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Optimisation of air exchange in thermally modernised buildings by means of natural ventilation

Valery Savin*

Senior Lecturer
Kryvyi Rih National University
50027, 11 Vitalii Matusevich Str., Kryvyi Rih, Ukraine
https://orcid.org/0009-0008-6013-7371

Pavlo Kirichenko

PhD in Technical Sciences, Associate Professor
Kryvyi Rih National University
50027, 11 Vitalii Matusevich Str., Kryvyi Rih, Ukraine
https://orcid.org/0009-0007-4031-7693

Abstract. The aim of the study was to compare the efficiency of the supply devices of passive ventilation systems (wind catcher of the original design and window ventilator with the options of location "above the window" and "under the window"). As a result, an assessment of the nature of air distribution and features of air flow circulation in the room with different options for supply air supply was provided. To collect and systematise information on passive ventilation, its effectiveness in thermally modernised buildings and to assess the possibility of ensuring standardised air exchange in the premises, methods of generalising the results of previous studies, as well as comprehensive and logical-structural analysis were used. Scientific and analytical analysis was used to process and evaluate the data obtained. Computer modelling made it possible to compare the results and evaluate the distribution of air flows, temperature gradients and air exchange efficiency in the room. A comprehensive analysis of the efficiency of passive ventilation in a thermally modernised building using different types of air inlets was carried out. Their influence on indoor air exchange under different climatic conditions (warm and cold seasons) is investigated, taking into account the distribution of temperature and air flow velocity. Optimal solutions for passive ventilation have been identified that reduce energy consumption while creating a standard air exchange in thermally modernised buildings, which is a key aspect for ensuring energy efficiency and comfortable living conditions. As a result of the modelling, data on the distribution of temperature and air flow velocity in the room for a window ventilator and a wind catcher were obtained. The data obtained were analysed in the frontal and horizontal planes, which allowed to assess the peculiarities of air distribution in the room volume. Particular attention was paid to the analysis of the area directly near the air inlet, which made it possible to study in detail the behaviour of the air flow at the initial stages of its distribution in the room and to assess changes in temperature and flow rate depending on air flow and distance from the air inlet. The results obtained allow for a detailed assessment of the air exchange in the room, taking into account the influence of the design features of the air inlets on the efficiency of air distribution and circulation

Keywords: passive ventilation; wind catcher; microclimate; energy efficiency

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*Corresponding author

Introduction

Insulation of the exterior walls of buildings remains a key measure to improve the energy efficiency of buildings, which suffer from freezing walls and humidity in winter and overheating in summer. External thermal insulation can significantly improve the microclimate in apartments by protecting walls from the negative effects of moisture, wind and ultraviolet radiation. Replacing outdated windows and balcony blocks with sealed profiles with double-glazed windows also helps to create a stable indoor climate, which in turn helps to significantly reduce energy consumption.

In the context of modern requirements for energy efficiency in buildings, it is important to find alternative ventilation methods that will reduce or even avoid dependence on mechanical systems. Ensuring efficient ventilation in thermally modernised buildings should take into account not only the standard air exchange, but also the minimum energy consumption. Ensuring effective ventilation in thermally modernised buildings should take into account not only the standard air exchange, but also the minimum energy consumption. The study by N. Fu *et al.* (2021) analyses and justifies the effectiveness of several mechanical ventilation strategies in high-rise buildings in terms of air quality and energy efficiency. A significant amount of research and development has been devoted to mechanical ventilation systems and improving their efficiency, among which the work of H.Y. Bai *et al.* (2022). But they all have one drawback in common: the need for significant energy consumption for operation. That is why it is promising to study passive ventilation, which makes it possible to reduce the energy consumption of mechanical ventilation systems by using wind power and buoyancy. The study by T. Ahmed *et al.* (2021) reveals the potential of natural ventilation in solving problems related to the quality of the indoor environment and confirms the viability of natural ventilation to ensure thermal comfort in the building.

One of the most well-known elements of a passive ventilation system used to improve indoor air quality is a wind catcher. As noted by V. Savin & V. Zhelykh (2023a), this element provides efficient ventilation due to its ability to direct wind flows towards the interior of the building. G. Allesina *et al.* (2019) and M. Alwetaishi & M. Gadi (2021) add that the wind catcher is a traditional architectural solution typical of the Middle East, where it is used to optimise ventilation using natural air flows. Authors P. Nejat & F. Jomehzadeh (2018) and A.H. Chohan & J. Awad (2022) note that wind catchers demonstrate high efficiency in providing natural air exchange, while A. Bekleyen & Y. Melĭkoğlu (2021) emphasise their importance in the cultural context and architectural design. In modern architecture, this device is also gaining popularity due to its versatility and ability to provide the required level of ventilation (Wahab *et al.*, 2019; Sangdeh & Nasrollahi, 2022). A study by A.H. Chohan *et al.* (2024) confirms that wind turbines contribute to improving the energy efficiency of buildings and addressing current environmental challenges, while also being key elements in modern environmental design.

