sciendo ŚRODOWISKO MIESZKANIOWE/ HOUSING ENVIRONMENT 52/2025 WYZWANIA STOJĄCE PRZED ZRÓWNOWAŻONĄ ARCHITEKTURĄ ŚRODOWISKA MIESZKANIOWEGO e-ISSN 2543-8700 https://doi.org/10.2478/he-2025-0017

Received: December 03, 2024; **Received in revised form:** Jenuary 13, 2025; **Accepted:** Jun 27, 2025

Citation: Martyka, A., Licholai, R., Nowak, W., Fernández Torres, I. (2025). Sustainable Design in the Housing Environment: Integration of Modern Technology and Cultural Heritage Protection on the Example of the National Archive in Krakow. Środowisko Mieszkaniowe/ Housing Environment, e2025017. https://doi.org/10.2478/he-2025-0017

ANNA MARTYKA*, RAFAŁ LICHOŁAI**, WERONIKA NOWAK***, IGNACIO FERNÁNDEZ TORRES****

Sustainable Design in the Housing Environment: Integration of Modern Technology and Cultural Heritage Protection on the Example of the National Archive in Krakow

Abstract

Contemporary challenges in the design of public buildings, such as archives, include the integration of some aspects of heritage conservation, quality of the housing environment, and sustainability. Using the example of the new headquarters of the National Archive in Krakow, architectural and technological solutions that can be adapted in residential development are analysed. The analysed building combines modernity with care for the historic urban fabric, improving the quality of life of the residents. The project demonstrates how the harmonious coexistence of public and residential uses can support the aspiration for a sustainable urban environment that combines the needs of residents with the need to protect the cultural landscape.

Keywords: sustainable construction, urban environment, housing development, Krakow, heritage conservation, archives, quality of life

INTRODUCTION

The design of public buildings, including national archives, is a multi-dimensional challenge, requiring harmonious consideration of functional, aesthetic, technological and cultural requirements (*Archival and Special Collections Facilities: Guidelines for Archivists, Librarians, Architects, and Engineers*, 2011). The national archive acts as a custodian of resources of strategic importance to national memory and must therefore simultaneously ensure their preservation and accessibility to a wide range of users. The challenge, therefore, is to strike a balance between sustainable preservation of resources and their openness, which requires innovative architectural and technological solutions (Ivović & Ivović, 2015)

Contemporary challenges such as climate change and environmental degradation are forcing a sustainable approach to the design of architectural and urban spaces. It is now no longer sufficient to focus solely on reducing greenhouse gas emissions or improving the energy performance of buildings. Sustainable design requires a comprehensive approach that also includes the protection of cultural heritage, integrating environmental strategies with the preservation of social and cultural integrity (Zuziak, 2006, 2015). An integrated approach to urban design not only supports the protection of cultural values but also contributes to improving the quality of the housing environment and enhances the resilience of urban communities to global challenges.

This study analyses the new headquarters of the National Archive in Krakow, where one of the main design challenges was to combine modern technical solutions with respect for cultural heritage values. This problem assumes particular importance in the context of the growing demand for projects that combine environmental protection with the integration and adaptation of historical values. Reflecting on the relationship between technology, form and function of architecture reveals the potential of such solutions both in the context of heritage conservation and development and in improving living conditions in urban areas. Despite a rich literature on sustainable architectural and urban design, there is still a wide field of research on integrating modern technology with heritage conservation in the design of public buildings. The research problem addressed in this article was to, through a specific case study, identify design principles and strategies that enable the creation of buildings that are sustainable, functional and compatible with the preservation of

*Anna MARTYKA, D.Sc. Ph.D. Eng. Arch. Professor of RzUT, Faculty of Civil and Environmental Engineering and Architecture, Rzeszów University of Technology, https://orcid.org/0000-0001-7582-78280, e-mail: amartyka@prz.edu.pl

**Rafał LICHOŁAI, Ph.D. Eng. Arch., Faculty of Civil and Environmental Engineering and Architecture, Rzeszów University of Technology, https://orcid.org/0000-0002-0904-7812, e-mail: r.licholai@prz.edu.pl

***Weronika NOWAK, MSc, Faculty of Civil and Environmental Engineering and Architecture, Rzeszów University of Technology, https://orcid.org/0009-0005-5445-8361, e-mail: wer.nowak@gmail.com

****Ignacio FERNÁNDEZ TORRES, Professor of US, Universidad De Sevilla, Escuela Técnica Superior De Arquitectura, https://orcid.org/0000-0001-7352-3601, e-mail: nachotorres@us.es

cultural heritage. This research hypothesis suggests that the integration of advanced building technologies and energy management systems with the requirements of heritage conservation enables the design of spaces that are environmentally friendly, preserve historical values and respond to contemporary urban challenges.

