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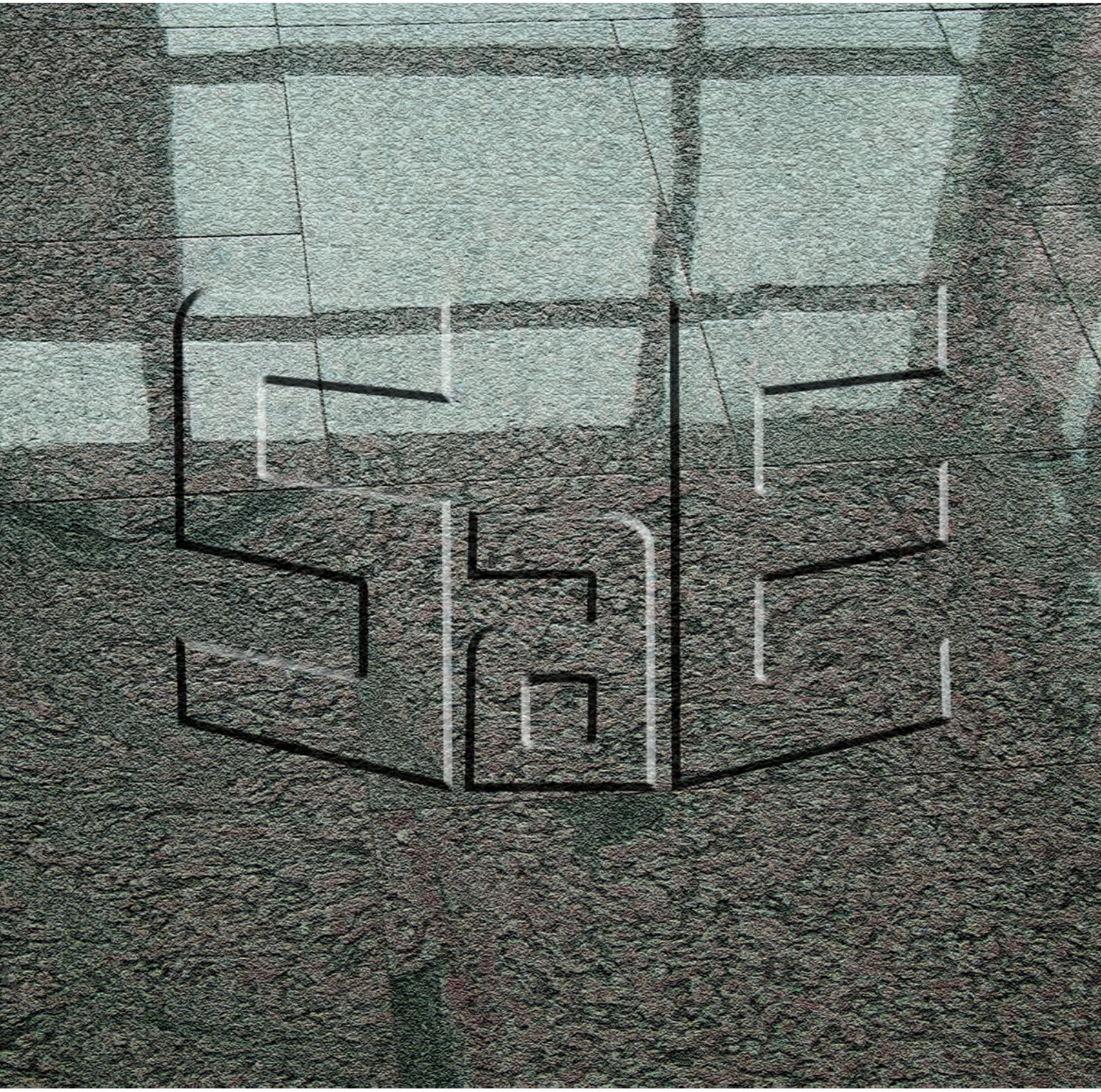

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DETERMINATION METHODS OF BOILING HEAT FLUX

METODY WYZNACZANIA GĘSTOŚCI STRUMIENIA CIEPŁA DLA WRZENIA

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Abstract

Boiling is a phase-change phenomenon, which is of significant practical application potential due to large heat flux values exchanged in the process. The paper provides an overview of calculation methods that enable to determine the values of pool boiling heat flux on smooth surfaces. The most commonly used correlations were analysed and the boiling phenomenon occurring on smooth surfaces has been discussed based on the experimental data. A modification of the Rohsenow model has been proposed with the values of the constants determined experimentally.

Keywords: boiling, correlations, heat transfer, heat flux

Streszczenie

Wrzenie to zjawisko związane ze zmianą fazy czynnika, które ma znaczny potencjał praktyczny z uwagi na wymianę dużych gęstości strumienia ciepła. Artykuł przedstawia metody wyznaczania gęstości strumienia ciepła wymienianego przy wrzeniu. Analizuje najczęściej stosowane korelacje i opisuje zjawisko wrzenia, odbywające się na powierzchniach gładkich, w oparciu o badania eksperymentalne. Zaproponowano modyfikację modelu Rohsenowa zawierającą nowe wartości stałych eksperymentalnych.

Słowa kluczowe: wrzenie, korelacje, wymiana ciepła, gęstość strumienia ciepła

1. INTRODUCTION

The boiling process enables to exchange large amounts of heat at very small temperature differences. This is both due to significant latent heat but also convention heat transfer. There are many parameters that have an impact on this thermodynamic phenomenon such as boiling liquid properties, thermophysical properties of the heater and it microgeometry, special orientation and etc. [1]. El-Genk and Bostanci [2] analysed the boiling performance at various surface inclination angles and found that for the angles above 90° and superheat above 13 K heat flux decreased with increasing angles. The findings were generally supported by the work of Priarone [3] who stated that heat flux at inclinations above 90° heat transfer is hampered due to bubbles' accumulation. However, for significant superheats and angles up to 90° no influence can be observed. Nishikawa and Ito [4] considered the impact of the boiling agents, which is mostly related to the surface tension characteristics. Its large value leads to the development of large bubbles. On the other hand, Henry and Kim [5] claim that the radius of the bubble at the departure stage depends on the forces acting within the bubble and outside of it during its growth. Apart from surface tension, thermo-capillary effects also play a role. Roughness is also very important. Nishikawa et al. [6] tested copper surfaces of different

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roughness (from 0.022 μm to 4.31 μm) and observed that boiling was intensified for rough surfaces, especially at reduced pressures. It might be related to increased density of nucleation sites as stated by Ribatski and Saiz Jabardo [7], who performed research on commercial refrigerants in the range of roughness values from 0.07 μm to 2.60 μm. Kang [8] focused his paper on the combined influence of roughness and special orientation. The author confirmed the favourable impact of roughness, especially for the vertical orientation of the heater.

Due to the considerable practical applications of the boiling process (for example in the refrigeration systems and installations). It is necessary to properly determine heat flux dissipated from the heater. It depends on the number of parameters and should be studied carefully, which is the focus of this paper.

2. BOILING ON THE SMOOTH SURFACES

Boiling is affected by the properties of the surfaces (especially roughness). Since no surface is perfectly smooth, boiling occurs on surfaces which have cracks, cavities and other types of irregularities. Figure 1 presents an example of the real surface, made of copper, with all the irregularities clearly visible with the help of the optical microscope (the height of the irregularities was up to 3.5 μm).

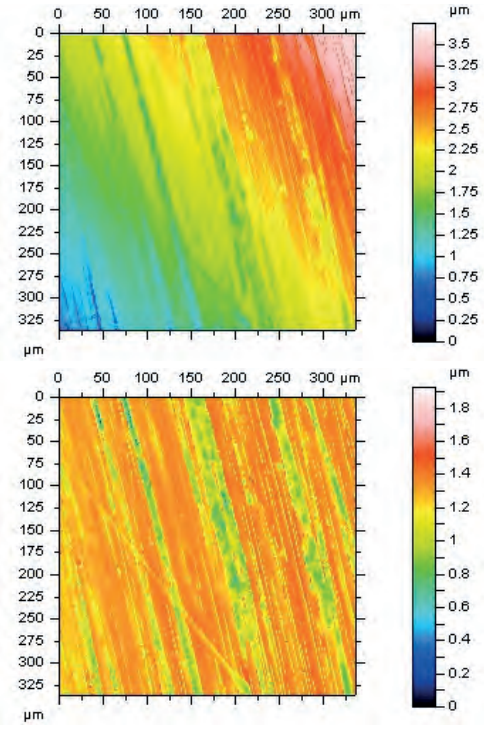

Fig. 1. Optical microscope images of the copper heater surface

The morphology of the surface was produced with fine emery paper. Consequently, it is very smooth. Also, as a result of this process, it has a groove – like pattern. This is due to the one-way movement of the emery paper on the surface. Some grooves are deeper, which might have been caused by a larger pressure exerted on the surface by the operator.

Boiling is initiated at locations where the irregularities occur, namely at cavities or cracks present on the surface. These sites are called 'nucleation sites' and, when they get activated, they serve as a location, where bubbles grow and from there they depart into the liquid pool. However, the subsequent bubbles are also created there. Thus, a single site operates continuously – after the departure of one bubble, the next one is being grown at the same location. The process of bubble growth in one site has been presented in Figure 2. The images were recorded with a high speed digital camera.

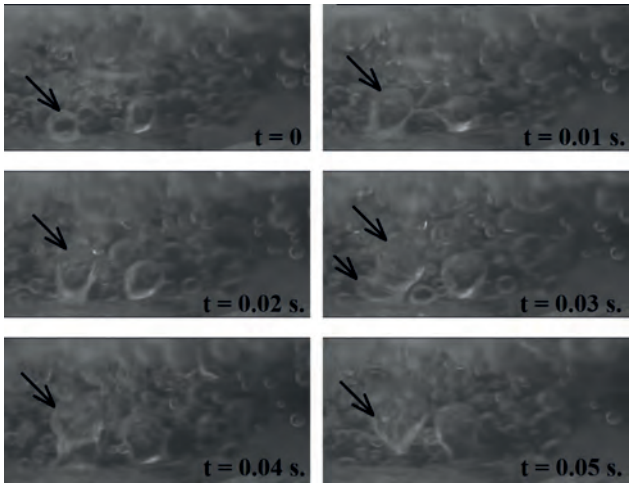

Fig. 2. Bubble growth on the copper heater surface; time interval between the photos: 0.01 s

Naturally, as the temperature of the heater increases, more and more nucleation sites become active. This leads to more heat being exchanged from the surface to the boiling liquid. Moreover, the generated bubbles can merge with each other both on the surface and in the liquid pool. Thus, large vapour bubbles can be observed at significant temperatures of the surface. Considerable vapour accumulation on the surface at large temperatures is an unfavourable phenomenon because a burnout of the surface can occur as a consequence. This is due to the difficulties in efficient heat removal to the pool of liquid.