Another element of passive ventilation that uses buoyancy and does not compromise the airtightness and thermal insulation properties of a thermally modernised building is a window ventilator (Hoffmann *et al.*, 2021). A window ventilator is a device that is mounted in the window frame and works on the principle of using buoyancy to ensure natural air exchange, but it does not have the ability to control the flow of incoming air. The greater the temperature difference between the outside and inside air, the more efficient the air exchange.

Despite a considerable amount of research on mechanical and passive ventilation systems, aspects of optimising natural air exchange in thermally modernised buildings remain poorly understood. This article was aimed at studying the influence of the design characteristics of air handling units on the uniformity of air distribution in the premises, as well as their ability to provide a standard level of air exchange in different climatic conditions.

Materials and Methods

The study analyses the results of modelling the impact of natural ventilation on the air exchange of a thermally modernised building on the example of a separate room, which is a key aspect for ensuring energy efficiency and comfortable living conditions. A thermally modernised one-storey residential building located in Kryvyi Rih was chosen for the study. The geometric dimensions of the room for which the modelling was carried out and the layout of the supply and exhaust elements are shown in Figure 1.

The supply air temperature, taking into account the climatic conditions of Kryvyi Rih, is -21°C in the cold season. The internal air temperature is assumed to be +20°C. The modelling of the impact of natural ventilation on the air exchange of the thermally modernised building was carried out using the licensed software Solidworks Flow Simulation.

To simulate the supply air flow, the air inlets were located as follows: the inlet of the wind catcher at a height of 2,700 mm; window ventilator, depending on the modelling conditions: "above the window" or "under the window". The maximum capacity of the window ventilator is 20 m^3/h (Mucha *et al.*, 2024), which was taken as a threshold value for modelling with flow rates from 5 to 20 m^3/h. The wind catcher was studied with a wider range of flow rates: from 5 to 100 m^3/h to identify the optimal conditions for efficient air exchange.

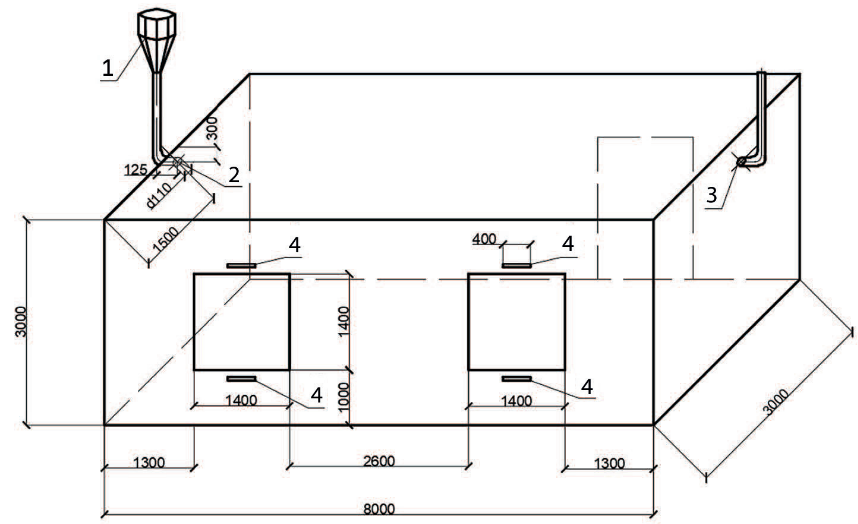

Figure 1. Layout of supply and exhaust elements in a room of a thermally modernised house
Notes: 1 – wind catcher; 2 – inlet of the wind catcher; 3 – exhaust opening; 4 – window ventilators
Source: developed by the authors

The study of passive ventilation efficiency analysis and assessment of air exchange in the room was carried out in several stages: 1. computer modelling of the operation of a wind catcher and a window ventilator under different conditions of supply air supply; 2. special conditions of air distribution and circulation in the room when using each type of supply equipment and different options for its location; 3. the influence of air flow rate on the efficiency of air distribution and features of air flow circulation in the room is analysed; 4. recommendations on the choice and installation location of supply devices of passive ventilation to ensure.

