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THE IMPORTANCE OF TECHNOLOGY IN THE STUDY OF SHAPING THE RELATIONSHIP BETWEEN ARCHITECTURE AND ITS ENVIRONMENT AND CLIMATIC CONDITIONS

ZNACZENIE TECHNIKI W BADANIACH NAD KSZTAŁTOWANIEM RELACJI MIĘDZY ARCHITEKTURĄ I JEJ OTOCZENIEM A UWARUNKOWANIAMI KLIMATYCZNYMI

Abstract

Contemporary architecture is inherently concerned with the dual objectives of functionality and aesthetic appeal. Its primary objective is to serve users through its durability and – what is worth adding – its ability to adapt to the requirements of modern times. Amongst other things, these requirements are met by technology and rapidly developing technologies. Their skillful application allows architecture to be highly valued and desired. However, it is not always possible to adapt buildings of historical value to new functions, among others, due to the technologies required for their construction at the time. Focusing attention also on new objects, it should be taken into account that technologies allow them to keep up with contemporary architectural and urban design trends. One of these trends is to design with respect for environmental assets. For this, it is necessary to take a broader view of architecture through the prism of the environmental conditions accompanying it.

This paper will present the results of research on the assessment of climatic conditions in the historic environment. The results of this research can be regarded as illustrative due to the short period of time for this type of research. However, they are sufficient to meet the primary research objective. The research aims to demonstrate that there are inextricable links between technology, architecture and urban

planning. Technology not only allows for the development of technologies used in the construction of architectural buildings but also for targeted research in the field of architecture and urbanism of both contemporary and historic nature.
Thus, the development of technology is necessary to conduct research on historical urban layouts and their accompanying architectural structures as well as on contemporary architecture, taking into account its surroundings, so that it is acceptable, beautiful, and useful in its functionality, and durability, but also up-to-dateness – adaptation to modern requirements and user needs.

Keywords: architecture, climatic conditions, technology, urbanism

S t r e s z c z e n i e

Współczesna architektura niezmiennie dąży do zachowania funkcjonalności oraz piękna. Jej zadaniem jest służyć swoim użytkownikom ze względu na trwałość i – należałoby dodać – możliwość dostosowania się do wymogów współczesności. Realizację tych wymagań zapewniają między innymi technika i dynamicznie rozwijające się technologie. Umiejętne ich zastosowanie pozwala na wysoką ocenę architektury i chęć jej użytkowania. Nie zawsze jednak istnieje możliwość adaptacji obiektów o wartości historycznej do nowych funkcji, m.in. ze względu na ówcześnie zastosowane technologie konieczne do ich budowy. Skupiając uwagę także na obiektach nowych, należy zauważyć, że to technologie pozwalają im nadążać za współczesnymi tendencjami w zakresie projektowania architektoniczno-urbanistycznego. Jedną z tych tendencji jest projektowanie z poszanowaniem dóbr środowiska przyrodniczego, do czego konieczne jest szersze spojrzenie na architekturę – także przez pryzmat uwarunkowań środowiskowych jej towarzyszących.
W artykule przedstawione zostaną wyniki badań dotyczące oceny uwarunkowań klimatycznych w historycznym otoczeniu. Wyniki tych badań można potraktować jako poglądowe ze względu na krótki jak na tego typu badania okres ich prowadzenia. Jednak są wystarczające, by zrealizować podstawowy cel badawczy, jakim jest wykazanie, że istnieją nierozerwalne związki między techniką, architekturą i urbanistyką. Technika pozwala nie tylko na rozwój technologii wykorzystywanych do budowy obiektów architektonicznych, ale także na prowadzenie ukierunkowanych badań w zakresie architektury i urbanistyki zarówno o współczesnym, jak i zabytkowym charakterze. Rozwój techniki jest więc konieczny do prowadzenia badań nad historycznymi układami urbanistycznymi i towarzyszącymi im obiektami architektonicznymi, a także nad współczesną architekturą z uwzględnieniem jej otoczenia, tak by była ona akceptowana, piękna, użyteczna przez swą funkcjonalność, trwałość, ale także aktualność – dostosowanie do współczesnych wymagań i potrzeb użytkowników.