This study was based on a combination of theoretical and empirical methods, considered typical for the disciplines of architecture and urban planning. A literature analysis of the subject was used in conjunction with a case study of the new headquarters of the National Archive in Krakow. The literature analysis served to define the theoretical interpretative framework and to formulate the research hypothesis. Interviews with architects, engineers and specialists involved in the design and ongoing management of the building were a valuable addition to the study. The expert opinions provided valuable insights that complemented the analysis of the design and technical documentation, offering a comprehensive view of the integration of modern technology with heritage conservation

THEORETICAL BACKGROUND FOR SUSTAINABLE ARCHIVE DESIGN IN URBAN ENVIRONMENTS

Aldo Rossi was probably the key reference in the 20th century attempt for a conciliation or contemporary interventions where heritage and significance has a main role in the production of architecture. In his seminal work *The Architecture of the City* (1984), Rossi pointed out the importance of monumentality and memory in urban space and its capacity to deal with heritage context with the background idea of cultural significance, seeing these characteristics as elements that give buildings a special role in preserving collective identity. Monumentality, according to Rossi, does not just mean the physical size of a building, but refers to its symbolic function and permanence over time. Louis Kahn (1991), on the other hand, saw monumentality as the spiritual dimension of architecture, in which the form of the building creates a bond between the users and the building structure itself (Kahn, 1991). In the case of state archives, monumentality plays a key role in underscoring the great importance for culture and national identity and the prestige of this type of institution. However, it must not dominate functionality; as Székely (2016) notes, monumentality should serve the logic of the building's operation, reinforcing its role as an institution, rather than being an end in itself. Moreover, archive buildings should fit into their spatial and cultural context. Integration with the urban environment and cultural landscape is becoming a significant challenge for contemporary designers. In cities with a centuries-old identity, such as Krakow, society expects modern buildings to fit harmoniously into the existing urban fabric, and respect cultural heritage. Rossi also pointed out that architecture is a carrier of the city's memory, and that buildings with socially significant functions should act as 'landmarks' in both a physical and symbolic sense (Rossi, 1984).

Rapid urbanisation, climate change and the depletion of natural resources exert pressures on modern cities, forcing them to transform towards sustainable urban infrastructure. This change is necessary to reduce the negative environmental impacts of urbanisation and improve the quality of life of citizens (Global Infrastructure Hub, 2024; UN-Habitat, 2024). The literature indicates that adapting cities to the challenges of climate change requires first and foremost reducing their carbon footprint and introducing solutions that support sustainability, such as energy-efficient building designs and resource management systems (OECD Urban Studies, 2020; Turok & McGranahan, 2013). The concept of sustainable development is one of the key policies of the European Union and Poland, enshrined in, among others, the Constitution of the Republic of Poland [Article 5], as the pursuit of sustainable socio-economic development based on environmental balance and the integration of activities in all its dimensions. This idea is reflected in urban planning and the shaping of urban spaces, the development of which should harmonise with the existing city structure, while ensuring an improved quality of life and the protection of cultural heritage. The idea of the compact city, which promotes a sustainable approach to space, minimises the effects of suburbanisation and supports the preservation of the historic urban fabric, may be an answer to these challenges.

Green building technologies, such as energy-efficient designs and renewable energy sources, are a key element of modern urban infrastructure. By implementing such technologies, it is possible to reduce energy consumption and thus reduce environmental impact. Studies show that buildings using green technologies consume on average 30–50% less energy compared to traditional buildings (Bilgen et al., 2004). Key elements of these technologies include, among others, energy-efficient lighting systems, building materials with a low carbon footprint and energy and water recovery systems (Asim et al., 2022; Pérez-Lombard et al., 2008). New developments, especially public buildings, need to incorporate energy efficiency principles and the use of green materials to reduce environmental impact and exploitation of natural resources. The Nearly Zero Energy Buildings (nZEB) standards introduced by Directive 2010/31/EU require a significant proportion of energy to come from renewable sources, in addition to high thermal insulation standards and technologies such as photovoltaic systems and heat pumps are now a priority in sustainable design (Fedorczak-Cisak et al., 2024).

The implementation of innovative technologies in urban environments is fundamental to the achieve sustainability (Hurlimann et al., 2021). Additionally, passive design strategies, such as optimization of the use of sunlight and natural ventilation, can reduce energy demand, as evidenced in research on building energy efficiency (Dekay & Brown, 2001; Olgyay, 2015). Green roofs also improve air quality, increase biodiversity and improve the thermal insulation of buildings, which also results in lower energy costs (Hosseinzadeh et al., 2022). All these design strategies are implemented by management with tools as Smart Building Systems, using the Internet of Things (IoT) to monitor and manage energy consumption (Nižetić et al., 2020), support the optimisation of non-renewable resource use and the reduction of CO_2 emissions (Chan et al., 2009; Hui et al., 2023).

It is also worth mentioning that the adaptation of historic buildings to contemporary needs is increasingly based on advanced technologies, such as BIM or 3D scanning, which enable the precise mapping of structures and the necessary intervention during conservation work. These tools, used as part of the smart city concept, support both the preservation of monuments and the management of the urban environment (Riganti, 2017). Examples from Amsterdam and Barcelona point to the effective use of digital technologies that combine heritage conservation with sustainable development principles. A sustainable approach to the preservation and revitalisation of historic urban landscapes requires consideration of local social values, contemporary needs and active community participation (Muminović et al., 2020). Technologies such as GIS support conservation efforts, enabling urban development to be

harmoniously combined with heritage conservation (Sánchez-Aparicio et al., 2020). However, over-modernisation can lead to a loss of authenticity, challenging designers to strike a balance between conservation and adaptation. The involvement of local communities plays an important role in the heritage conservation process, strengthening the bond with its values and raising awareness of the responsibility for its preservation. European heritage conservation policies emphasise international cooperation, involving governments, educational institutions and NGOs. The aim is to create consistent conservation standards to manage cultural resources more effectively (ICOMOS, 1975; UNESCO, 2011; UNESCO World Heritage Centre, 2023).