Results

The modelling results showed that at the minimum flow rate (5 m^3/h) in each of the two variants of the window ventilator location (“above the window” and “under the window”), the air flow develops slowly, which ensures gradual mixing of the supply air with the internal air, although circulation is limited to areas close to the window ventilators. The flow remains in the lower layers of the room when supplied through the lower window ventilators or in the upper layers – through the upper window ventilators, which does not ensure full coverage of the room volume.

As the flow rate increases, the air flow penetrates deeper into the room, reaching the middle layers, which ensures more efficient mixing with the indoor air. Regardless of the location of the window ventilator, the air flow covers a large part of the room, distributing evenly. With a maximum flow rate of 20 m^3/h in both the upper and lower outlets (Fig. 2), the airflow demonstrates high speed, actively circulating throughout the room. The air flow is evenly distributed in both horizontal and vertical planes, with complete mixing of supply and internal air, providing full coverage of the room volume and intensive air exchange.

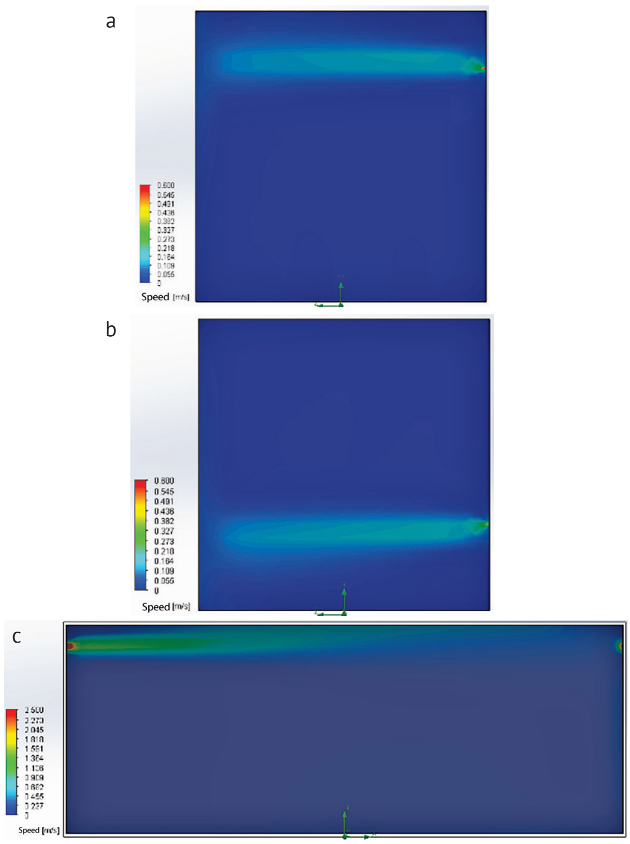

Figure 2. Modelling the inflow velocity in the frontal plane
Notes: a – through a window ventilator located “above the window”; b – through a window ventilator located “under the window”; c – through a wind catcher
Source: developed by the authors

The combination of the modelling results for the upper and lower air supply is possible due to the identical temperature conditions of the supply and internal environments (+20°C). Under such conditions, both air supply options, although they have different directions of distribution at the initial stages, demonstrate similar patterns in air distribution at the same flow rates. The main differences in the flow behaviour are smoothed out at the mixing stage, when the air is evenly distributed throughout the room, indicating a similar effect on the microclimate.

Modelling of the intake air flow through the wind catcher showed that at minimum flow rates, the intake air flow is uniform, without sudden changes in direction. Due to the low velocity, the flow does not penetrate far from the wind catcher outlet and quickly dissipates in the room. As the flow rate increases, the ability of the air flow to distribute evenly throughout the room gradually increases. At flow rates in the range of 15-40 m^3/h, the air flow circulates well without significant turbulence, and at high flow rates (from 60-80 m^3/h) turbulent zones begin to appear, which can cause discomfort. At a maximum flow rate of 100 m^3/h, the most intense air flow is provided (Fig. 2). The turbulence becomes significant, and the air movement can create unpleasant sensations for the occupants due to excessive speed and uneven distribution of air flows throughout the room.

According to the modelling data, at low flow rates (5 m^3/h), and thus low velocities, the cold supply air is slowly mixed with the warm indoor air. The air flow remains close to the window ventilator, with a gradual decrease in speed as it moves away. The cold air settles, causing cold zones to form in the lower layers of the room. The slow spread of air with a temperature of -21°C has a slight effect on the temperature of the room. Low temperatures remain in the area close to the window ventilator.