Słowa kluczowe: architektura, uwarunkowania klimatyczne, technologia, urbanistyka

1. INTRODUCTION

Architectural structures have always formed strong links with surrounding urban conditions, including the environment.

Today, these relationships are seen even more clearly due to the need to maintain concern for the state of the natural environment and its resources. The consideration of natural elements in the creation of urban spaces is not indifferent to the formation of the microclimate of urban interiors with the accompanying architecture. Research on this topic is being conducted by the authors of this study, recognizing the relationships that occur between the microclimate and architectural and urban conditions.[1]

[1] J. Kobylarczyk, D. Kuśnierz-Krupa, M. Nowak-Ocłoń, *Impact of paving surface material on thermal conditions within a residential building*, "Archives of Thermodynamics" 2023, no. 44(4), pp. 141–155; Vallati C.V. et al., *Energy retrofit optimization for social building in temperate climate zone*, "Energy and Buildings" 2023, vol. 282, art. no. 11271. DOI: 10.1016/j.enbuild.2023.112771 (access: 17.06.2024).

In particular, in recent years there has been intensive scientific research grounded in the issues of climate change and the impact of architecture and urban design on microclimates. The relationship between urban structure and climate has been written about by S.W. Kang team, for example. Among other things, their work showed that cities with dispersed structures are most vulnerable to flooding, as well as to greenhouse gas emissions from the transportation sector.[2]

Studies have shown that transitions between rural and urban areas established using local climate zones (LCZs) are more effective in characterizing development features in comparison to those obtained from concentric ring analysis. The usefulness of LCZs in urban studies was further confirmed in a study conducted in Seoul.[3]

All the referenced studies show the relationship between urban form and climate emphasizing the need to adapt planning strategies and manage urban development patterns to optimize the energy efficiency and resilience of urban structures in different climate contexts. Climate research can be an important factor in gaining knowledge about the performance of historic districts while significantly improving the quality of historic residential buildings. As highlighted by A. Egusquiza et al. this can be achieved through the integration of sustainable practices and adaptation strategies.[4]

By analyzing past architectural practices, contemporary solutions can be developed to improve the sustainability of historic residential buildings while preserving their cultural values. This approach not only protects cultural heritage but also improves overall resilience to climate change.[5] However, this resilience has been found to be unevenly distributed in urban structures, highlighting the problem of climate justice. A study conducted by N. Mothat and L. Khirfan highlights the unequal spatial distribution of climate risks in urban areas and concludes that there is a strong need to include disadvantaged groups in adaptation interventions planned to enhance resilience.[6]

As a rule, these research studies are conducted in a specific area – a specific urban interior, city, region, etc., depending on the scale adopted by the researchers. Often, the studies cover zones with extreme climatic conditions, with specific energy requirements.[7] Moreover,

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[2] S.W. Kang, M.S. Lee, J.C. Jung, *Analysis of sustainable urban forms for climate change adaptation and mitigation*, "Environmental and Sustainability Indicators" 2024, vol. 22, art. no. 100337. DOI: 10.1016/j.indic.2024.100337 (access: 17.06.2024).

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[4] A. Egusquiza et al., *Paving the Way for Climate Neutral and Resilient Historic Districts*, "Open Research Europe" 2023, vol. 3, art. no. 42, [version 1; peer review: 1 approved, 2 approved with reservations]. DOI: 10.12688/openreseurope.15392.1 (access: 17.06.2024).

[5] C. Rubio-Bellido, J.A. Pulido-Arcas, J.M. Cabeza-Lainez, Understanding climatic traditions: A quantitative and qualitative analysis of historic dwellings of Cadiz, "Indoor and Built Environment" 2016, no. 27(5), pp. 665–681. DOI: 10.1177/1420326X16682580 (access: 17.06.2024).

[6] N. Mohtat, L. Khirfan, *The climate justice pillars vis-à-vis urban form adaptation to climate change*, "Urban Climate" 2021, vol. 39, art. no. 100951. DOI: 10.1016/j.uclim.2021.100951 (access: 17.06.2024).