Modern archives require advanced air-conditioning and energy technologies to ensure appropriate document storage conditions and long-term preservation. Research indicates that environmental controls, supported by innovative technologies, underpin the efficiency and sustainability of such facilities (Bibri & Krogstie, 2020). The design of such buildings should also consider access for people with special needs, ensuring inclusivity for all users. Adapting public spaces to the needs of the elderly and disabled is now a standard of modern design (Fedorczak-Cisak et al., 2024).

Further investment and development of green building technologies and urban planning strategies are important to achieve sustainable urban development (C40 Cities and Arup, 2021; IEA, 2024). Policy makers, urban planners and architects should take coordinated action to implement green technologies and promote innovative urban planning practices. Sustainable practices in urban infrastructure, such as climate-resilient design and integrated urban planning, can address the challenges of modern cities (Abuwaer et al., 2023; Zuziak, 2006).

The integration of green technologies in architectural and urban design has multidimensional benefits. Not only does it promote environmental protection, but it also improves the quality of life for residents. Environmentally friendly cities, through solutions such as improving air quality, reducing noise or creating green spaces, have a positive impact on the physical health and well-being of their inhabitants. (Passos Neto et al., 2023; Singla, 2024; WHO, 2016). The development of sustainable spaces enhances and resilience of cities to climate change, while promoting healthy lifestyles (Shashua-Bar et al., 2009; Tzoulas et al., 2007).

CASE STUDY: NEW BUILDING OF THE NATIONAL ARCHIVE IN KRAKOW

The primary motivation for constructing the new National Archive building was to consolidate Poland's historically valuable archival materials, previously dispersed across multiple branches, and to ensure optimal storage conditions to prevent degradation. The new building is part of a nationwide network, providing storage space to accommodate archival materials that should reach the state's holdings as quickly as possible. The architectural proposal for the building, on which the technical design was based, was selected through an architectural competition. The design includes key guidelines such as integrating the building harmoniously into the surrounding urban landscape, meeting the requirements of the functional-utility programme and ensuring a high operational efficiency. Particular attention was paid to compliance with the then applicable provisions of the 2012 EU Directive, which required Member States to reduce the energy demand of government and public institution buildings (Directive of the European Parliament and of the Council, 2023). The new headquarters of the National Archive in Krakow is

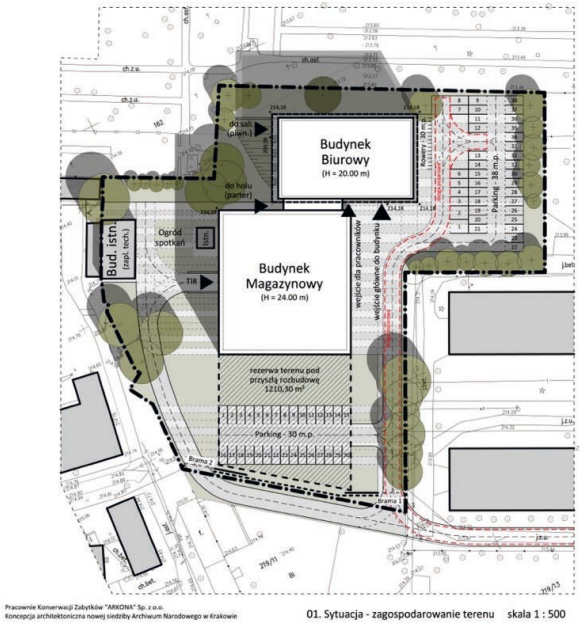

Fig. 1. Site plan and schematic development of the project site. By Michał Misiak. Source: PKZ Arkona Sp. z o.o.

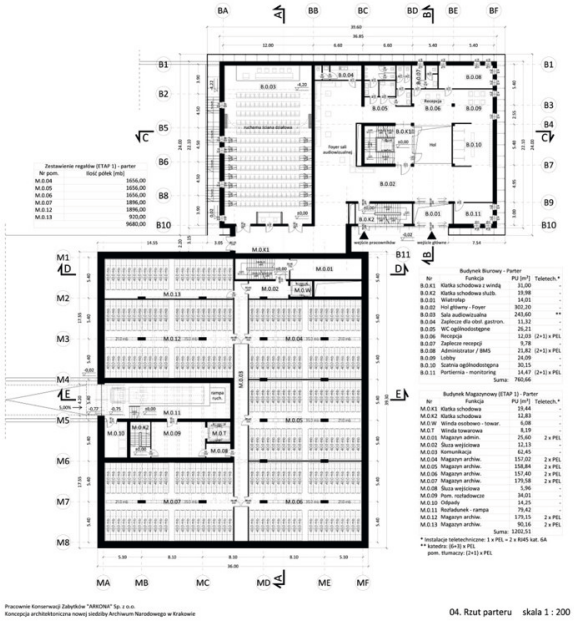

Fig. 2. Diagram of the ground floor plan of the building of the National Archive in Krakow. By Michał Misiak. Source: PKZ Arkona Sp. z o.o.