With increased flow rates, the mixing of cold and warm air is more efficient. The cold air is more actively distributed throughout the room, but there are still significant temperature gradients between the area near the window ventilator and the farther parts of the room. The temperature in the room begins to drop, especially closer to the floor. At the maximum capacity of the window ventilator (20 m^3/h), the air flow has a high velocity, which ensures uniform mixing of the cold supply air with the warm internal air (Fig. 3). The flow extends over the entire area of the room, covering all its nooks and crannies. The simulation results illustrate that the air no longer settles in the lower layers, but is evenly distributed throughout the room.

The room temperature remains more stable, although the cold air still has an impact on the temperature drop near the window ventilator (Fig. 4). However, at the maximum flow rate, the air exchange becomes intense enough to avoid the formation of excessively cold zones.

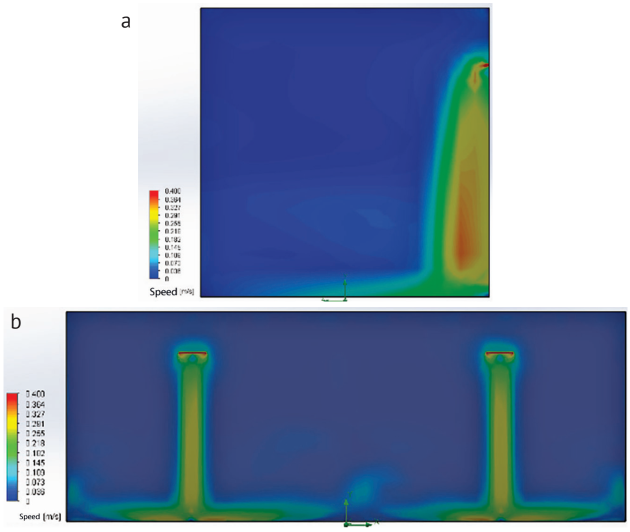

Figure 3. Simulation of the inflow velocity through the window ventilator with the location "above the window" in the frontal plane

Notes: a – along the axis of the window ventilator; b – along the wall

Source: developed by the authors

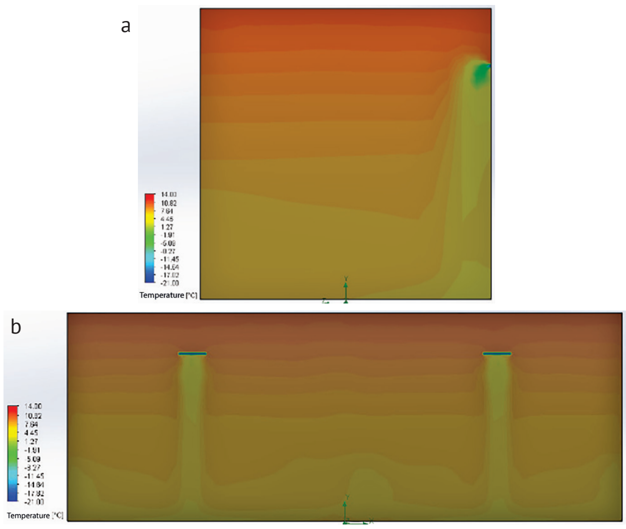

Figure 4. Simulation of the supply air velocity through a window ventilator with the location "above the window" in the frontal plane

Notes: a – along the axis of the window ventilator; b – along the wall

Source: developed by the authors

The simulation results show that at a cold supply air flow rate of 5 m^3/h, the cold air slowly rises and gradually mixes with the warm room air. The air velocity remains low, and the cold zone near the floor is maintained over a large area. Cold air settles in the lower layers of the room, creating temperature gradients. The temperature patterns show that a large proportion of the air remains cold near the floor and heating is slow due to limited mixing with the warm room air.

As the flow rate increases, the cold air starts to spread upwards more quickly. This results in a more even distribution of cold air, but there is still some zonal cooling near the floor, which affects the temperature comfort in the room. At a flow rate of 20 m^3/h, the cold air actively rises upwards, providing better mixing with the warm air (Fig. 5). The modelling results show that the air reaches the upper layers of the room, ensuring uniform air exchange. The air flow rate avoids the formation of cold stagnation zones near the floor. The results of the simulation of temperature changes in the room demonstrate a more even temperature distribution throughout the room (Fig. 6). Cold zones become less pronounced, and temperature gradients are reduced.