[7] M. Benchekroun et al., *Improving the indoor climate of the traditional Ottoman houses in the Medina*

studies planned as cross-sectional consider only a few selected geographic locations.[8] The outcomes cannot be referred to the temperate climate zone, resulting in the need to expand the spectrum of research to areas located in central Europe.

Therefore, the authors of this study investigated climatic factors in a selected area of the downtown zone of Krakow, an area of historical significance. Although this area is historical, it has its references to the present day. The Officer's Estate, where the analyses were carried out, was built following the principles of E. Howard's Garden City. The modern Garden City can be referred to as the idea of a Green City, or Eco-city, for which technologies are important in minimizing environmental risks.

Preserving the historic character of the area with attention to fulfil the modern requirements of a high-quality residential environment is a challenge of the present day, therefore the choice of study location was of great importance.

2. STUDY AREA – OFFICERS' HOUSING ESTATE IN THE INNER CITY ZONE OF KRAKOW

The Officers' Housing Estate was selected as the study area according to the boundaries marked in Ill. 1. It is one of the historic districts of Krakow. Both its urban layout and most of its buildings have a historic character.

The estate was built in Krakow in the interwar period. It can be said that it is one of the most interesting urban planning assumptions in the entire city. At the time of its establishment, it was located on the then northeastern outskirts of Krakow, in an area that was the foreground of the Lubicz fort.

The name of the estate is not coincidental, as the housing development was designed and built for officers and officials of the Polish Army, which was due, among other things, to the close proximity of both the military barracks and the fort, as well as the Rakowice military airport. The Officers' Housing Cooperative, founded in 1922, was responsible for the project.

It should be noted that the area of the Officer's Estate at the time was previously almost completely uninvested. Between 1924 and 1926, three regulatory plans for the area were drawn up at the City Regulation Office, on which the few existing land use elements were marked. These plans were made by Andrzej Kłeczek, Kazimierz Teleśnicki and Marian Lenk.

The estate originally consisted of, among other things, low-rise residential buildings of varied architecture, built evenly along the streets. The greenery between the buildings was designed in an orderly manner, and the streets were laid out in a well-thought-out layout.

of Algiers, "IOP Conference Series: Materials Science and Engineering" 2019, no. 609(4), art. no. 042073. DOI: 10.1088/1757-899X/609/4/042073; S. Bensehla, Y. Lazri, M.C. Brito, *Solar potential of urban forms of a cold semi-arid city in Algeria in the present and future climate*, "Energy for Sustainable Development" 2021, vol. 62, pp. 151–162. DOI: 10.1016/J.ESD.2021.04.004 (access: 17.06.2024); C. Rubio-Bellido, *op. cit.*

[8] R. Lemoine-Rodríguez, L. Inostroza, H. Zepp, *Does urban climate follow urban form? Analysing intraurban LST trajectories versus urban form trends in 3 cities with different background climates*, "Science of The Total Environment" 2022, vol. 830, art. no. 154570, DOI: 10.1016/J.SCITOTENV.2022.154570 (access: 17.06.2024).

One wide Belina-Prażmowskiego Avenue dominates here, with a green belt between the roadways. The estate was created as a defined layout, based on a previously prepared plan. The entire area was divided into plots and resold to future owners, who built the houses themselves, but had to do so according to established guidelines and parameters in order to maintain a high level of construction. About 600 development plots were laid out, on which about 300 residential buildings were built by 1939. Building the Officers' housing estate took quite a long time. The first house designs were drawn up in the 1920s, but construction continued until World War II.

It is worth noting that prominent architects of the first half of the 20th century, i.e. Józef Pokutyński, Adolf Siódmak, Władysław Warczewski, Alfred Kramarski, Samuel Manber, Samuel Nebenzahl and Edward Skawiński,[9] were involved in the development of the estate.

Due to the development of Krakow over the past few decades, the Officers' Settlement went from being an area located on the outskirts of the city to being a settlement located in its centre.

Ill.1. Officers' housing estate in Krakow on the orthophotomap. The white color indicates the study area, elaborated by M. Krupa using map in: www.geoportal.gov.pl (access: 10.02.2024).