located on a plot of just under one hectare, in the city centre, on the site of the former Krakow Fortress. The building is directly adjacent to the Rakowicki Cemetery – one of Krakow's most important monuments and a symbol of past generations. In the close vicinity of the archive there is a military base, the Museum of Photography and the Home Army Museum, the University of Economics campus and the Main Railway Station. In addition to public buildings, the surrounding area is saturated with residential functions. In the immediate vicinity of the archive there are both new development projects and older residential buildings, varying in terms of period of construction, scale and intensity. Modern residential development in the vicinity of the archive creates an urban space with a concentrated character, characterised by high standards and high housing prices. This

complex urban context placed high demands on the designers in terms of both architectural aesthetics and harmonious integration of the building into the surrounding space. The architects' challenge was to create a building that respectfully referred to the historical and cultural heritage of the site, while responding to functional and ecological guidelines. Emphasis was placed on the preservation of greenery and concern for the environment. The project envisages maximum preservation of the existing vegetation on the plot. As a compensatory measure for the necessary felling on the site, around 250 new trees were planted in the Wolski Forest, close to the Krakow Zoo.

In terms of urban composition, the building builds an intimate, clearly defined urban interior, harmonising with the neighbouring six-storey residential buildings. The dense greenery of the old trees of the Rakowicki Cemetery is an important element that shapes this space and enriches the aesthetics and ecology of the area, while improving the microclimate and biodiversity. The landscaping design also includes street furniture solutions such as bicycle racks, which fit in with the concept of sustainable transport. The bicycle, as an alternative means of transport, is becoming increasingly popular in congested Krakow. Despite its central location, the area around the archive remains relatively quiet and green. The proximity of the Central Railway Station and access to the tram line along Rakowicka Street provide convenient transport connections, increasing the functionality and accessibility of this part of the city.

The new headquarters of the National Archive in Krakow is distinguished by its architectural form, which harmoniously combines elements of monumentalism and minimalism. The building consists of two differentiated masses: an office mass (20 m lower) located on the cemetery side and a storage mass

Fig. 3. Visualisation of the National Archive building from the Rakowicki cemetery. By Michał Misiak. Source: PKZ Arkona Sp. z o.o.

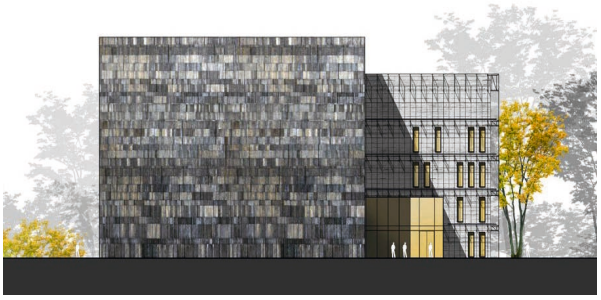

Fig. 4. Colour scheme for the south elevation with the main entrance to the Archives building. By Michał Misiak. Source: PKZ Arkona Sp. z o.o.

Fig. 5. View towards the north of the urban interior defined by the National Archive building and the new development. Source: A. Martyka.

Fig. 6 View towards the south. On the right, the glazed elevation of the office volume. Source: A. Martyka.

(24 m higher) located on the south side. The two volumes are connected by a connecting passageway, which ensures both functionality and efficient use of available space. The spatial arrangement of the masses was adapted to the shape of the plot, but at the same time reflects the clear functional division into a storage zone and an office zone. This solution emphasises both the pragmatic and symbolic dimensions of the building. The storage area symbolises the security and importance of the collections stored, while the office area, responsible for providing access to source materials (Rice, 2023), opens to users through glazed and reflective facades. A noteworthy architectural element is the glazed facade in the form of a 'second skin', which enriches the aesthetics of the building while improving its energy efficiency. The facade colour scheme, which is kept in natural tones, promotes a harmonious integration of the building into the surrounding landscape.

Functional and design solutions [1]

The new premises of the National Archive in Krakow have been designed with the highest standards of collections storage and convenience of use in mind, while providing a functional division of space. The layout of the building, like the mass, is based on two main functional zones: office and storage, and on two separate accessibility paths for archive employees and for the public (Górkiewicz, 2015) what obviously contributes to an easy understanding of its nature for the users and citizens as part of its monumentalism which a clear and readable message for the context.

Within the office volume, the basement houses key technical rooms such as the fan room, electrical switchgear with a UPS system, a heat pump room, a pumping station, water connections and cloakrooms and administrative storage. The basement also contains part of a two-storey conference room, with a foyer and sanitary facilities for the public. On the ground floor, the main entrance for visitors leads to a spacious hall divided into two areas: the first, on the left, houses the cloakroom and reception area, and the second, the conference room for 182 people. In addition, there are sanitary facilities on this level and a separate entrance exclusively for staff. On the first floor, an extensive reading room with 100 seats is planned, with a reception area and transitional storage. The second and third floors are exclusively for employees, with office, social and technical spaces arranged around a circulation shaft. The fourth floor of the office mass houses the conservation, digitisation, reprography and bindery workshops, as well as a digital repository with precision air conditioning.

The storage mass has been designed with maximum protection for the collections and flexibility to adapt the space to changing needs. The main storage area is located on six floors from the first to the sixth floor, with a three-tier layout. Each storey has symmetrically arranged shelving and a central corridor, allowing for future expansion of the mass in the southern direction. On each floor, entrance airlocks separate the circulation cores from the storage area to maintain stable climatic conditions. Vertical circulation is provided by two staircases and lifts – one freight elevator and one passenger elevator in the main storage core and another freight elevator in the delivery area. The basement contains the collection reception and preservation areas, the selection, cleaning and technical rooms (fan room and pump room for the water mist extinguishing system), and a specialised photographic collection storage area, equipped with a system of two cold rooms. The ground floor of the storage volume includes an unloading ramp suitable for TIR trucks, unloading rooms and archive storage.