The arrow in Figure 2 indicates a single bubble, which is quite small at $t = 0$, and with time it becomes

larger (also by overtaking a smaller bubble at t = 0.03 s) until it departures at t = 0.06 s (the last image taken at t = 0.05 s presents the state just before the take off, when the bubble takes on a mushroom-like shape).

The condition of the surface as well as the material properties of both the surface and the liquid can play a significant role in the process of bubble grow and departure and should be considered for proper determination of the heat flux value transferred from the heater surface to the boiling agent.

3. BOILING HEAT FLUX CORRELATIONS

Determination of pool boiling heat flux has been the focus of many papers throughout the recent decades. Models and correlations have been proposed, however, only a few have been commonly applied. Nevertheless, it needs to be noted that they are still not fully accepted and rely mostly on experimental coefficients. This makes them less successful when new refrigerants come into the market.

The most widely used correlation was proposed by W.M. Rohsenow several decades ago. It is based on the assumption that the motion of the vapour bubbles is responsible for the heat exchange as a results of convection. Consequently, heat flux can be calculated with the general convection equation [9]:

$$\mathrm{Nu} = C\mathrm{Re}_b^n \mathrm{Pr}_l^m \tag{1}$$

where Nu, Re and Pr are the Nusselt, Reynolds and Prandtl numbers, while b and l refer to „bubble" and „liquid", respectively. C, n and m are constants, which are determined experimentally. All the numbers (Nu, Re, Pr) and the constants are dimensionless.

Having conducted the necessary mathematical transformations, the following formula for the heat flux (q, in W/m^2) is obtained as a function of the difference between the wall temperature and the saturation temperature of the boiling liquid:

$$q = \left[\frac{c_{pl}(T_w - T_{sat})}{Cr}\right]^{\frac{1}{0.33}} \sqrt{\frac{g(\rho_l - \rho_v)}{\sigma}}\mu_l r \mathrm{Pr}_l^{-\frac{s}{0.33}} \tag{2}$$

The constants C and s depend on the type material and morphology of the heater as well as on the type of the boiling agent, T_w and T_{sat} denote wall and saturation temperatures (in K), respectively. The other symbols are: specific heat (c_{pl}, J/kgK), gravitational acceleration (g, m/s^2), heat of vaporization (r, J/kg), viscosity (μ, kg/ms) and density (ρ, kg/m^3) of the liquid (l) and vapour (v) phases.

Another set of correlations has been proposed by Stephan and Abdelsalam [10], based on the regression analyses of the experimental results. The set includes four equations for various boiling agents. Non-dimensional values of the fluids' physical properties were used in the developed correlations.

According to Heider and Webb [11], the liquid from the pool moves into the heater to the sites of bubble development in order to fill in the void after the previous bubble. Thus, a rotational movement of the liquid is created in the direction to the bottom of the bubble. The interaction area of a single bubble has been assessed as equal to two its diameters. The cyclical process of the creation of bubbles means that heat and mass transfer is unsteady and laminar forced convection is the dominant heat exchange mechanism. Superheated liquid is sucked after the departing bubble and undergoes evaporation within it. The following equation for the heat flux has been proposed [11]:

$$q = 2\sqrt{\pi \lambda_l \rho_l c_{pl} f} \times$$
$$\times D^2 N (T_w - T_{sat}) \left[1 + \left(\frac{\pi 0.66C}{\mathrm{Pr}_l^{\frac{1}{6}}}\right)^n\right]^{\frac{1}{n}} \tag{3}$$

where λ – denotes thermal conductivity (W/mK), f is the frequency of bubbles' creation (s^{-1}), D – bubble diameter (m), N – density of nucleation sites in number of sites per square meter (which could be adopted from [12]), while the constants C and n were provided by the authors for selected boiling agents.

Chai et al. [13] created a non-linear model of pool boiling taking into account bubble growth and interactions between neighbouring nucleation sites. The authors provided numerical solutions of energy balance and bubbles' dynamics equations as well as the probability aspect of the bubble creation phenomenon. It was proposed that the boiling heat flux is a total of the natural convection heat flux (due to bubbles' agitation of the liquid pool) and the latent heat of vaporisation. The model adopted the equation for the density of nucleation sites according to [12]. The resulting equation for boiling heat flux takes the following form [13]:

$$q = 10^{-3}\frac{\lambda_l^2\left(T_w - T_{sat}\right)^3}{\sigma T_{sat}\nu_l} + \\ + \frac{\pi 218.8\,\mathrm{Pr}_l^{1.63}\,\mathrm{H}^{0.4}\left(\dfrac{\rho_v r}{\rho_l c_{pl}}\right)^4 C\,\lambda_l a_l \times}{2\xi^2\left(\dfrac{\lambda_w\rho_w c_{pw}}{\lambda_l\rho_l c_{pl}}\right)^{0.5}} \\ \times\left(\frac{0.3}{\xi}+\sqrt{\frac{0.09}{\xi^2}+\frac{12}{\xi}}\right) \qquad (4)$$

where:

$$H = 14.5 - 4.5\left(\frac{R_a p}{\sigma}\right) + 0.4\left(\frac{R_a p}{\sigma}\right)^2 \qquad (5)$$

$$\xi \quad \frac{\rho_v r}{\rho_l c_{pl}(T_w - T_{sat})} \qquad (6)$$

The dimensionless constant C takes the values from 5 to 10, while R_a is the average surface roughness (in μm) and p denotes pressure (in Pa). The authors claim that the non-linearity is most evident, if the coefficient of conductivity of the surface material is low. The analysed model correctly correlated various experimental test results adopted from literature.

Quite recently a mathematical model has been proposed [14], where the temperature difference between the surface and the boiling liquid as well as macrolayer thickness and time were taken into account for heat flux determination. Apart from the model, the authors also found out that heat transfer through conduction across a microlayer was the major force in the case of nucleate pool boiling at high heat fluxes.

An overview of the models and mechanisms of the boiling phenomenon can be found in the review paper [15], which is focused on the application of boiling for nuclear reactors cooling. On the other hand, numerical simulations of boiling are also performed and analysed. Kamel et al. [16] worked on the concept of correcting the coefficient of the bubble waiting time and afterwards correlating it with the superheat temperature. The authors compared their model with the experimental results available in literature and obtained good agreement.

The correctness of the determination of heat flux using the Rohsenow's correlation has been tested using recent experimental data provided by Kaniowski and Pastuszko [17]. The calculation results according to the model [9], where the values of the constants were adopted from [18], have been shown in Figure 3 as curves "1" and "2", respectively. The figure presents dependence of heat flux (q) vs. temperature difference between the surface (T_w) and the saturated liquid (T_{sat}), referred to as boiling curves, for a copper surface on which distilled water boils.

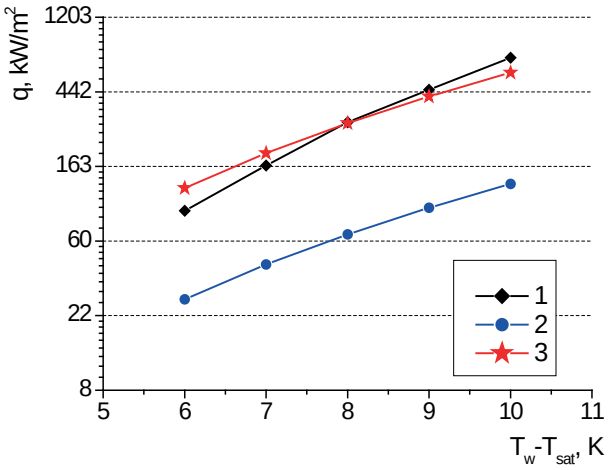

Fig. 3. Boiling curves: 1 – experimental data according to [17], 2 – calculation results according to the Rohsenow's correlation [9], 3 – calculation results according to the modified Rohsenow's correlation

As can be seen, the original Rohsenow's correlation failed to properly predict the experimental data (the calculated values were lower than the research results). However, the character of changes was properly addressed – the values were only vertically shifted. Thus, a modification of the original model was proposed. It was based on the idea of providing new values of the constants in equation (2) as follows: C = 0.01 and s = 0.65. Consequently, a significant agreement between the experimental and calculation results could be observed in Figure 3.

Another, and still not fully understood problem, is the issue of incorporating various modes of nucleate boiling heat transfer (as described in [19]) – from initial stage with only a few bubbles created on the surface through developed and fully developed mode into the new model. It is a large challenge and should be addressed in the future works. It also needs to be noted that increased efficiency of heat exchangers due to their proper morphology can help reduce the costs of heat exchangers operation. As an example, Janaszek and Kowalik [20] analysed a case study regarding a domestic heat exchanger.

4. CONCLUSIONS

The literature provides various models and correlations for boiling heat flux determination. Due to the complexity of the phenomenon, none of these models can be considered as successful in predicting the heat flux for all types of heaters and boiling agents. The most commonly applied correlation was proposed by Rohsenow and this has been validated in the present paper. Due to the significant differences with the experimental data, a modified correlation was proposed with two constants being changed. Thus, a very good agreement with the research data has been observed.

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ASSESSING THE IMPACT OF LAND COVER AND LAND USE CHANGE ON URBAN INFRASTRUCTURE RESILIENCE IN ABUJA, NIGERIA: A CASE STUDY FROM 2017 TO 2022

OCENA WPŁYWU ZMIAN POKRYCIA I UŻYTKOWANIA GRUNTÓW NA ODPORNOŚĆ INFRASTRUKTURY MIEJSKIEJ W STOLICY NIGERII, ABUDŻY: STUDIUM PRZYPADKU Z LAT 2017-2022

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Abstract

The remarkable feature of rapid urbanisation, which has fundamentally altered the distribution of land cover and land use (LULC), is what sets the contemporary era apart. The impact of these modifications on the resilience of Abuja's metropolitan infrastructure from 2017 to 2022 is examined in this study. Our study examined the dynamic changes in LULC using information from remote sensing, geospatial analysis software, and land cover categorization techniques. The findings indicate major changes in Abuja's topography, including a decrease in the number of water bodies, a decrease in the number of trees, the expansion of urban areas, changes in agricultural land use, and fluctuations in the amount of grazing land. The previously mentioned changes have significant consequences for urban infrastructure resilience, affecting various sectors such as water supply, transportation, housing, utilities, and food distribution systems. The infrastructure supporting water supply and sanitation may be severely stretched as the number of water bodies decreases, affecting the quantity and quality of accessible water supplies. As metropolitan areas expand, greater strain is placed on transportation infrastructure, exacerbating traffic congestion and complicating road maintenance difficulties. Changes in agricultural land use can have an impact on food production and distribution, hence affecting food security. Deforestation can cause ecological deterioration, affecting a variety of aspects such as temperature regulation, biological diversity, and atmospheric purity. Adaptive approaches, green infrastructure, and adopting sustainable urban design can all strengthen the resilience of urban infrastructure, according to this study. The significance of renewable energy adoption, community participation, green building laws, the establishment of public-private partnerships, integrated water resource management, and data-driven decision-making is emphasised. Improving legal frameworks that prioritise resilience and sustainability is critical. It is critical to have a complete grasp of the complicated links between changes in LULC, and the resilience of urban infrastructure in order to enable educated urban design and decision-making processes. Policymakers and urban planners may address and minimise the negative consequences of climate change while improving the overall quality of life in cities by using sustainable development practises. The findings of this study have the potential to dramatically improve Abuja's people's well-being and sustainability, especially given the variety of urban difficulties they encounter.