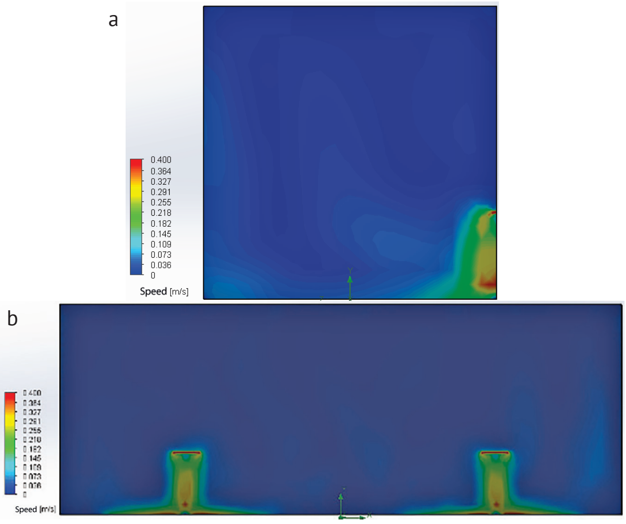

Figure 5. Simulation of the inflow velocity through the window ventilator with the location "under the window" in the frontal plane

Notes: a – along the axis of the window ventilator; b – along the wall

Source: developed by the authors

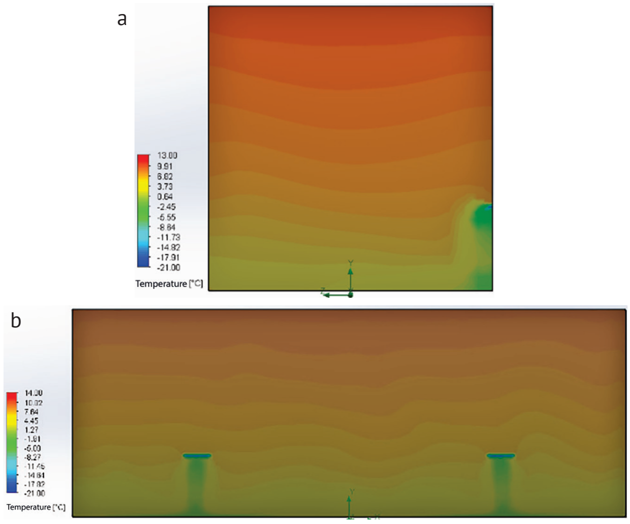

Figure 6. Simulation of the supply air velocity through a window ventilator with the location "under the window" in the frontal plane

Notes: a – along the axis of the window ventilator; b – along the wall

Source: developed by the authors

As the cold supply air flow rate increases, the likelihood of localised cooling zones is reduced due to more efficient mixing of the cold supply air and warm indoor air. However, the increased air flow rate associated with the increase in air velocity may cause some discomfort to the occupants.

Discussion

Due to the high level of airtightness and thermal insulation, thermally modernised buildings significantly reduce heat loss. M.S. Ünlütürk & T.G. Özbalta (2024) note that such measures contribute to a significant increase in energy efficiency, but at the same time create new challenges in ensuring adequate ventilation. In turn, M. Bhandari *et al.* (2018) and C. Banister *et al.* (2022) point out that the increased airtightness of structures significantly limits natural air exchange, which affects the quality of the indoor environment. Z.-Y. Chen *et al.* (2024) analyse the impact of external sources of pollution on indoor air, pointing out the particular importance of ventilation systems in such conditions. M. Mannan & S.G. Al-Ghamdi (2021) and S. Fujiyoshi *et al.* (2022) add that a significant source of air pollution is internal factors such as furniture, finishing materials, and occupants' household activities. Mechanical ventilation systems are commonly used to address this problem. As noted by V. Savin & V. Zhelykh (2023b) note that such systems allow controlling air exchange and microclimate parameters, however, according to Y. Tang *et al.* (2022), they are characterised by high energy consumption. This contradicts the main goal of thermo-modernisation, which is to reduce energy consumption by the building.

The authors of M. Carlsson *et al.* (2019) conducted a study of different methods of sealing the building envelope using heat recovery ventilation in multi-room buildings. Based on the results of the study, they concluded that proper modernisation reduces the overall energy demand for heating by 78% and greenhouse gas emissions by 83%. The work of N. Bianco *et al.* (2023) focused on analysing the impact of building insulation on ventilation systems with heat recovery technologies. The authors of the study emphasise that building insulation significantly reduces heat loss due to the low thermal conductivity of the building envelope, limiting natural air exchange, which in turn negatively affects indoor air quality and requires the introduction of additional ventilation solutions. The use of heat recovery systems can reduce energy consumption for heating and cooling and ensure efficient ventilation. The results of the study show that regenerative and recuperative systems technologies effectively maintain microclimate parameters, but are dependent on additional electricity use.