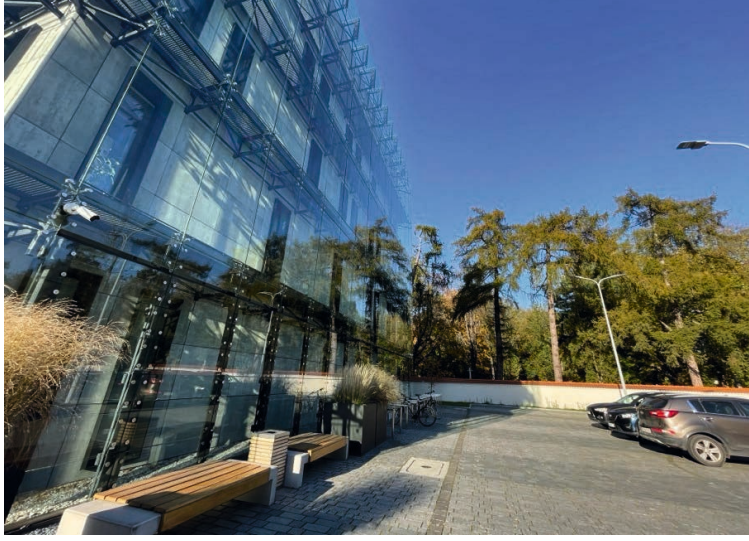

Fig. 7. View towards Rakowicki Cemetery. Source: A. Martyka.

Technical and material solutions

In designing the archive, technical and material solutions were used that meet high standards of thermal protection and energy efficiency, reducing the building's operating costs while maintaining reasonable investment costs.

The office segment is constructed in monolithic reinforced concrete construction, with a slab-and-column system and a slab-and-beam-wall system within the conference room. The outer wall of the office section with thermal insulation and GRC architectural concrete finish and an additional external glazed façade, the so-called 'second skin' located away from it, form a dynamic and flexible system that acts as a cooling air curtain in summer and as a thermal buffer in winter. The glazed 'second skin' facade features automated louvres at the top and bottom for climate control. Depending on the season, time of day, temperature, wind strength and sunshine, the movement of air in the partition can be regulated (ventilation based on the natural draught effect) or completely removed (improving the thermal inertia of the partition). The control of the louvres is based on data obtained from sensors of the weather station distributed on the façade, integrated into the building's BMS.

The structure of the storage cubicle is post-and-beam with 35 cm thick monolithic reinforced concrete external walls, guaranteeing not only structural rigidity but also high thermal inertia. The external cladding of the storage cubicle is made of GRC panels with the texture of crushed stone, supported on an independent steel substructure, minimising thermal bridges and heat transfer coefficient. Thanks to this solution, the number of penetrations through the thermal insulation layer was reduced to the necessary minimum

Renewable energy sources such as heat pumps and photovoltaic systems have been designed for the archive building, resulting in energy efficiency (to NF40 energy standard) for the office building) and low energy consumption (to NF15 energy standard) for the warehouse building). Solutions have also been applied to stabilise the climate in a passive way in the storage areas. Interestingly, the foundations of both segments, due to the properties of the soil and the loads, are based on reinforced concrete drilled piles, which additionally serve as ducts for technical systems and ground heat exchangers.

Internal systems and energy efficiency

Both segments of the National Archive building use internal systems to ensure high energy efficiency. Key elements of the energy-saving system are the mechanical ventilation, the

heating and cooling system and alternative energy sources.
Mechanical ventilation has the following key features:

- Central air handling units equipped with rotary heat exchangers (for rooms without chemical pollutants) provide a temperature efficiency of more than 80%, making it possible to recover heat and cold from the extracted air.
- In laboratories where chemical contamination may occur, crossflow heat exchangers are used.
- Air flow control using inverter motors adapts the ventilation to current needs.
- In the storage segment, fresh air is only supplied when necessary due to the contaminants present, the mechanical ventilation has the option of running on 100% recirculated air improving energy efficiency.

Heating and cooling have the following key features:

- The storage segment uses a ventilation system combined with air heating, with a central ventilation system with a rotating heat exchanger based on ground probes.
- Cooling and heating in both buildings is provided by ground-source heat pumps, offering both active and passive cooling.

The building incorporates the following renewable energy systems:

- A 40 kW photovoltaic system was planned for the roof of the warehouse building, maximising energy efficiency while avoiding the need for a licence to generate and sell energy.

Due to the nature and importance of the building, a building management system (BMS) has been designed for the electrical and low-current systems (including, for example, control of general lighting in relation to the presence in the rooms, control of administrative lighting and night lighting, UPS monitoring, monitoring of lifts, monitoring of electrical switching stations, monitoring of current electricity consumption – EMS, monitoring of room occupancy and presence in the passageways) and sanitary systems (for example, control of supply and exhaust, control of heat pump operation, control of air-conditioning equipment, monitoring of room temperature and humidity, stabilisation of temperature and humidity in selected rooms, monitoring of utility meters and monitoring of energy consumption for individual components of the facility, monitoring of the heat centre, monitoring of technological systems for cooling and central heating, control of ventilation, heating and cooling automation systems – HVAC). The building management system (BMS) also includes the building security system (e.g., fire detection and signalling, lift fire exit, unlocking of doors on the escape route).