Keywords: geospatial analysis, infrastructure resilience, remote sensing, sustainability, urbanization

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Streszczenie

Współczesną erę wyróżnia niezwykle szybka urbanizacja, która zasadniczo zmieniła rozkład pokrycia terenu i użytkowania gruntów (LULC). W niniejszym badaniu przeanalizowano wpływ tych zmian na odporność infrastruktury metropolitalnej Abudży w latach 2017-2022. Dynamiczne zmiany LULC zbadano przy użyciu informacji z teledetekcji, oprogramowania do analizy geoprzestrzennej oraz technik kategoryzacji pokrycia terenu. Wyniki wskazują na poważne zmiany w topografii Abudży, w tym spadek liczby zbiorników wodnych, spadek liczby drzew, ekspansję obszarów miejskich, zmiany w użytkowaniu gruntów rolnych i wahania w ilości pastwisk. Zmiany te mają znaczące konsekwencje dla odporności infrastruktury miejskiej, wpływając na różne sektory, takie jak zaopatrzenie w wodę, transport, mieszkalnictwo, usługi komunalne i systemy dystrybucji żywności. Infrastruktura wspierająca zaopatrzenie w wodę i urządzenia sanitarne może być poważnie obciążona, ponieważ malejąca liczba zbiorników wodnych odbija się na ilości i jakości dostępnych zasobów wody. Wraz z rozwojem obszarów metropolitalnych rośnie obciążenie infrastruktury transportowej, co zwiększa natężenie ruchu i komplikuje utrzymanie dróg. Zmiany w użytkowaniu gruntów rolnych wpływają na produkcję i dystrybucję żywności, a tym samym na bezpieczeństwo żywnościowe. Wylesianie może powodować pogorszenie stanu środowiska, wpływając na regulację temperatury, różnorodność biologiczną i czystość atmosfery. Według naszych badań podejście adaptacyjne, zielona infrastruktura i przyjęcie zrównoważonego projektowania urbanistycznego mogą wzmocnić odporność infrastruktury miejskiej. Podkreśla się znaczenie energii odnawialnej, udziału społeczności, przepisów dotyczących zielonego budownictwa, ustanowienia partnerstw publiczno-prywatnych, zintegrowanego zarządzania zasobami wodnymi i podejmowania decyzji w oparciu o dane. Kluczowe znaczenie ma poprawa ram prawnych, które powinny priorytetowo traktować kwestie odporności miejskiej oraz zrównoważonego rozwoju. Świadome projektowanie urbanistyczne i procesy decyzyjne możliwe są jedynie przy zrozumieniu skomplikowanych powiązań między zmianami w LULC a odpornością infrastruktury miejskiej. Zastosowanie praktyk zrównoważonego rozwoju umożliwi decydentom i urbanistom zminimalizowanie negatywnych konsekwencji zmian klimatycznych oraz podniesienie ogólnej jakości życia w miastach. Wyniki tego badania mogą potencjalnie znacznie poprawić dobrobyt i zrównoważony rozwój mieszkańców Abudży, zwłaszcza biorąc pod uwagę różnorodność napotykanych przez nich trudności miejskich.

Słowa kluczowe: analiza geoprzestrzenna, odporność infrastruktury, teledetekcja, zrównoważony rozwój, urbanizacja

1. INTRODUCTION

Cities have become key social change agents in an era of unprecedented global urbanisation. Because of the increasing expansion of metropolitan regions, both the physical settings and patterns of human habitation are changing dramatically (Nuissl & Siedentop, 2020). These changes affect more than just the surface of cities; they also affect basic infrastructure and interact with crucial elements that maintain our modern life. In this environment, assessing changes in LULC and their consequences for the robustness of urban infrastructure appears as an important and intriguing area of research (Alp et al., 2020; Noi et al., 2021).

Urbanisation has emerged as one of the most noteworthy characteristics of the twenty-first century, the modern time (Hölscher & Frantzeskaki, 2021). As the world's population congregates in metropolitan areas, cities face continual challenges in caring for, housing, and assuring the well-being of their residents. Changes in LULC that precede urban expansion are usually caused by a variety of variables, including population growth, economic development, and shifting societal demands. These improvements, however, come at a significant cost and pose a serious threat to the stability of urban infrastructure (Rode, 2013). This covers vital networks responsible for delivering basics including energy distribution, water supply, sewage treatment, transportation, and other services.

The word "land cover" refers to the apparent aspects of the Earth's surface, such as farms, forests, water bodies, and urban infrastructure. The term "land use" refers to how a plot of land is used; it might be used for residential, commercial, industrial, agricultural, or other permissible purposes. These two interconnected principles have a significant impact on how cities evolve and take shape. Changes in LULC have a substantial impact on urban infrastructure, which in turn determines how vulnerable it is to various stresses such as population increase, climate change, and natural disasters (Akaolisa et al., 2023).

Changes in LULC in metropolitan areas are driven by a number of factors, including population growth, economic expansion, and technological advancements. Land cover changes refer to changes in the physical properties of the land, such as the transformation of vegetated zones into impermeable surfaces (Naikoo et al., 2020; Lamichhane & Shakya, 2021). Changes in land use, on the other hand, refer to changes in the way land is used, such as transitioning from residential to commercial or from agricultural to industrial.

Urban infrastructure includes a variety of systems such as energy, telecommunications, water supply,

sewerage, and transportation. These systems are linked because their resilience is critical to ensuring the general well-being of city dwellers (Gonçalves & Villena-Manzanares, 2021). Resilience refers to an infrastructure's ability to successfully absorb, adapt to, and recover from a variety of disruptive events and long-term stresses. The need of analysing infrastructure resilience in order to improve urban sustainability and catastrophe preparedness is emphasised in research conducted by (Mottahedi et al., 2021).

It is critical to have a good understanding of the intricate connections between changes in LULC, as well as the resilience of urban infrastructure, in order to enable sensible urban design. Land cover changes, namely the addition of impermeable surfaces, can result in urban heat island effects, which can have an impact on public health, transportation systems, and energy usage (Nwakaire et al., 2020; Vujovic et al., 2021). It explains how switching from a residential to a mixed-use zoning plan affects a variety of aspects, including traffic flow, accessibility, and public transportation use.

Many academic research has been conducted to study how changes in LULC affect urban infrastructure resilience (Aliyu et al., 2023; Bernard & Bilal, 2023). Changes in land cover, notably an increase in impermeable surfaces, may make floods and heat-related difficulties more likely, according to the findings of a study conducted by Derdouri et al., (2021), Singh et al., (2022), Ramzan et al., (2022), Bernard & Bilal, (2023) and Ha & Nguyen, (2023). These changes may weaken the resilience of transportation, power, and water supply systems, making it more difficult for them to withstand and recover from comparable disasters. The consequences of land use changes, such as the move to mixed-use development, on transport infrastructure have shown variable results, highlighting the necessity for assessments tailored to specific scenarios.

Adoption of sustainable urban development is critical in raising the general standard of life in urban areas while mitigating the negative effects of climate change. It is impossible to exaggerate the importance of resilient urban infrastructure in reducing disaster risk and increasing the general well-being of urban dwellers. Policymakers and urban planners can utilise the study's key results to inform their decisions. By embracing these notions, policymakers and planners can effectively promote sustainability and economic progress. They can also improve infrastructure to better manage environmental challenges, strengthen a city's ability to endure extreme events, and ultimately provide a good standard of living for its residents. The goal of this study is to conduct a thorough examination of the influence of changes in LULC on the resilience of urban infrastructure.

2. GEOGRAPHICAL AND DEMOGRAPHIC OVERVIEW OF THE STUDY AREA

The topography of Abuja exemplifies a well-coordinated blend of purposeful urban architecture and natural beauty. The disputed territory is located in central Nigeria at around 8.532°N to 9.337°N latitude and 6.745°E to 7.545°E longitude. The city centre is positioned on the visually beautiful Jos Plateau, part of the broader Guinea Savanna region. The region's gently sloping hills and valleys provide spectacular views of the surrounding agricultural area (Enoguanbhor et al., 2019; Shuaibu & Kara, 2019).

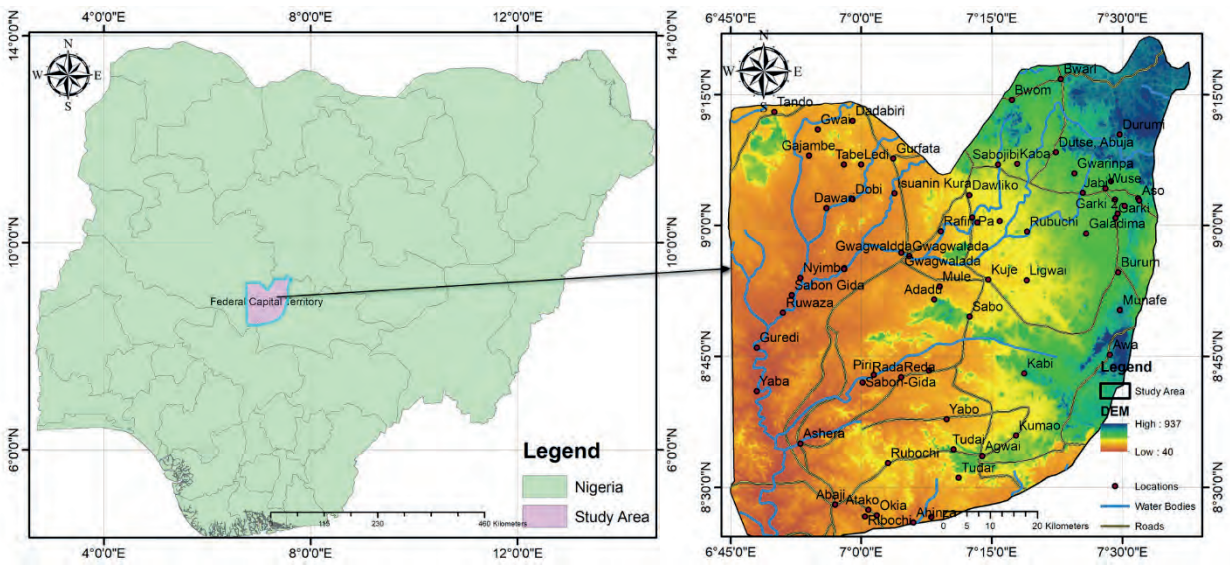

Fig. 1. Map of Nigeria and Digital Elevation Model of the Study Area

The Aso Rock, a massive rock that rises abruptly upwards from the surrounding land, is one of Abuja's most noticeable topographical features. Aso Rock is included in Nigeria's national emblem due to its significance as a landmark and symbolic value as a representation of the city. The rock adds a particular visual appeal to the cityscape by serving as a magnificent feature behind a number of significant government buildings.

