf{PI}}$	$\overline{\mathbf{PH}}$	$\overline{PL}$	$\overline{\mathbf{PI}}$	$\overline{\mathbf{PH}}$	$\overline{PL}$	$\overline{\mathbf{PI}}$	$\overline{\mathbf{PH}}$
$\overline{WCI_{DD}}$	24	58	18	25	60	15	29	56	15
$\overline{WCI_{BD}}$	23	70	7	24	72	4	42	57	2
$\overline{WCI_{OD}}$	20	69	11	21	73	6	32	66	2
$\overline{\boldsymbol{WCI}} \approx$	22	66	12	23	69	8	34	60	6

Table 8. Average Thermal Comfort Index after adding greenery and buildings. . Source: K. Bajor, 2025

	BUILDING		BUILDING + GREENERY		BUILDING + BUILDINGS	
$\overline{WCI_{si}}$	$\overline{PM}$	PN	$\overline{PM}$	PN	$\overline{PM}$	PN
$\overline{WCI_{DD}}$	77	23	59	41	59	41
$\overline{WCI_{BD}}$	74	26	67	33	70	30
$\overline{WCI_{OD}}$	61	39	53	47	57	43
$\overline{WCI} \approx$	71	29	60	40	62	38

Table 7, Table 8, Table 9 and Table 10 present the quality of the obtained results in terms of colour, with the best results marked in green, the average results in orange and the worst results in red.

4. RESULTS

Analysis of simulations conducted in Autodesk Forma for three typologies of development (detached - DD, block perimeter - BD, organic - OD) in the area of Zielona Góra allowed for the assessment of their impact on wind comfort (WCI) and thermal comfort (TCI). Average results for each typology, based on the analysis of multiple variants, are presented below:

Wind Comfort (WCI): The average surface shares for the wind speed categories (L: 0-3 m/s, I: 3-5 m/s, H: >5 m/s) were:

Table 9. Wind Comfort (WC) results for selected building types. . Source: K. Bajor, 2025

$\overline{WCI_{si}} \approx$	$\overline{PL}$	$\overline{PI}$	$\overline{PH}$
$\overline{WCI_{DD}} \approx$	19	73	8
$\overline{WCI_{BD}} \approx$	24	73	3
$\overline{WCI_{OD}} \approx$	24	69	7

Ranking: BD > OD > DD. Block perimeter development (BD) offered the largest share of areas with the best wind comfort results (WCI), while detached development (DD) had the worst results in terms of wind comfort (WCI). Thermal Comfort (TCI): The average surface shares for the thermal stress category (M: stress >25°C & <3m/s, N: no stress) were:

Table 10. Thermal Comfort Results (TCI). . Source: K. Bajor, 2025

$\overline{WCI_{si}} \approx$	$\overline{PM}$	$\overline{PN}$
$\overline{WCI_{DD}} \approx$	66	34
$\overline{WCI_{BD}} \approx$	64	36
$\overline{WCI_{OD}} \approx$	53	47

Ranking: OD > BD > DD. Organic development (OD) showed the lowest share of areas with high heat stress (PM) and the highest share of areas with low heat stress (PN). The worst results, as in the case of the thermal comfort index (TCI) Tab.9, were achieved by detached development (DD). Impact of the intervention: analysis of the selected variants (Step 4) showed that adding greenery in places with the worst Windy and Thermal Comfort scores improved the average Wind Comfort Index (WCI) score by 1% and Thermal Comfort Index (TCI) by 11%, while adding small buildings improved these scores by 12% and 9%, respectively.

5. CONCLUSIONS

The aim of the study was to assess the impact of development on the local microclimate. After analyzing the results of the created models, the organic development (OD) turned out to be the most beneficial overall, offering the best compromise between wind and thermal comfort. It showed the second best results for areas with low wind speed and the lowest share of areas affected by heat stress. The block perimeter development (BD) provided good protection against strong wind, taking first place, while the detached development (DD) was the weakest in both aspects studied.

It was also confirmed that the deliberate introduction of additional elements, such as greenery or small architecture, can effectively mitigate negative microclimatic phenomena, with greenery having a greater impact on improving thermal comfort and low-rise buildings having a clearly greater impact on improving wind comfort..

These results contribute to filling the research gap regarding the influence of urban form on microclimate, providing quantitative arguments supporting the use of more complex and integrated spatial layouts..

Based on the research conducted, the following design recommendations can be formulated:

- To improve wind comfort, you should:
    - Prefer organic or block development over detached development.
    - Use additional protective elements (e.g. lower development, screens, small architecture) in areas exposed to strong winds.
    - Consider designing dedicated ventilation corridors for block or organic development, but take into account potential discomfort.
    - Include greenery as an element that slightly modifies wind flow.
- In order to reduce the urban heat island effect and improve thermal comfort:
    - Prefer organic structures, i.e. those with streamlined shapes, which, thanks to irregularity and potential self-shading, exhibit the best thermal properties.
    - Maximize the share of greenery, which significantly improves thermal comfort.
    - For wind comfort, ventilation corridors in perimeter-block or organic development, especially parallel to the wind direction

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