ANALYSIS OF THE RELATIONSHIP BETWEEN THE NATIONAL ARCHIVE AND THE URBAN ENVIRONMENT AND CULTURAL HERITAGE

Urban context

The new headquarters of the Archive is in an area with a complex urban structure, combining modern housing developments with the historic buildings of the former Krakow Fortress (Ill. 8). The revitalised fortress buildings house public and cultural institutions such as universities and museums. To the west, the archive is adjacent to the dynamically developing housing estates that dominate this part of the city and contrast with the historic fortifications. The proximity of the cemetery and green spaces encourages a harmonious design that respects the natural landscape. The building is part of the development of this part of the city, enriching its functionality with its unique institutional role. It is integrated with the urban fabric through the organisation of public spaces, the provision of access to green areas and an infrastructure conducive to pedestrian and cycle traffic. Its monumental approach throughout scale and disposition in terms of public space, characteristic of public institutions, has been softened by an appropriate choice of facade materials and spatial relationships with the surroundings, allowing it to fit coherently into the urban context.

Fig. 8. Schematic diagram of the urban context of the National Archive in Krakow and its relationship to the historical heritage. Source: A. Martyka.

Relationship to historical heritage

The heritagisation of architecture requires analyses to go beyond dominant discourses, starting by acknowledging the multiplicity of stakeholders and their role in the identification of attributes (Spoormans et al. 2023). The historical heritage of the site is an important element influencing the design of the archive. In the immediate vicinity are the historic bastions of the Krakow Fortress, whose origins date back to the mid-19th century, when the city was recognised by the Austrians as a key defensive point. The new building not only respects these historical overhangs but also incorporates them into its architectural language through an appropriate choice of materials and colours. The façade of the warehouse building is clad with GRC panels in a horizontal layering pattern, with colours inspired by rock and earth. The surface texture, reminiscent of broken stone, further emphasises the reference to the historical and cultural context of the site and strongly remarks the action of both monolithic volumes erecting from the ground as a natural event. The administrative section, on the other hand, is characterised by a reflective glass façade that softens its shape like a curtain and subtly reflects the greenery of the nearby cemetery, enhancing the effect of visual integration with the surroundings. That offers a complex response to what David Michael Levin termed 'frontal ontology' – a concept describing the tendency of dominant solutions in contemporary architecture to rely on a psychological approach akin to advertising, aiming for instant persuasion through memorable visual images or patterns (Jameson, 1995). These approaches often replace plastic and spatial strategies based on surfaces where time plays a secondary role, which inevitably impacts their capacity for architectural prominence. The interior of the building shares this approach of preservation and connection to the local heritage values that reproduce the standard public building sequence of spaces. The entrance area and foyer have incorporated an exhibition function, making it possible to organise temporary and permanent exhibitions on the history of Krakow and the region.

In this way, the Archives will become not only an institution for preserving documents, but also a place for active participation in the process of popularising cultural heritage.

Social inclusion and accessibility

The new archive headquarters is not a closed institution, but a space open to residents and researchers. There is an extensive archive reading room open to the public and a library to complement the research facilities. In addition, the institution organises educational and cultural events, strengthening its links with the local community. The accessibility of the building has been designed to eliminate architectural barriers with a fully adapted circulation infrastructure for people with reduced mobility. The areas around the building and the foyer encourage social interaction and integration of different user groups, depending on the weather conditions of each season.

SUMMARY AND CONCLUSIONS

The new headquarters of the Archive is an example of the well-planned integration of the building with its urban, historical and social surroundings. Its location between new housing developments and the historic bastions of the Krakow Fortress creates a dynamic dialogue between past and present. The archive not only fulfils an institutional function but also acts as a catalyst for social and educational activities. Through the appropriate use of space, choice of materials and attention to accessibility and functionality, the building is a good example of the harmonious combination of modern architecture with the city's historical and cultural heritage.

The presented analysis of the new headquarters of the National Archive in Krakow shows that an integrated approach to the design of public buildings is essential to achieve the goals of sustainable development and the protection of cultural heritage. The following aspects are particularly important:

- technological innovations and their impact on efficiency – the introduction of systems such as BMS, passive climate solutions and renewable energy sources such as heat pumps and photovoltaic systems, enables a significant reduction in operating costs and environmental impact.
- functional separation and protection of the collections – the separation of the use areas into public and storage areas allows the archives to be effectively protected, while ensuring functionality and user comfort. Humidity and temperature control systems guarantee appropriate conditions for the long-term storage of documents.
- harmonious integration with the surroundings – the building has been designed with respect for Krakow's historical urban context, which can be seen in its architecture and compensatory measures related to the preservation and supplementation of greenery.
- long-term adaptability – the modular storage layout allows flexible adaptation to future needs, which is an important element of sustainable planning.
- improvement to the quality of the urban environment – the implementation of the project has had a positive impact on the surroundings using ecological solutions, such as the introduction of compensatory greenery and systems to improve the microclimate. The harmony with the residential development and the creation of a resident-friendly space are conducive to raising the standard of living in this part of the city.