Because of the city's ideal position, a wide range of agricultural activities are conceivable, promoting the creation of a diverse food market. Furthermore, the Usuma Dam created a reservoir in Abuja, which offers a critical supply of clean drinking water to the local people. Furthermore, the Gurara Falls, which are located near the city, provide people with the opportunity to engage in leisure activities and find solace in wildlife (Momoh et al., 2022).

As of January 2022, Abuja's population had increased significantly, which has been attributed to urbanisation, government centralization, and the availability of employment possibilities. Since it became the country's capital in 1991, Abuja has welcomed a varied population representing many different ethnic groups. Because of the presence of foreign embassies and government institutions in the city, government personnel and diplomats are concentrated in the city, which has a significant impact on the local economy and society (Zubair et al., 2015). Abuja has a big number of young people, which has numerous ramifications in the domains of work and education. However, as a result of urbanisation, a number of issues have arisen, including strain on existing infrastructure, a housing shortage, and traffic congestion. As a result, in order to stimulate growth and enhance overall living standards, sustainable solutions must be devised (Aniekwe & Igu, 2019).

Abuja is a metropolis that has been meticulously planned and separated into zones, each serving a specific demography and performing specific functions. The CBD is home to a multitude of government buildings, diplomatic offices, and business enterprises distinguished by modern skyscrapers and manicured green spaces. Garki is defined as a community with both residential and commercial sectors, as well as a variety of facilities such as malls and various types of housing. Asokoro is an affluent suburb mostly inhabited by diplomats and government officials. Wuse is best defined as a bustling metropolitan district with a vibrant street scene that includes both commercial and residential areas. The plethora of expensive mansions, diplomatic embassies, and sumptuous amenities attest to Maitama's affluence. As a result of development, the Gwagwalada neighbourhood has grown dramatically.

3. METHODOLOGY

Because of the improved availability and accessibility of remote sensing data, the use of satellite imaging and geospatial analysis tools to explore changes in LULC has expanded recently. The study is notable because it employs European Space Agency (ESA) Sentinel-2 data with a 10-meter resolution, allowing for a more detailed analysis of the topography. Using data preparation techniques enhances image quality and removes errors, resulting in more accurate results (Kumar et al., 2021; Agdas & Yenen, 2023). Furthermore, the well-known geospatial analytics tool ArcGIS 10.8 offers a reliable approach to identify and study land cover data.

It has been proved that supervised classification systems can correctly classify various types of land cover. The accuracy of the categorization can be improved further by employing high-resolution images to confirm training data from field surveys. Post-classification comparison is a popular way for assessing how LULC has changed over time (Akaolisa et al., 2023). This method compares categorise land cover maps created over a range of time periods.

4. DATA PROCESSING

The use of training data to guide a computer system on how to classify pixels in a photograph into multiple land cover categories is a major component of supervised classification algorithms. Using supervised classification algorithms, Sentinel-2 photos were sorted into different land cover classes, including forests, aquatic bodies, farms, and urban areas. The training data for the study came from field surveys, and it was confirmed using high-resolution images (Zhang et al., 2021). The main purpose of this stage was to ensure that the training dataset accurately reflected the variety of land cover types found in the specified research location. Using high-resolution photos to assess the training set improved classification accuracy.

Post-classification comparison requires studying classed land cover maps from many temporal eras to detect variations in LULC throughout time. The post-classification comparison method was employed in this study to find disparities in LULC in Abuja, Nigeria. Maps of land cover, separated into numerous categories, were compared across time periods to find sites where major changes in land cover occurred (Asenso et al.,

2020; Otoo et al., 2021). Post-classification comparison analysis is a useful method for analysing changes in LULC over time since it makes it easier to discover patterns and understand the underlying causes of these changes. It also makes it straightforward to identify places that are undergoing significant change and those that may require support for successful land use management (Twisa & Buchroithner, 2019).

This study employed supervised classification methods and post-classification analysis to precisely classify Sentinel-2 imagery into multiple land cover classes and identify temporal oscillations in LULC. The previously mentioned methodology is quite useful in tracking environmental changes and identifying areas that require action for effective land use change management.

5. RESULT AND DISCUSSION

Table 1 and Figure 2 depict an evaluation of changes in LULC within Abuja between 2017 and 2022. These images provide crucial insights into the dynamic changes that are taking place in the city's physical landscape.

The observed variations in the size of water bodies may be due to dynamic changes in precipitation patterns and the implementation of water management strategies. The observed reduction in water area between 2017 and 2022 could be attributable to rising urbanisation and climate change, both of which frequently necessitate the reclamation of water bodies for development. The observed drop in the number of Tress areas over time is most likely due to deforestation and urban growth. Reduced tree cover has a negative impact on the environment, including lower biodiversity, higher temperatures, and poorer air and water quality (Sun et al., 2022).

Submerged plant life changes have the potential to serve as indicators of changes in hydrological patterns and urbanisation processes. The changes could have a significant influence on adjacent ecosystems and increase the risk of flooding, necessitating adaptation and mitigation measures (Hussein et al., 2020). Changes in land usage and farming practises may be the cause of reported crop area fluctuations. Changes in agriculture may have a significant impact on a number of aspects, including food security, rural wellbeing, and the long-term sustainability of land resources. The consistent rise in developed regions indicates the prevalence of urbanisation and the concurrent construction of infrastructure (Chou et al., 2015). This trend indicates greater population numbers, increased economic activity, and higher living standards. It may, however, create new issues, such as greater demand for resources and services. Changes in land usage and land reclamation efforts may result in differences in the number of exposed ground surfaces. These modifications could have an impact on habitat loss, land degradation, and soil erosion. Increased rangeland area could be influenced by urban encroachment as well as land-use practises (Du et al., 2019). Because the region has historically relied on pastoralism, changes in animal grazing supplies have a substantial impact.

The loss of tree cover and the expansion of built-up areas may result in environmental degradation, a decrease in biodiversity, and an increase in climate-related difficulties. Aquatic system modifications can have a significant impact on the availability of water resources and surrounding ecosystems. The expansion of urbanised areas reflects the city's rising population and economic activities, necessitating the creation of necessary amenities and infrastructure (Grêt-Regamey et al., 2020). Crop area changes can have an impact on food production, agricultural sustainability, and the economic well-being of rural populations, among other things. Differences in exposed soil and rangeland areas indicate changes in land use and future land management plans, which affect ecosystems and farming practises. Maintaining an eye on these developments is critical for

Table 1. Dynamic LULC Landscape of the study area between 2017 to 2022

LULC Type	Area (km²)						Change (%)				
	2017	2018	2019	2020	2021	2022	17/18%	18/19%	19/20%	20/21%	21/22%
Water	32.57	37.27	41.84	41.64	38.25	39.94	14.44	12.26	-0.47	-8.14	4.42
Trees	2631.65	2467.32	2205.70	1952.04	1863.01	1468.26	-6.24	-10.60	-11.50	-4.56	-21.19
Flooded vegetation	0.93	1.99	2.98	1.05	0.33	0.65	113.67	49.44	-64.83	-68.51	97.98
Crops	2299.93	2399.10	2447.10	2228.69	2441.37	2359.55	4.31	2.00	-8.93	9.54	-3.35
Built Area	535.77	573.88	614.73	638.67	665.69	712.10	7.11	7.12	3.90	4.23	6.97
Bare ground	1.80	1.53	2.37	3.12	2.67	1.30	-15.20	55.03	31.43	-14.36	-51.24
Rangeland	1850.49	1872.03	2038.41	2487.91	2318.60	2771.32	1.16	8.89	22.05	-6.81	19.53

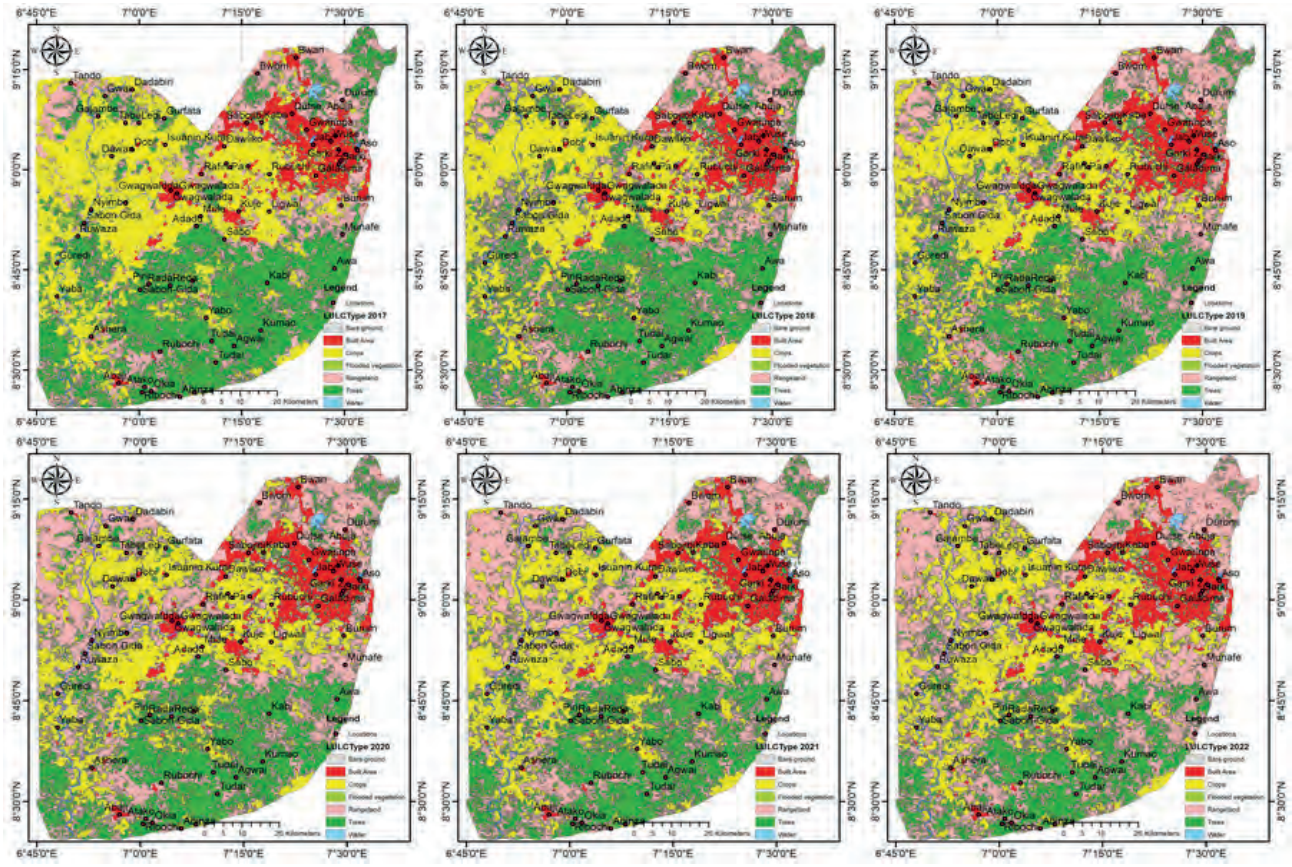

Fig. 2. LULC between 2017 to 2022 in the study area

resilience strategies and urban planning, particularly in the context of climate change. It is critical to ensure that ecosystems and infrastructure can adapt and respond to changing conditions.