[9] M. Motak, *Osiedle Urzędnicze w Krakowie. Urbanistyka i Architektura 1924–1942*, Wydawnictwo PK, Kraków 2020, passim; M. Motak, *Ewolucja funkcjonalno-przestrzenna rejonu osiedla Oficerskiego w Krakowie. Od kolonii mieszkaniowych na peryferiach miasta do wielofunkcyjnego zespołu śródmiejskiego*, "*Środowisko Mieszkaniowe* – Housing Environment" 2019, no. 17, pp. 30–40; M. Baczyńska, *Osiedle Oficerskie w Krakowie*, "Rocznik Krakowski" 2014, vol. 80, pp. 157–178; D. Chernyshev et al., *Preservation of the Historical Kadetskyi Hai Ecosystem During A Military Threat Using Polish Experience*, "International Journal of Conservation Science" 2024, vol. 15(SI 1), pp. 291–304.

Ill. 2. Contemporary orthophotomap of Kraków, showing the Officers' Settlement (light circle) in relation to the Main Square (dark circle), compiled by M. Krupa using Google Earth, https://earth.google.com/web/ (access: 10.02.2024).

2.1. RESEARCH METHOD

The paper uses as a research method the measurement of temperature, humidity, as well as pressure using a Steinberg weather station, model: SBS-WS-200. The device is enriched with a design that allows its mobility. The station is equipped with a screen that monitors the magnitude of the parameters of the various climatic factors.

The weather station was set up on the west side, 0.5m. from the wall of the building, on a grassy ground. All measurements were taken at a height of 2.0m above the ground surface. Measurements were read taking into account the time from 6:00 am – 11:59 pm at night.

Previous observations by the Authors (J. Kobylarczyk, D. Kuśnierz-Krupa, M. Krupa) have shown measurement differences depending on the location of the study, taking into account the exposure of the walls to the sides of the world and the type of pavement.[10]

Measurements using the applied technology captured trends in changes and differences in temperature, pressure and humidity from June 2024 to September 25, 2024.

The primary goal of the study was to demonstrate that the use of technology is important in conducting research on the relationship of architecture and its surroundings to climatic conditions, including in historical surroundings.

Measurements were taken during the day and night at equal intervals (every 15 minutes).

The observations made are complementary to previous studies on the same or similar topics. The results of the research can be useful in the process of planning urban neighborhood interiors in residential areas of different character.

3. RESEARCH RESULTS AND THEIR ANALYSIS

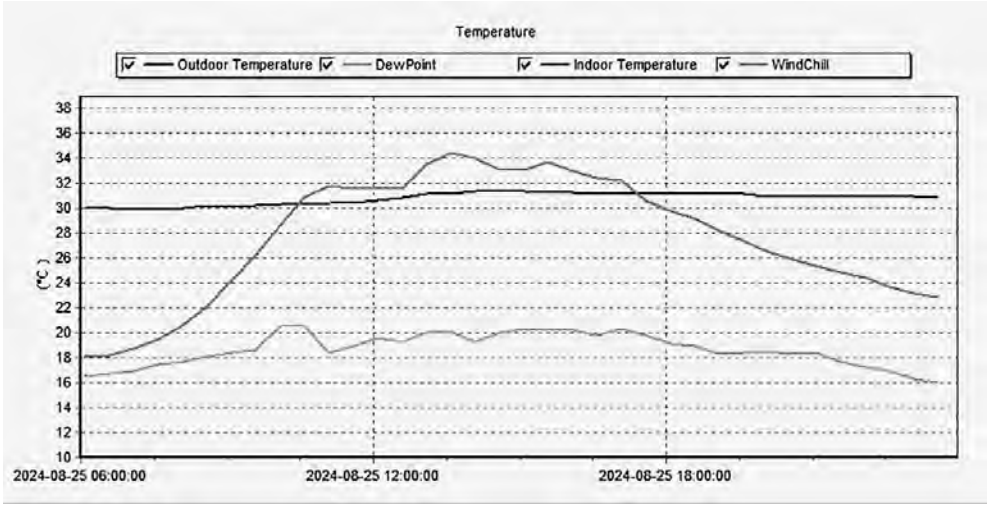
The results of the surveys are presented in graphical form. In this study, only the lowest and highest measurement results obtained from June to September 2024 are presented and shown in Ill. 3–6.