The authors H.Y. Bai *et al.* (2022) point out the possibility of increasing the efficiency of traditional air handling units by modernising them or integrating them with other ventilation systems. The paper emphasises that the combination of air handling units with mechanical components or the use of adaptive solutions helps to eliminate air stagnation zones and improve the uniformity of air exchange even in difficult climatic conditions. Unlike traditional mechanical ventilation systems described in H.Y. Bai *et al.* (2022), the proposed solution is aimed at reducing energy consumption and ensuring high indoor air quality. This approach emphasises the potential of passive ventilation as an effective alternative to mechanical systems.

The results of the study demonstrated the high efficiency of the wind catcher in creating a standard air exchange in thermally modernised buildings, while ensuring an even distribution of the supply air throughout the entire volume of the room, which meets modern requirements for energy efficiency and a comfortable microclimate. Similar conclusions were reached by the authors of T. Ahmed *et al.* (2021) and P.K. Sangdeh & N. Nasrollahi (2022), who note that due to their design features, wind catchers are able to provide efficient air circulation regardless of external climatic conditions. The results of modelling the operation of window ventilators show that their use is not able to ensure proper air exchange, in particular in the cold season, when there are significant temperature gradients and the formation of cold air stagnation zones, which negatively affects the indoor climate.

It is also important to compare the results obtained with the studies of M. Alwetaishi & M. Gadi (2021) and A.H. Chohan & J. Awad (2022), which analysed wind catchers of various designs and the possibility of their integration into modern architectural solutions. The modelling results showed that wind turbines can become a key component of the natural ventilation system, functioning effectively in different climatic conditions without the need for additional energy consumption.

The authors of the study by Z. Liu *et al.* (2019) emphasise the need to introduce modern approaches to fresh air treatment to improve the energy efficiency of buildings. The use of innovative technologies helps to reduce energy consumption and carbon emissions, which is important in the context of global sustainable development goals. The results emphasise the feasibility of using energy-saving solutions in the ventilation systems of thermally modernised buildings, especially in cases where it is necessary to ensure high air quality with minimal energy consumption. In general, the results obtained indicate that the wind catcher is an effective solution for ensuring regulatory air exchange in thermally modernised buildings, which is confirmed by the data of many scientists mentioned in the article.

Conclusions

The analysis of the modelling results showed that the use of ventilators in the warm season, regardless of their location ("above the window" or "under the window"), can partially distribute the air in the room, but even with the maximum performance of the ventilators, the standard air exchange is not ensured. During the cold season, there are significant temperature gradients in the vicinity of the air handlers, especially when supplying through the lower air handler. This creates cold zones in the lower layers of the room, which leads to a decrease in thermal comfort in the room and an increase in energy consumption required for additional heating of the room.

Due to its design features, the wind catcher ensures standard air exchange in the room regardless of the temperature difference between the internal and external environment, promotes efficient circulation of the supply air and prevents the formation of stagnant zones, which is confirmed by the modelling results. Thus, the results of the study prove the high efficiency of the wind catcher as a passive ventilation element capable of providing standard air exchange in the room regardless of the season, which makes it a universal passive ventilation solution for use in different climatic conditions.

The modelling of the impact of natural ventilation on the air exchange of a thermally modernised building was carried out on the example of a single room, which limited the study, since the specifics of air exchange in multi-room premises were not taken into account. The study also adopted modelling conditions without taking into account possible changes in external factors (wind speed, etc.). Further research should be aimed at analysing the behaviour of air handling units in multi-room buildings, determining the optimal design parameters of wind catchers for different types of buildings and expanding research to take into account climatic features. This will provide more accurate recommendations for the effective use of passive ventilation to improve the energy efficiency of buildings.

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Conflict of Interest

None.

References

[1] Ahmed, T., Kumar, P., & Mottet, L. (2021). Natural ventilation in warm climates: The challenges of thermal comfort, heatwave resilience and indoor air quality. *Renewable and Sustainable Energy Reviews*, 138, article number 110669. doi: 10.1016/j.rser.2020.110669.

[2] Allesina, G., Ferrari, C., Muscio, A., & Pedrazzi, S. (2019). Easy to implement ventilated sunspace for energy retrofit of condominium buildings with balconies. *Renewable Energy*, 141, 541-548. doi: 10.1016/j.renene.2019.04.037.

[3] Alwetaishi, M., & Gadi, M. (2021). New and innovative wind catcher designs to improve indoor air quality in buildings. *Energy and Built Environment*, 2(4), 337-344. doi: 10.1016/j.enbenv.2020.06.009.