The observed changes in LULC between 2017 and 2022 are being used to estimate the risk of critical infrastructure components in Abuja, Nigeria. The evaluation's findings give critical new information on the dangers and concerns that may develop as a result of these changes in LULC. In this work, we will examine vulnerability assessment in depth, with a focus on how changes in LULC affect infrastructure vulnerability. We will highlight significant discoveries as well as any concerns associated with this link.

Water availability and infrastructure resilience may be impacted by the urban region's lower water supply as a result of water area shrinking. The extension of built-up regions is a symptom of the phenomenon of urban expansion, which places increased demand on transport infrastructure. Traffic, road maintenance, and the need for public transport are three primary impediments (Faiyetole & Adewumi, 2023). The evolution of built-up areas has a significant impact on housing and utility infrastructure. It has an impact on issues such as housing scarcity and increased demand for utilities, particularly water and electricity. Variations in crop acreage may have an impact on the entire food supply chain as well as agricultural infrastructure. Changes in agricultural land allocation can have a considerable impact on food distribution and production.

The development of developed regions indicates a significant urbanisation trend. Although the previously described phenomenon has the potential to create economic opportunities, it also places strain on existing infrastructure, perhaps resulting in traffic bottlenecks, higher power costs, and difficulties in providing enough housing and services. Some of the consequences of forest canopy decline include decreased air and water quality as well as elevated temperatures (Bernard & Bilal, 2023). It is critical to consider how infrastructure aspects such as energy and transportation may impact people's health and well-being (Bianchini et al., 2021). Crop region variations may have an impact on agricultural infrastructure. Changes in the networks that produce and distribute food can have an impact on the infrastructure of supply chains as well as food security. Reduced water body size, which is a shift in aquatic ecosystems, can have a significant impact on sanitation and water supply systems, perhaps reducing the quantity and quality of accessible water. Rapid urbanisation and population

growth can strain existing infrastructure, resulting in issues such as traffic, housing shortages, and increased demand for essential utilities such as power, water, and transportation. The loss of tree cover and the resulting ecological repercussions may have an impact on other sections of infrastructure, such as energy supply, air conditioning requirements, and transportation networks, worsening the state of the environment (Fan et al., 2022).

Understanding the city's ability to withstand and recover from shocks necessitates evaluating the robustness of existing urban infrastructure in light of observed changes in LULC. The spread of urban growth and the unequal distribution of land resources may put strain on transportation infrastructure. Problems such as traffic congestion, poor road conditions, and impediments to public transport may put the current transport system to the test (Gonçalves & Ribeiro, 2020). The relocation of metropolitan areas has a considerable influence on housing and utility infrastructure. Rapidly increasing metropolitan areas may face resilience challenges due to a lack of housing and increased demand for basics such as power and water. Variations in crop acreage may have an impact on the entire food supply chain as well as agricultural infrastructure. Building solid infrastructure in the agriculture business is crucial to assuring the stability and dependability of food security while also optimising supply chain processes.

Table 2. Impact of LULC changes between 2017 to 2022 in the study area on Urban Infrastructure Resilience

Major LULC Type Change	Area (Km²)					
	2017	2018	2019	2020	2021	2022
Trees	2631.65	2467.32	2205.70	1952.04	1863.01	1468.26
Crops	2299.93	2399.10	2447.10	2228.69	2441.37	2359.55
Built Area	535.77	573.88	614.73	638.67	665.69	712.10
Rangeland	1850.49	1872.03	2038.41	2487.91	2318.60	2771.32

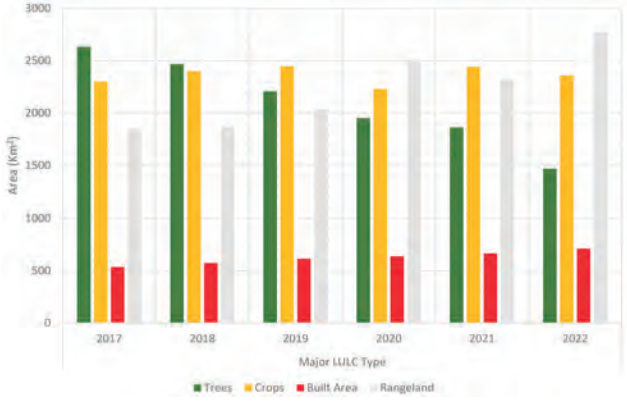

Fig. 3. Stack plot of major LULC Type change in the study area

Table 2 and Figure 3 show how changes in the LULC categories have a direct impact on the resilience of urban infrastructure. This is especially true when considering the "Built Area" category as a representative of urban infrastructure. The high growth in Built Area shows that metropolitan areas are growing in size, putting more burden on infrastructural services. Urbanisation frequently puts a strain on critical infrastructure and services such social amenities, water supply, transportation networks, and garbage disposal. The loss of natural land cover, particularly trees, as a result of development has the potential to affect environmental quality as well as the resilience of metropolitan areas to shocks.

Table 3 shows the correlation between various LULC in the study region from 2017 to 2022, providing insight into the dynamics of the relationship within the study area. The built area and range land have a high positive correction, indicating that development is encroaching on range areas, potentially affecting the natural ecology. Trees have a negative link with built area and rangeland, implying that there is less tree cover, implying a loss of green spaces and urban trees, which would have an impact on the urban heat island and air and water quality. Water and crops have a weak positive association. Tress with Crops and Bare terrain, Flooded Vegetation and Bare Ground, Crops with Built Area, Built Area with Bare Ground, and Bare Ground with Rangeland are all examples of bare terrain. These would affect irrigation operations and agricultural land near sources of water, indicating that there is a transition zone between urban areas and natural rangeland.

Table 3. Matrix correlation for LULC changes between 2017 to 2022 in the study area

	Water	Trees	Flooded vegetation	Crops	Built Area	Bare ground	Rangeland
Water	1.000						
Trees	–0.621	1.000					
Flooded vegetation	0.319	0.435	1.000				
Crops	0.111	-0.043	0.355	1.000			
Built Area	0.654	–0.993	–0.381	0.146	1.000		
Bare ground	0.431	–0.079	–0.037	–0.227	0.092	1.000	
Rangeland	0.570	–0.964	–0.514	–0.221	0.930	0.113	1.000

Reduced tree cover, an important component of green infrastructure, may have an impact on ecosystem services as well as urban heat islands. Changes in

Rangeland may also imply changes in land use practises, which may have additional consequences for adjacent ecosystems and urban growth.

The notable expansions in the "Water-Built Area" and "Crops-Built Area," as illustrated in Figure 4, indicate significant urban development. The current expansion has a significant impact on the spatial needs that accompany the growth of urban infrastructure. The transitions "Trees-Built Area" and "Rangeland-Built Area" show the process of converting natural regions into constructed settings, which may have an impact on biodiversity and green spaces. Changes in "Water-Trees" and "Water-Crops" have been seen as a result of changes in water bodies, which are significant for controlling urban water supply. Transitions associated to "Bare Ground" may indicate changes in the land's features, which may have an impact on soil production and quality.

Abuja's rapidly expanding urban area and population have placed significant strain on the city's existing infrastructure, particularly in the areas of utilities, housing, and transportation. To meet the increased demand for electricity, water, and transportation services, infrastructure resilience necessitates careful planning and investment. Growth in urban areas has exacerbated traffic congestion, demanding infrastructure expansion to improve resilience and the implementation of adaptive transportation management solutions.

The rapid pace of urbanisation and land-use changes can strain existing infrastructure, resulting in a variety of issues such as insufficient housing supply, transportation congestion, and inadequate utility availability. The difficulties listed above have the potential to reduce the citizens' overall standard of living. Changes in crop-growing regions can have an impact on local agricultural methods and the interdependent systems that assist distribute food. The economic fallout from fluctuations in food output may have a considerable influence on food security and lives (Okeleye et a., 2023). The decline in tree canopy and the resulting increase in air pollution may have a negative impact on public health. The overall health and well-being of individuals in impacted areas may be jeopardised because there is a link between poor air quality and the prevalence of respiratory and cardiovascular disorders. The loss of habitat caused by deforestation, as well as alterations