The article answers the research question by demonstrating with a case study how contemporary architectural, urban and technological solutions can support sustainable development, heritage conservation and the improvement of the quality of the living environment. The design strategies presented in the analysis support the hypothesis that the integration of advanced building technologies and energy management systems with the requirements of heritage conservation enables the design of environmentally friendly spaces that are compatible with historical values and meet contemporary urban challenges. The archive is an example of the synergy between tradition and modernity, creating a space that is functional, aesthetically pleasing and in keeping with the urban context of Krakow.

Acknowledgements

We would like to thank Wojciech Feliks from the Monument Conservation Studio PKZ "Arkona" Sp. z o.o in Krakow for his valuable assistance and for making available the materials that were necessary for the creation of this article.

ENDNOTES

[1] This section uses information from the technical design (Górkiewicz, 2015) and information obtained during interviews with the designers and technical administration of the archive building.

BIBLIOGRAFIA

[1] Abuwaer, N., Ullah, S., & Al-Ghamdi, S. G. (2023). Building Climate Resilience Through Urban Planning: Strategies, Challenges, and Opportunities. In: *Sustainable Cities in a Changing Climate: Enhancing Urban Resilience*. https://doi.org/10.1002/9781394201532.ch12

[2] Archival and Special Collections Facilities: Guidelines for Archivists, Librarians, Architects, and Engineers. (2011). *Journal of Documentation*, *67*(4). https://doi.org/10.1108/00220411111145089

[3] Asim, N., Badiei, M., Mohammad, M., Razali, H., Rajabi, A., Chin Haw, L., & Jameelah Ghazali, M. (2022). Sustainability of Heating, Ventilation and Air-Conditioning (HVAC) Systems in Buildings—An Overview. *International Journal of Environmental Research and Public Health* (Vol. 19, Issue 2). https://doi.org/10.3390/ijerph19021016

[4] Bibri, S. E., & Krogstie, J. (2020). Environmentally data-driven smart sustainable cities: applied innovative solutions for energy efficiency, pollution reduction, and urban metabolism. *Energy Informatics*, *3*(1). https://doi.org/10.1186/s42162-020-00130-8

[5] Bilgen, S., Kaygusuz, K., & Sari, A. (2004). Renewable energy for a clean and sustainable future. *Energy Sources*, *26*(12). https://doi.org/10.1080/00908310490441421

[6] C40 Cities and Arup. (2021). *Green and Thriving Neighbourhoods Guidebook*. https://www.c40.org/wp-content/uploads/2021/10/C40-Arup-GTN-Guidebook_2021.pdf

[7] Chan, M., Campo, E., Estève, D., & Fourniols, J. Y. (2009). Smart homes – Current features and future perspectives. In *Maturitas* (Vol. 64, Issue 2). https://doi.org/10.1016/j.maturitas.2009.07.014

[8] Dekay, M., & Brown, G. Z. (2001). SUN, WIND & LIGHT: Architectural Design Strategies. *Society of Building Science Educators*.

[9] Directive of the European Parliament and of the Council. (2023). *On energy efficiency and amending Regulation (EU) 2023/955* (1791).

[10] Fedorczak-Cisak, M., Haupt, P., Markiewicz-Zahorski, P., & Cechini, K. (2024). Climate-neutral historic buildings, Slowacki Theatre in Poland – case study. *MATEC Web of Conferences 396*, 1–13. https://doi.org/10.1051/matecconf/202439620010.

[11] Global Infrastructure Hub. (2024, March 6). *Assessing Climate Change Costs with Systemic Resilience Metrics: A Forward-Looking Approach*. Global Infrastructure Hub. https://www.gihub.org/articles/assessing-climate-change-costs-with-systemic-resilience-metrics-a-forward-looking-approach/

[12] Górkiewicz, P. (2015). Projekt architektoniczno-budowlany budowy nowej siedziby Archiwum Narodowego w Krakowie, remontu i przebudowy dwóch istniejących budynków, drogi dojazdowej oraz bramy wjazdowej – architektura. In: *Pracownie Konserwacji Zabytków Arkona Sp. z o.o.*