[10] J. Kobylarczyk, D. Kuśnierz-Krupa, M. Nowak-Ocłoń, *op. cit*.

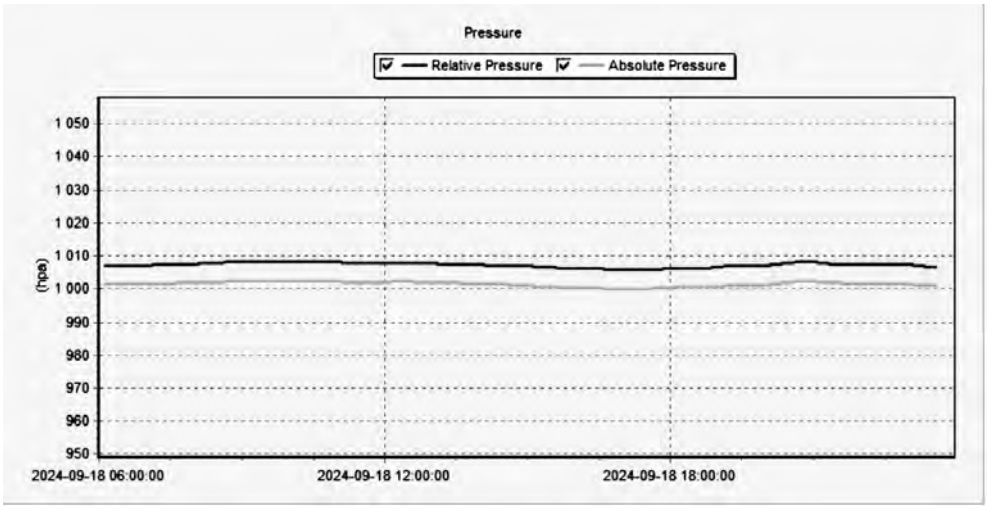
It has been noticed that often the highest and lowest values of air temperature occur on the same days as the highest and lowest values of air pressure and humidity although this is not the rule.

During the period from June to September 25, 2024, the days with the highest temperature were recorded; this included the day of 26.08.2024. The temperature then was 34° C. Among other things, 11.07.2024. recorded the highest value of DewPoint – 23°C, and although the pressure value was also high it was not the highest. The highest pressure was recorded on 18.09.09.2024 – 1010 hPa, among others.

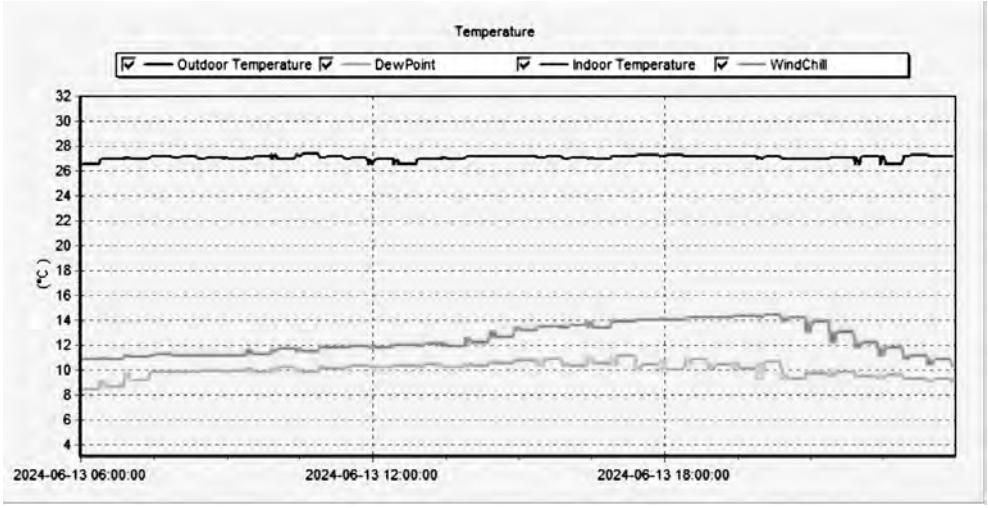
The lowest temperature was, among others, 13.06.2024 (measurements were taken until 25.09.2024) and was 14°C, while the lowest DewPoint value was recorded on 21.09.2024 – 6°C. The lowest pressure was recorded on 10.06.2024 (980 hPa), among others.