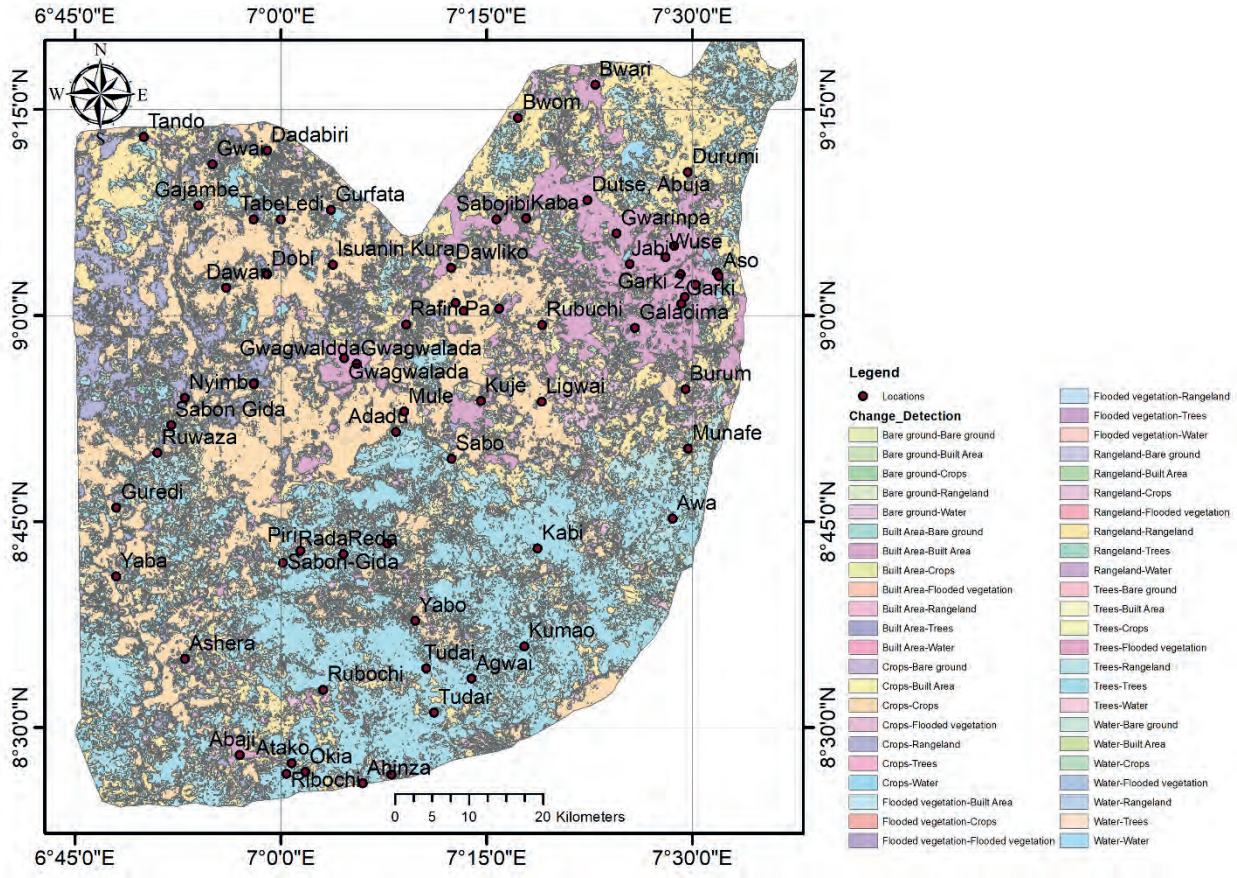

Fig. 4. LULC changes in the study area between 2017 to 2022

to wetland ecosystems, may have a negative impact on biodiversity. As biodiversity declines, citizens may have less possibilities for leisure and education. Changes in aquatic ecosystems and decrease of water quality have serious implications for the supply of safe drinking water. Water quality preservation is critical for sustaining public health and increasing general welfare. The expansion of urban areas shows the presence of favourable economic conditions and the emergence of new work opportunities. Uncontrolled growth, on the other hand, can lead to urban issues such as unequal social conditions and inadequate urban development plans.

There is an opportunity to reduce the burden on infrastructure by implementing adaptable urban design principles that incorporate sustainable land use practises. Infrastructure systems can be made significantly more resilient by using sound zoning and urban planning practises. Transit infrastructure resilience can be strengthened by using adaptive measures such as better traffic management, greater public transit, and road repair programmes. Resilient water and power supply systems necessitate the allocation of resources for infrastructure upgrades and the implementation of effective utilities management practises. The implementation of adaptive agricultural practises, such as crop diversity and the adoption of sustainable farming techniques, could increase the resilience of the infrastructure sustaining food supply (Okeleye et al., 2023).

It is critical to implement and enforce inclusive land use plans that prioritise sustainable growth and the preservation of natural areas. Zoning restrictions are critical for regulating urban growth, fostering the development of green spaces, and conserving critical ecosystems. Implement afforestation and reforestation efforts to minimise deforestation and expand urban green spaces. Incorporating green infrastructure into urban design entails incorporating elements such as parks, tree-lined boulevards, and green roofs to enhance air quality and sustain biodiversity (Gavrilidis et al., 2019; Ronchi et al., 2020). Strengthen rules aimed at protecting and advancing long-term maritime environment management. Water conservation tactics and pollution control measures are critical for guaranteeing water quality preservation. Infrastructure resilience can be increased by improving design, maintenance, and adaptive measures, allowing it to withstand and recover from a variety of shocks. In order to successfully limit possible flooding threats, it is critical to prioritise the installation of sustainable urban drainage systems and flood management techniques (Tachaudomdach et al., 2018; Karamouz et al., 2019).

The goal is to develop climate-resilient urban development policies and strategies in order to effectively mitigate the rising risks connected with climate-related factors. It is recommended to use integrated water resource management techniques that incorporate sustainable urban drainage systems that take both water quantity and quality into account. To minimise carbon emissions, this idea encourages the widespread adoption of renewable energy sources as well as increased energy efficiency in infrastructure and buildings. The goal is to increase community engagement and understanding about sustainable land use practises, conservation projects, and disaster preparedness in order to build a resilient and knowledgeable population. Green building regulations, which encourage the construction of environmentally friendly and energy-efficient structures, must be implemented and carefully enforced in order to limit the harmful consequences of new construction on the environment. Encourage the formation of public-private partnerships to aid in infrastructure development, with a focus on resilient and sustainable projects that benefit both the public and private sectors equally. Provide a comprehensive framework for acquiring and tracking data on changes in land use, environmental markers, and infrastructure performance in order to provide meaningful information to guide decision-making procedures. In terms of urban expansion and planning, strengthen legislative frameworks that prioritise resilience, sustainability, and environmental preservation.

6. CONCLUSION

The changing patterns of LULC in Abuja have a substantial impact on the vulnerability of critical infrastructure assets. The observed loss in aquatic ecosystems poses a major danger to water supply and sanitary infrastructure, potentially resulting in a water deficit and decreasing water quality. The expansion of metropolitan regions places a significant strain on the transportation infrastructure, raising worries about road upkeep, traffic congestion, and the availability of public transportation. Given the implications for food security, crop area alterations on agricultural infrastructure and the food supply chain are cause for concern. Furthermore, the loss of tree canopy and submerged vegetation has significant ecological consequences that affect numerous infrastructure

components such as atmospheric conditions, water reservoirs, and energy provision.

Abuja must assess the resilience of its urban infrastructure to address the challenges posed by urbanization and environmental changes. Sustainable land use planning, zoning regulations, green infrastructure, water conservation, afforestation, and adaptive measures are essential for reducing infrastructure demand and ensuring water quality preservation. Enforestation and reforestation efforts can mitigate deforestation effects and improve urban green spaces. Infrastructure resilience can be increased through design, maintenance, and adaptive measures.

To reduce flooding threats, sustainable urban drainage systems and flood management measures should be prioritized. Green building laws should be enforced to promote ecologically friendly and energy-efficient structures. Public transit, pedestrian-friendly infrastructure, and bicycle networks can alleviate traffic congestion and environmental damage caused by carbon emissions. Mixed-use projects can reduce commute time and promote conservation farming practices.

Establishing climate-resilient policies and approaches is crucial for mitigating climate change hazards. Integrated water resource management techniques should incorporate sustainable urban drainage systems, and renewable energy resources should be used to reduce carbon emissions. Increased community engagement and awareness of sustainable land use practices, conservation projects, and disaster preparedness can create a resilient citizenry. Collaborative efforts between public and private groups can help develop robust and sustainable infrastructure.

A comprehensive framework for acquiring and tracking information on land use, environmental indicators, and infrastructure performance can help make sound decisions. Abuja must act now to ensure a resilient and sustainable future for all parties involved.

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structure

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MULTI-CRITERIA EVALUATION OF ACCESSIBILITY OF CONTEPORARY PUBLIC UTILITY BUILDINGS – ON THE EXAMPLE OF KIELCE

WIELOKRYTERIALNA OCENA DOSTĘPNOŚCI WSPÓŁCZESNYCH BUDYNKÓW UŻYTECZNOŚCI PUBLICZNEJ – NA PRZYKŁADZIE KIELC

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Abstract

The article analyzes the accessibility of selected examples of public utility buildings, implemented at the end of the 20th century and at the beginning of the 21st century, in the structures of the conteporary city of Kielce. In order to learn about the functioning and architectural solutions of buildings that are among the most frequented by the general public, an in situ study was conducted, using a multi-criteria method that allows comparative analysis and is an effective tool in making an accurate assessment. The selection of the most relevant evaluation criteria was based on the actual needs and psychophysical condition of today's society. The research was locationally focused on the Kielce city area, taking into account current reports and statistics indicating the largest increase in the number of people over 65 in the Świętokrzyskie voivodeship. The studies carried out have led to conclusions and recommendations to help in the design and management of facility spaces.

Keywords: universal design, accessibility, barrier, alternative access, public utility facility, contemporary architecture, city

Streszczenie

W artykule dokonano analizy dostępności wybranych przykładów obiektów użyteczności publicznej, zrealizowanych pod koniec XX i na początku XXI wieku w strukturach współczesnego miasta Kielce. W celu zapoznania się z funkcjonowaniem oraz rozwiązaniami architektonicznymi budynków, należących do najczęściej uczęszczanych przez ogół ludzi, przeprowadzono badania in situ, wykorzystano metodę wielokryterialną, umożliwiającą przeprowadzenie analiz porównawczych i stanowiącą skuteczne narzędzie w dokonaniu precyzyjnej oceny. Wyłonienie najistotniejszych kryteriów oceny oparto na rzeczywistych potrzebach oraz kondycji psychofizycznej dzisiejszego społeczeństwa. Badania skoncentrowano lokalizacyjnie na obszarze Kielc, mając na uwadze aktualne raporty i statystyki wskazujące na największy przyrost liczby osób powyżej 65 lat w województwie świętokrzyskim. Przeprowadzone studia pozwoliły na sformułowanie wniosków i zaleceń pomocnych w projektowaniu i zarządzaniu przestrzeni obiektów.

Słowa kluczowe: projektowanie uniwersalne, dostępność, bariera, dostęp alternatywny, obiekt użyteczności publicznej, architektura współczesna, miasto

1. INTRODUCTION

In recent years, there has been a widespread push for accessibility in many Polish and European cities. More and more buildings and spaces are becoming more convenient and safer, and the newly-realized facilities of philharmonics or train stations are completely

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accessible. Expressions such as "accessible city", "accessible space for all" have become the foundation of many activities and investments, carried out by municipal authorities, various organizations and scientific and academic circles, such as the POWR partnership project "Accessibility Hub – a center for practical learning of accessibility" [1], implemented at the Kielce University of Technology and Kraków University of Technology. Thanks to joint efforts, the urban space is changing, together we are overcoming external barriers but also those that lie in our beliefs.

The accessibility of buildings and public spaces is undoubtedly a complex and interconnecting concept, related to the principles of universal design pioneered by architect and urban planner Selwyn Goldsmith, and developed by Ronald Mace. Based on his own experience, Mace founded the Center for Universal Design in 1989, which has become a major source of information and research on universal design internationally. The premise of this concept assumes equal and equitable access to various types of goods, taking into account the broadly understood limitations of users. Designed in this way, the flexible space accommodates all types of disabilities and responds to the diverse needs of the users, regardless of their age, social status or education. New facilities and public spaces are being built in the spirit of universal design, and existing ones are being adapted to people with different needs. All this is to ensure that no user, regardless of their preference or level of fitness, is excluded and discriminated against.