[13] Hosseinzadeh, A., Bottacin-Busolin, A., & Keshmiri, A. (2022). A Parametric Study on the Effects of Green Roofs, Green Walls and Trees on Air Quality, Temperature and Velocity. *Buildings*, *12*(12). https://doi.org/10.3390/buildings12122159
[14] Hui, C. X., Dan, G., Alamri, S., & Toghraie, D. (2023). Greening smart cities: An investigation of the integration of urban natural resources and smart city technologies for promoting environmental sustainability. *Sustainable Cities and Society*, *99*. https://doi.org/10.1016/j.scs.2023.104985
[15] Hurlimann, A. C., Moosavi, S., & Browne, G. R. (2021). Climate change transformation: A definition and typology to guide decision making in urban environments. *Sustainable Cities and Society*, *70*. https://doi.org/10.1016/j.scs.2021.102890
[16] ICOMOS. (1975). *European Charter of the Architectural Heritage*. https://www.icomos.org/en/and/169-the-declaration-of-amsterdam
[17] IEA. (2024). *World Energy Outlook 2024*. https://www.iea.org/reports/world-energy-outlook-2024
[18] Ivović, S. P., & Ivović, I. (2015). Archival Building Design Challenge: Architects, Archivists and Conservators an the Same Task in Order to Ensure Adequate Protection of Archivers. *Atlanti*, *25*(2). https://doi.org/10.33700/2670-451x.25.2.11-120(2015)
[19] Jameson, F. (1995). *El posmodernismo o la lógica cultural del capitalismo avanzado*. Paidós.
[20] Kahn, L. (1991). *Louis I. Kahn: Writings, Lectures, Interviews (A. Latour, Ed.). Rizzoli International Publications* (Latour, A). Rizzoli International Publications.
[21] Muminović, E., Radosavljević, U., & Beganović, D. (2020). Strategic planning and management model for the regeneration of historic urban landscapes: The case of historic center of Novi Pazar in Serbia. *Sustainability (Switzerland)*, *12*(4). https://doi.org/10.3390/su12041323
[22] Nižetić, S., Šolić, P., López-de-Ipiña González-de-Artaza, D., & Patrono, L. (2020). Internet of Things (IoT): Opportunities, issues and challenges towards a smart and sustainable future. *Journal of Cleaner Production*, *274*. https://doi.org/10.1016/j.jclepro.2020.122877
[23] OECD Urban Studies. (2020). *The Circular Economy in Cities and Regions: Synthesis Report*. OECD Publishing. https://doi.org/https://doi.org/10.1787/10ac6ae4-en
[24] Olgyay, V. (2015). Design with climate: Bioclimatic approach to architectural regionalism: New and expanded edition. In: *Design with Climate: Bioclimatic Approach to Architectural Regionalism: New and Expanded Edition*.
[25] Passos Neto, G. da M., Alencar, L. H., & Valdes-Vasquez, R. (2023). Multiple-Criteria Methods for Assessing Social Sustainability in the Built Environment: A Systematic Review. In: *Sustainability (Switzerland)* (Vol. 15, Issue 23). https://doi.org/10.3390/su152316231
[26] Pérez-Lombard, L., Ortiz, J., & Pout, C. (2008). A review on buildings energy consumption information. *Energy and Buildings*, *40*(3). https://doi.org/10.1016/j.enbuild.2007.03.007
[27] Rice, L. (2023). After Covid-19: urban design as spatial medicine. *Urban Design International, 28*(2). https://doi.org/10.1057/s41289-020-00142-6
[28] Riganti, P. (2017). Smart cities and heritage conservation: Developing a smartheritage agenda for sustainable inclusive communities. *Archnet-IJAR: International Journal of Architectural Research*, *11*(3). https://doi.org/10.26687/archnet-ijar.v11i3.1398
[29] Rossi, A. (1984). *The Architecture of the City*. The MIT Press.
[30] Sánchez-Aparicio, L. J., Masciotta, M. G., García-Alvarez, J., Ramos, L. F., Oliveira, D. V., Martín-Jiménez, J. A., González-Aguilera, D., & Monteiro, P. (2020). Web-GIS approach to preventive conservation of heritage buildings. *Automation in Construction*, *118*. https://doi.org/10.1016/j.autcon.2020.103304.
[31] Shashua-Bar, L., Pearlmutter, D., & Erell, E. (2009). The cooling efficiency of urban landscape strategies in a hot dry climate. *Landscape and Urban Planning*, *92*(3–4). https://doi.org/10.1016/j.landurbplan.2009.04.005
[32] Singla, A. (2024). Sustainable Urban Infrastructure: Innovations in Green Building Technologies and Urban Planning. *Universal Research Reports*, *11*(4). https://doi.org/https://doi.org/10.36676/urr.v11.i4.1316
[33] Spoormans, L., Pereira Roders, A., Czischke, D., & de Jonge, W. (2023). Web of attributes: analysing residents' appreciation of a Dutch neighbourhood from a new heritage perspective. *Journal of Housing and the Built Environment*, *38*(4), 2473–2499. https://doi.org/10.1007/s10901-023-10042-0
[34] Székely, J. (2016). (Non-)Monumental Layers of Berlin. *International Journal for History, Culture and Modernity*, *4*(1). https://doi.org/10.18352/hcm.497
[35] Turok, I., & McGranahan, G. (2013). Urbanization and economic growth: The arguments and evidence for Africa and Asia. In: *Environment and Urbanization* (Vol. 25, Issue 2). https://doi.org/10.1177/0956247813490908
[36] Tzoulas, K., Korpela, K., Venn, S., Yli-Pelkonen, V., Kaźmierczak, A., Niemela, J., & James, P. (2007). Promoting ecosystem and human health in urban areas using Green Infrastructure: A literature review. In: *Landscape and Urban Planning* (Vol. 81, Issue 3). https://doi.org/10.1016/j.landurbplan.2007.02.001
[37] UNESCO. (2011). Recommendation on the Historic Urban Landscape. *Records of the General Conference – 31st Session*, *1* (November).
[38] UNESCO World Heritage Centre. (2023). *Operational Guidelines for the Implementation of the World Heritage Convention*.
[39] UN-Habitat. (2024). *World Cities Report 2024: Cities and Climate Action*. https://unhabitat.org/sites/default/files/2024/11/wcr_2024_-_front_matter.pdf
[40] WHO. (2016). *Urban green spaces and health. A review of evidence*.
[41] Zuziak, Z. (2006). Planning and designing for sustainable development of a historic city. The case study of Kraków. *Environment Protection Engineering*, *32*(1).
[42] Zuziak, Z. (2015). Urbanistyka i dziedzictwo kultury. Strategie, aktorzy i struktury w labiryntach miejskości. *Wiadomości Konserwatorskie – Journal of Heritage Conservation*, *44*, 19–32.