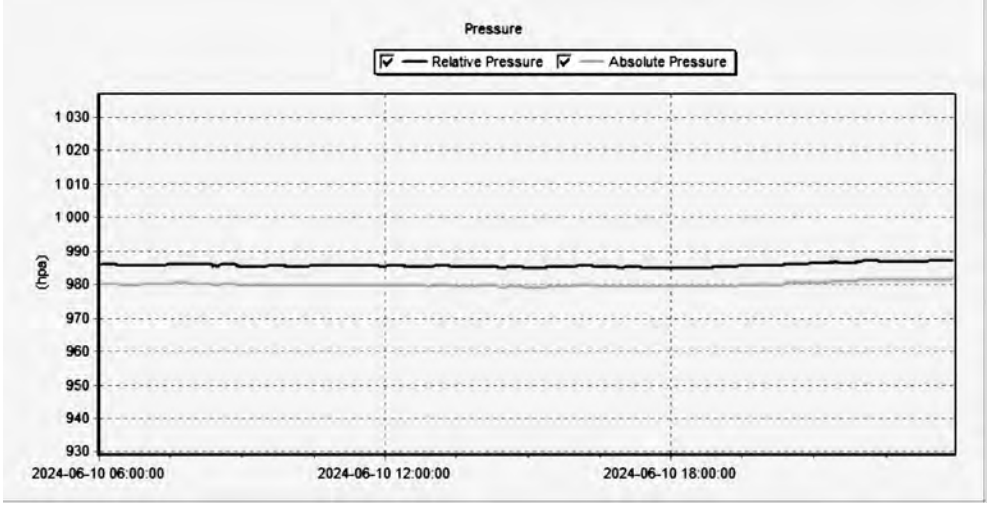
Ill. 3. Measurement results on the day when one of the highest temperatures was recorded.



Ill. 4. Measurement results on the day when one of the highest pressure values was recorded.



Ill. 5. Measurement results on the day when one of the lowest temperatures was recorded.



Ill. 6. Measurement results on the day when one of the lowest pressure values was recorded.

To analyze climatic factors, measurement technologies were used using a weather station mounted 0.5 m. away from the building wall, on the east side of the grassy area. The results of the study confirmed that technological tools are helpful in conducting research on architecture and its relationship with the environment and climatic conditions. The authors' previous research, also conducted in the downtown zone of Krakow in an adjacent neighborhood, showed the influence of the type of pavement on the temperature, which was higher near the wall of the building where the measurements were conducted. The pavement next to the building was paved. Hence, this time the research was carried out only considering the unpaved surface.

In addition, the results described in this paper showed that usually the highest and lowest values of air temperature occur on the same days as the highest and lowest values of air pressure and humidity although this is not the rule. There are fluctuations in the values of the parameters that do not allow confirmation of the rule.

4. FINAL COMMENTS AND CONCLUSIONS

Conclusions on contemporary architecture, technology and climate research are multifaceted and address both the relationship of architecture to the environment, including urban and environmental conditions. Today, these relationships are even more noticeable. The climate in which buildings are located can directly affect the form and function of architectural structures and urban layouts. Research around the world shows that appropriate design strategies that take into account local climatic conditions can significantly improve the energy efficiency and resilience of urban structures. In addition, the redevelopment and adaptation of historic buildings should include both cultural preservation and adaptation to contemporary standards of utility, climatic comfort and energy efficiency requirements.

The authors' research has shown that the historic buildings of the Officers' Housing Estate and its surroundings have a significant impact on the microclimate. The use of measurement technologies, such as a mobile meteorological station, has made it possible to precisely study the climatic factors in the estate's surroundings. This made it possible to identify differences in temperature, pressure and humidity, highlighting the role of environmental determinants of architecture in urban space. The results of the research show that the application of modern technology in the analysis of climatic factors is crucial for optimizing design and revitalization activities, as well as for gaining a broader knowledge of how historic urban areas function. The results of this research are an important contribution to the understanding of the impact of development on microclimates and can support future revitalization and design work.

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