[4] Bai, H.Y., Liu, P., Justo Alonso, M., & Mathisen, H.M. (2022). A review of heat recovery technologies and their frost control for residential building ventilation in cold climate regions. *Renewable and Sustainable Energy Reviews*, 162, article number 112417. doi: 10.1016/j.rser.2022.112417.

[5] Banister, C., Bartko, M., Berquist, J., Macdonald, I., Vuotari, M., & Wills, A. (2022). Energy and emissions effects of airtightness for six non-residential buildings in Canada with comparison to contemporary limits and assumptions. *Journal of Building Engineering*, 58, article number 104977. doi: 10.1016/j.jobe.2022.104977.

[6] Bekleyen, A., & Melīkoğlu, Y. (2021). An investigation on the thermal effects of windcatchers. *Journal of Building Engineering*, 34, article number 101942. doi: 10.1016/j.jobe.2020.101942.

[7] Bhandari, M., Hun, D., Shrestha, S., Pallin, S., & Lapsa, M. (2018). A simplified methodology to estimate energy savings in commercial buildings from improvements in airtightness. *Energies*, 11(12), article number 3322. doi: 10.3390/en11123322.

[8] Bianco, N., Fragnito, A., Iasiello, M., & Mauro, G.M. (2023). A CFD multi-objective optimization framework to design a wall-type heat recovery and ventilation unit with phase change material. *Applied Energy*, 347, article number 121368. doi: 10.1016/j.apenergy.2023.121368.

[9] Carlsson, M., Touchie, M., & Richman, R. (2019). Investigating the potential impact of a compartmentalization and ventilation system retrofit strategy on energy use in high-rise residential buildings. *Energy and Buildings*, 199, 20-28. doi: 10.1016/j.enbuild.2019.06.035.

[10] Chen, Z.-Y., Petetin, H., Méndez Turrubiates, R.F., Achebak, H., García-Pando, C.P., & Ballester, J. (2024). Population exposure to multiple air pollutants and its compound episodes in Europe. *Nature Communications*, 15, article number 2094. doi: 10.1038/s41467-024-46103-3.

[11] Chohan, A.H., & Awad, J. (2022). Wind catchers: An element of passive ventilation in hot, arid and humid regions, a comparative analysis of their design and function. *Sustainability*, 14(17), article number 11088. doi: 10.3390/su141711088.

[12] Chohan, A.H., Awad, J., Elkahlout, Y., & Abuarkub, M. (2024). Evaluating windcatchers in UAE heritage architecture: A pathway to zero-energy cooling solutions. *Ain Shams Engineering Journal*, 15(10), article number 102936. doi: 10.1016/j.asej.2024.102936.

[13] Fu, N., Kim, M.K., Chen, B., & Sharples, S. (2021). Comparative modelling analysis of air pollutants, $PM_{2.5}$ and energy efficiency using three ventilation strategies in a high-rise building: A Case study in Suzhou, China. *Sustainability*, 13(15), article number 8453. doi: 10.3390/su13158453.

[14] Fujiyoshi, S., Dovjak, M., Vaupotič, J., & Maruyama, F. (2022). Understanding effects of ventilation on airborne microorganisms in build environments. In *Proceedings of CLIMA 2022 conference*. Rotterdam: REHVA. doi: 10.34641/clima.2022.60.

[15] Hoffmann, C., Geissler, A., Hauri, C., & Huber, H. (2021). Passive window ventilation openings in every-day use. *Building and Environment*, 206, article number 108259. doi: 10.1016/j.buildenv.2021.108259.

[16] Liu, Z., Li, W., Chen, Y., Luo, Y., & Zhang, L. (2019). Review of energy conservation technologies for fresh air supply in zero energy buildings. *Applied Thermal Engineering*, 148, 544-556. doi: 10.1016/j.applthermaleng.2018.11.085.

[17] Mannan, M., & Al-Ghamdi, S.G. (2021). Indoor air quality in buildings: A comprehensive review on the factors influencing air pollution in residential and commercial structure. *International Journal of Environmental Research and Public Health*, 18(6), article number 3276. doi: 10.3390/ijerph18063276.

[18] Mucha, W., Mainka, A., & Brągoszewska, E. (2024). Impact of ventilation system retrofitting on indoor air quality in a single-family building. *Building and Environment*, 262, article number 111830. doi: 10.1016/j.buildenv.2024.111830.

[19] Nejat, P., & Jomehzadeh, F. (2018). Windcatcher as a Persian sustainable solution for passive cooling. *Civil Engineering Research Journal*, 6(1), article number 555679. doi: 10.19080/CERJ.2018.06.555679.