In order to learn about the functioning and architectural solutions of buildings that are among the most frequented by the general public, such buildings were identified (case studies) and *in situ* studies were carried out in several of them [1].

1.1. Purpose and scope of the research

The main objective of the studies became to conduct accessibility analyses of selected public facilities that have been functioning in the structures of the conteporary city of Kielce from the end of the 20th century and the beginning of the 21st century. The authors focused their research locationally on the Kielce city area, keeping in mind current reports and statistics indicating the largest increase in the number of people over 65 in the Świętokrzyskie voivodeship [more: 2]. An important part of the work also became the identification of the most relevant criteria based on the actual needs and psychophysical condition of today's society.

In order to provide a broader context for the studies, a synthetic analysis of the current state of knowledge was made at the same time. Then, using previous research [3-5] facility analyses were conducted based on selected examples and adopted criteria.

2. BASIC TERMINOLOGY AND LEGAL CONSIDERATIONS

The topic of universal design is absorbing much of the scientific community, being addressed in numerous studies and current research that emphasize the needs of people with disabilities and identify design guidelines for all. Among the studies conducted, attention is drawn to the multifaceted nature and focus on a well-defined context, the specific needs of users, such as the residential environment, the needs of seniors [6, 7], the qualitative aspect related to the arrangement of space [8] or innovation [9].

In the collective work *Architekci zmian. Innowacje dla osób z niepełnosprawnością* [10], recognized leaders and social innovators come together to create a new disability paradigm with significant national and international impact. A significant source of knowledge are expert studies, such as: *Diagnoza głównych barier architektonicznych w przestrzeni publicznej Warszawy* [11] or *Możliwości zwiększenia dostępności budynków użyteczności publicznej* [12] – including an accessibility audit of the building interior and its surroundings, as the most sensitive places for people with disabilities. In turn, guides like: *Włącznik. Projektowanie bez barier* [13], *Projektowanie bez barier – poradnik* [14], *Standardy dostępności budynków dla osób z niepełnosprawnościami* [15], contain comprehensive universal design guidelines for the design of buildings and spaces, and present the most common issues regarding the design of accessible environments and adaptability of the immediate environment in which a person with a disability lives and resides.

A large spectrum of the knowledge base is formed by documents of governmental organizations, international organizations and regulations [16].

The main premise of universal design according to Ronald Mace is a strategic approach to designing, planning and creating buildings, spaces, products to serve and be accessible to all people, without the need for adaptation or specialized design. In 1997, the Center for Universal Design developed 7 principles of universal design: identical use, flexibility in use, simple and intuitive use, noticeable information, fault tolerance, effortless use, and size and space appropriate for access and use [17, 18]. In 2009 Konrad Kaletsch additionally formulated the 8th principle, which emphasizes perception of equality. Article 2 of the Convention on the Rights of Persons with Disabilities

emphasizes the importance of universal design for products, environments, programs and services to be usable by all, to the greatest extent possible, without the need for adaptation or specialized design [19].

The Act of August 27, 1997, on Vocational and Social Rehabilitation and Employment of Persons with Disabilities [20] defines the concept of a person with special needs, which also includes the elderly, persons with disabilities, permanently or temporarily impaired mobility or perception. In turn, the Act on Ensuring Accessibility to Persons with Special Needs indicates the meaning of terms such as accessibility, alternative access, barrier and the division into architectural, digital or information and communication barriers[1] [21]. The basic legal act in Poland sanctioning the rights of people with disabilities is the Constitution of the Republic of Poland [22], which ensures freedom and human and civil rights, prohibits discrimination against citizens in social life, social and cultural rights, emphasizes that every person has inalienable dignity and, regardless of their degree of disability, should be treated equally with others, have equal rights in access to public spaces and services. The Constitution imposes an obligation to comply with binding international law and regulations concerning people with disabilities, such as the UN "Convention on the Rights of Persons with Disabilities" [23] and the EC Communication "European Disability Strategy 2010-2020" [24].

In addition, there are laws and regulations, such as, among others, the Act of August 27, 1997, on Vocational and Social Rehabilitation and Employment of Persons with Disabilities [20], which mandates that people with disabilities be enabled to participate in society by, among other things, eliminating barriers, particularly architectural barriers. The Construction Law act [25] indicates the need to provide the necessary conditions for the use of public facilities and multi-family housing by people with disabilities, especially those in wheelchairs. The Regulation of the Minister of Infrastructure on the technical conditions to be met by buildings and their location [26] defines a public utility building, a multi-family residential building and a collective residence, for which accessibility by persons with disabilities must be ensured in accordance with the Building Law, as well as the specific requirements for these facilities met in terms of accessibility.

[1] Existing architectural barriers can be divided into: external – directly related to communication: pedestrian, road, rail, bus and associated facilities; internal – directly related to the form and function of various buildings [19].

3. SUBJECT OF RESEARCH AND EVALUATION CRITERIA

The selection of public utility buildings included in the study was based on their importance and significance in the daily life of the residents of the city of Kielce and Kielce poviat, in terms of culture and access to public administration. The following public utility facilities in Kielce were analysed for accessibility:

1. Kielce Cultural Centre (1992)
2. Public Library in Kielce (2007)
3. Świętokrzyskie Philharmonic in Kielce (2011)
4. Poviat Starosty Office in Kielce (2013)

Conducted literature studies and previous research [3-5] made it possible to formulate criteria as a tool for evaluating the accessibility of the proposed significant facilities in the city of Kielce. The study used a multi-criteria method, which enabled comparative analyses and is an effective tool to help make an accurate assessment.

Finally, 3 evaluation criteria were formulated:

Criterion No. 1

External access to the facility:

- designation of a motor vehicle parking system near one of the main entrances, including the location of traveller drop-off points,
- unobstructed pedestrian routes leading to the entrance,
- entrances and exits at ground level,
- information at the entrance to the facility,
- wide door openings and easy door operation,
- sufficient space around the door to allow a person in a wheelchair to open and close the door.

Criterion No. 2

Traffic in the internal space of the building – reaching all necessary functions and zones in the petitioner/customer service area:

- organization and hierarchy of space – a simple and logical functional layout of the interior space,
- available connections of the utility floors of the facility,
- easy access to elevators and toilets, including those adapted to the needs of people with disabilities, intuitive, obvious and accessible fire escape routes,
- spacious elevators equipped with access systems for people with limited perception, safe stairways that are convenient to use and will allow safe evacuation in emergency situations, non-slip surfaces for pedestrian routes,
- appropriate height, location and easy operation of buttons (for example in elevators),
- the visual aspect, the appropriate contrast of walls, floors, doors and signage.

Criterion No. 3
Petitioner/customer service area:
- easy access to information points,
- appropriate height of service points,
- clear and universally understandable signage,
- the transmission of important information through two or more modalities – the senses of perception (touch, sound and visual content),
- hearing support systems.

Criteria that are more important from the point of view of contemporary development and required by law regulations:
- designation of a motor vehicle parking system near one of the main entrances,
- entrances and exits at ground level,
- information at the entrance to the facility,
- sufficient space around the door to allow a person in a wheelchair to open and close the door,
- easy access to elevators and toilets, including those adapted to the needs of people with disabilities,
- spacious elevators equipped with access systems for people with limited perception,
- appropriate height, location and easy operation of buttons (for example in elevators),
- the visual aspect, the appropriate contrast of walls, floors, doors and signage,
- clear and universally understandable signage,
- the transmission of important information through two or more modalities – the senses of perception (touch, sound and visual content),
- hearing support systems.

4. MULTI-CRITERIA EVALUATION OF ACCESSIBILITY OF PUBLIC UTILITY BUILDINGS

4.1. Kielce Cultural Centre,

year of establishment: 1992, finalization of construction: 2002, designer: arch. Daniel Olędzki (Figs. 1-8)

The building of the Kielce Cultural Centre (KCC) was modelled after the plans for the Musical Theatre in Gdynia. Construction was completed in 1992, and the last construction works were finalized in 2002. The Centre is located at Moniuszki Square and is one of the most important cultural facilities in the city.

Criterion No. 1
External access to the facility:
- parking spaces for the disabled are located approximately 10 m from the building, near the main entrance to the building,
- the entrance for the disabled is located at the main entrance from the ground level,
- the pavements leading from the parking lot to the building's main entrance have slight slopes and are free of obstructions,
- there is clear signage and information at the entrance to the building,
- the door in the main entrance area of the building is sliding and wide, which significantly facilitates and affects the comfort of the user,
- sufficient space around the door allows it to open and close freely, including for a person in a wheelchair,
- the functional layout of the exterior is simple, logical and clear.

Criterion No. 2
Traffic in the interior space of the building:
- the main lobby area with a cloakroom for customers has been adapted for people with disabilities, the hall is spacious and easy for everyone to move around,
- vertical traffic for wheelchair users between floors is not possible due to the lack of elevators in the building's public areas,
- to get to the auditorium, a wheelchair user must be assisted by a staff person, and must be guided through the staff area, where there is a passenger elevator,
- the facility's staff is distinguished by their great sensitivity and extensive knowledge of the needs of people with disabilities and the requirements resulting from accessibility needs. Because of its conscious approach to many problems, and despite the facility's obstacles, the staff allows each user full access to the vast majority of activities and events that take place at the facility,
- the management board's ongoing efforts to subsidize the introduction of an elevator in the main hall area are of note. The proposed location will not deteriorate the functional assumptions of the building, but will significantly facilitate the use of the facility,
- the functional layout of the building is complicated, so moving around the facility requires assistance from KCC staff each time,
- the facility has clearly marked vertical traffic and handicapped toilet areas,
- the corridor areas are wide and spacious, with smooth anti-slip surfaces,

- traffic areas in the building have contrast elements for the visually impaired. Graphical solutions refer to the description of doors, toilets and main service areas in the building, as well as the directions of evacuation,
- fire escape routes are not cluttered with any obstacles.

Criterion No. 3

Customer service area:

- information desks are located at the main entrance to the building,
- access to information desks is difficult due to their height – not adapted to people with disabilities,
- the main hall area with a cloakroom for customers has been adapted for people with disabilities, has a smooth surface without architectural barriers,
- hearing aids are located in the ticket office area, where an induction loop is installed to help serve the hearing impaired.

Conclusions: The KCC building has been partially adapted to people with disabilities.

The building's big assets include an entrance for people with disabilities at ground level, an induction loop in the ticket office area, and spacious corridors and staircases. A major problem is the lack of elevators in the general traffic area, which means that wheelchair users must use the elevators in the service area. Of great importance is: the right approach, sensitivity and knowledge of the people managing the facility regarding the needs of people with disabilities, the corrective actions taken.