[20] Sangdeh, P.K., & Nasrollahi, N. (2022). Windcatchers and their applications in contemporary architecture. *Energy and Built Environment*, 3(1), 56-72. doi: 10.1016/j.enbenv.2020.10.005.

[21] Savin, V., & Zhelykh, V. (2023a). Recuperators as an important element for energy efficiency in building ventilation systems. *Construction of Optimized Energy Potential*, 12, 71-78. doi: 10.17512/bozpe.2023.12.08.

[22] Savin, V., & Zhelykh, V. (2023b). Review of peculiarities of using wind catchers in energy-saving ventilation systems. *Ventilation, Illumination and Heat-Gas Supply*, 47, 53-62. doi: 10.32347/2409-2606.2023.47.53-62.

[23] Tang, Y., Ji, J., Wang, C., Xie, H., & Ke, W. (2022). Performance prediction of a novel double-glazing PV curtain wall system combined with an air handling unit using exhaust cooling and heat recovery technology. *Energy Conversion and Management*, 265, article number 115774. doi: 10.1016/j.enconman.2022.115774.

[24] Ünlütürk, M.S., & Özbalta, T.G. (2024). Analysis of airtightness performance of residential areas in Mediterranean climate: Balıkesir houses. In *Proceedings of the Institution of Civil Engineers – engineering sustainability*. London: ICE Publishing. doi: 10.1680/jensu.23.00075.
[25] Wahab, I.A., Aziz, H.A., & Salam, N.N.A. (2019). Building design effect on indoor natural ventilation of tropical houses. *International Journal of Sustainable Construction Engineering and Technology*, 10(1), 23-33. doi: 10.30880/ijscet.2019.10.01.003.

Оптимізація повітрообміну в термомодернізованих будівлях за допомогою природної вентиляції

Валерій Савін

Старший викладач
Криворізький національний університет
50027, вул. Віталія Матусевича, 11, м. Кривий Ріг, Україна
https://orcid.org/0009-0008-6013-7371

Павло Кіріченко

Кандидат технічних наук, доцент
Криворізький національний університет
50027, вул. Віталія Матусевича, 11, м. Кривий Ріг, Україна
https://orcid.org/0009-0007-4031-7693

Анотація. Метою дослідження було порівняння ефективності роботи припливних пристроїв пасивних систем вентиляції (вітровловлювача оригінальної конструкції та віконного провітрювача з варіантами розташування «над вікном» і «під вікном»). В результаті надано оцінку характеру повітророзподілу та особливостей циркуляції повітряних потоків в приміщенні при різних варіантах подачі припливного повітря. Для збору та систематизації інформації про пасивну вентиляцію, її ефективність застосування у термомодернізованих будинках та оцінки можливості забезпечення нормативного повітрообміну в приміщеннях було використано методи узагальнення результатів попередніх досліджень, а також комплексний та логіко-структурний аналіз. Для обробки та оцінки отриманих даних було застосовано науково-аналітичний аналіз. Комп'ютерне моделювання дозволило порівняти результати та оцінити розподіл повітряних потоків, температурні градієнти та ефективність повітрообміну в приміщенні. Проведено комплексний аналіз ефективності пасивної вентиляції в термомодернізованому будинку із використанням різних типів припливних пристроїв. Досліджено їхній вплив на повітрообмін у приміщенні за різних кліматичних умов (теплий та холодний періоди року) з урахуванням розподілу температури та швидкості повітряного потоку. Визначені оптимальні рішення для пасивної вентиляції, які дозволяють знизити енерговитрати при створенні нормативного повітрообміну в термомодернізованих будинках, що є ключовим аспектом для забезпечення енергоефективності та комфортних умов проживання. В результаті моделювання отримано дані про розподіл температури та швидкості повітряного потоку в приміщенні для віконного провітрювача та вітровловлювача. Проведено аналіз отриманих даних у фронтальній та горизонтальній площинах, що дозволило оцінити особливості розповсюдження повітря в об'ємі приміщення. Особлива увага приділена аналізу зони безпосередньо біля припливного пристрою, що дозволило детально вивчити поведінку повітряного потоку на початкових етапах його розподілу в приміщенні та оцінити зміни температури й швидкості потоку залежно від витрати повітря і відстані від припливного пристрою. Отримані результати дозволяють детально оцінити повітрообмін у приміщенні, враховуючи вплив конструктивних особливостей припливних пристроїв на ефективність розподілу та циркуляції повітря

Ключові слова: пасивна вентиляція; вітровловлювач; мікроклімат; енергоефективність