Fig. 1. View of the main entrance to the building of the Kielce Cultural Center

Fig. 2. View of the KCC building
Source: https://www.4dkielce.eu, accessed on: 02.2023

Fig. 3. Access to the main entrance

Fig. 4. Parking spaces for the disabled at the main entrance to the building

Fig. 5. Main entrance area with glazing markings

Fig. 6. Cloakroom and hall area on the ground floor

Fig. 7. Horizontal communication on the first floor

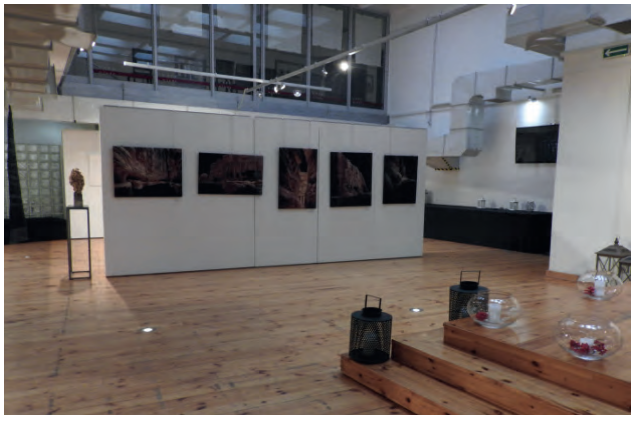

Fig. 8. Art gallery accessible to the public with a disability

Photographs: the author, February 2023.

4.2. Gombrowicz Voivodeship Public Library in Kielce, year of establishment: 2007, designer: Detan Pracownia Architektoniczna, Kielce (Figs. 9-22)

The building is located on Ściegiennego street is a local government cultural institution, maintained from the budget of the Świętokrzyskie Voivodeship.

Criterion No. 1

External access to the facility:

- parking spaces for people with disabilities are located in the parking lot behind the library (about 30 m from the main entrance area of the building),
- the road leading from the parking lot to the Library building has a smooth, paved and level surface free of obstacles,
- the main entrance to the building is not suitable for people with disabilities who use a wheelchair, due to the stairs leading up to the entrance and the lack of a ramp for people with disabilities in this area,
- entrances for people with physical disabilities, including those in wheelchairs, are located on the side of the building to the right of the main entrance – directly from ground level,
- access for wheelchair users is through a wide gate, followed by a convenient sidewalk with a smooth paved surface without architectural barriers,
- in the entrance area for people with disabilities, the space at the entrance door has the required dimensions for manoeuvring,
- the doors in the entrance area for people with disabilities are swinging and wide enough,
- the space around the door is wide enough for manoeuvring and allows wheelchair users to open and close the door.

Criterion No. 2
Traffic in the interior space of the building:
- right at the entrance dedicated to people with disabilities, there is an elevator that allows vertical traffic to all floors. The elevator is spacious and includes buttons at the right height with braille signage,
- the functional layout of the building is simple, logical and legible, corridors and horizontal traffic spaces are wide and do not contain elements that impede traffic for people with disabilities, and have smooth anti-slip surfaces,
- the facility's floors are accessible to all users via elevators,
- elevator and restroom access for people with disabilities is easy and logical,
- the vertical and horizontal traffic zones, as well as the restroom area, have clear signage for people with disabilities,
- fire escape routes are not cluttered with any obstacles.

Criterion No. 3
Service area:
- access to information desks, elevators and restrooms for people with disabilities is easy and clear,
- there are reception and information desks at the entrances to the lending and reading rooms, adapted for people with disabilities who use wheelchairs,
- within the lending and reading rooms, there is a blue zone aimed at people with the autism spectrum disorder and impaired social interaction. Using placards with graphic markings, these people can easily communicate their desire to borrow a book, return a book or other usage preferences at the facility,
- in addition, for people with disabilities, including the elderly, there is a program – Books on call, book delivery, access to the media archive. In addition, access to board games and multimedia (more than 16,000 CDs and DVDs of movies, music and about 5,000 audiobooks) which are made available externally is available to all users,
- the reading room has specialized equipment such as: a printer, which convert written text into the Braille alphabet, and devices that magnify text for the visually impaired, specialized scanners that convert text into speech,
- the website is adapted for people with disabilities in terms of colour, contrast, and accessibility and legibility of information,
- there are no assistive listening components in the facility.

Conclusions: The Voivodeship Public Library building has been adapted for use by people with disabilities and equipped with specialized assistive equipment. The main entrance area does not meet accessibility requirements, so access has been provided via wide paths with a level surface, leading to the door on the east side from ground level. Inside the building, assets include the legibility of the building's layout, a spacious elevator, corridors and staircases, as well as accessible information areas in the lending and reading rooms with many facilities for the visually impaired, autistic or those in wheelchairs.

Fig. 9. Entrance to the Public Library from the front side

Fig. 10. View of the Public Library building
Source: https://www.4dkielce.eu, accessed on: 02.2023

Fig. 11. Pavement zone on the front side

Fig. 12. Passage through a gate to a wheelchair-accessible area

Fig. 13. Elevator located at the entrance to the building

Fig. 14. Horizontal communication in the zone in the entrance area on the eastern side

Fig. 15. Horizontal communication at the rental

Fig. 16. Lowered desk for people with disabilities

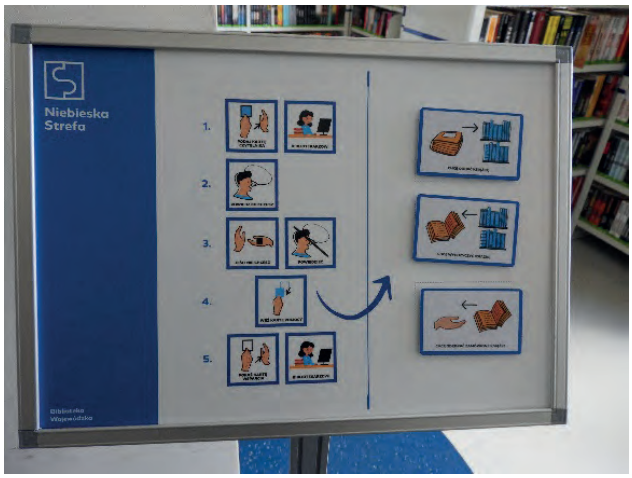

Fig. 17. Blue zone – cards for users with autism spectrum disability for expressing preferences

Fig. 18. Blue zone in the lending room for users with autism spectrum disability

Fig. 19. Service area in the lending room

Fig. 20. Entrance to the lending room – sliding door

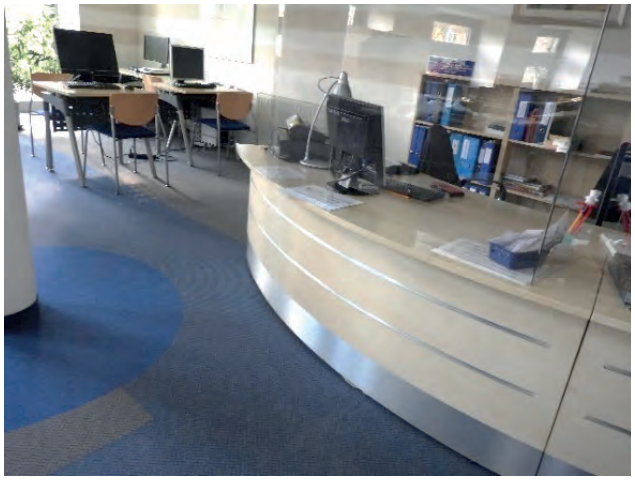

Fig. 21. Service area in the reading room

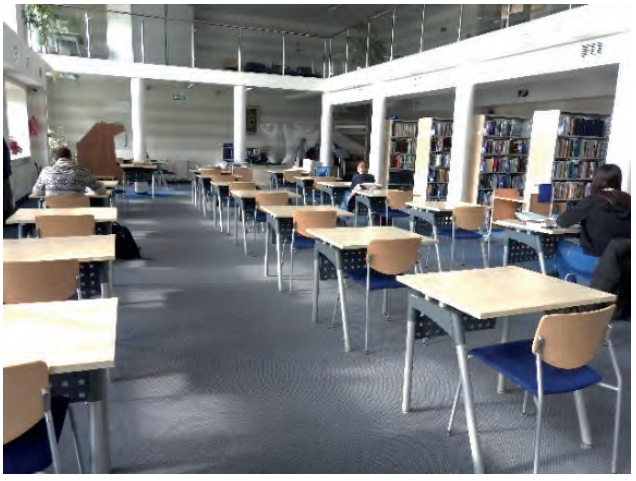

Fig. 22. Reading room – passage between desks

Photographs: the author, February 2023.

4.3. Świętokrzyskie Philharmonic in Kielce,
year of establishment: 2011, designer: PIW-PAW Architekci (Figs. 23-34)

The philharmonic building is located at ul. Żeromskiego in Kielce and is one of the most important cultural facilities in the city.

Criterion No. 1
External access to the facility:
- parking spaces for the disabled are located in the underground parking lot closest to the general circulation areas to the building,
- the pedestrian routes inside the building leading to the entrance are free of obstacles,
- the entrance for the disabled is located at the main entrance, on the ground level,
- the road that leads from the parking lot to the Świętokrzyskie Philharmonic building has a smooth even surface,
- signage and information at the entrance to the building is clear and legible,
- in the main entrance area of the building, the doors are swinging and wide enough,
- the space at the door is of adequate size and allows free manoeuvring for wheelchair users,
- the functional layout of the exterior is simple, logical and clear.

Criterion No. 2
Traffic in the interior space of the building:
- the functional layout in the building is simple and clear, corridors and horizontal traffic spaces are wide and do not contain elements that impede traffic for people with disabilities, and have smooth non-slip surfaces,
- the floors are accessible to all users via spacious elevators,
- the vertical and horizontal traffic areas and toilets for the disabled are clearly and intuitively marked,
- traffic areas in the building have contrast elements for the visually impaired. Contrasts have been used on both the walls and floors, which is certainly a significant convenience for the visually impaired,
- graphical solutions refer to the description of doors, toilets and main service areas in the building, as well as the directions of evacuation,
- fire escape routes are not cluttered with any obstacles,
- elevators have buttons at the appropriate height with braille markings,
- there are no elements of hearing support.

Criterion No. 3
Customer service area:
- access to the information points in the building is simple and clear,
- information desks were conveniently located at the main entrance to the building,
- the customer service area has not been adapted for the disabled, with no lowering of the countertop for wheelchair users,
- the cloakroom area has been adapted for wheelchair users.

Conclusions: The Philharmonic building, with the exception of the ticket office area, is an accessible facility for all user groups. Noteworthy features include a convenient main entrance, a clear functional-spatial and traffic layout, spacious corridors, elevators and staircases, and auditoriums that are accessible to all.

Fig. 23. Main entrance to the Świętokrzyska Philharmonic


Fig. 24. View of the Świętokrzyska Philharmonic
Source: https://www.4dkielce.eu, accessed on: 02.2023

Fig. 25. Ticket office area

Fig. 26. Horizontal communication in the building

Fig. 27. Locker room in the building

Fig. 28. Elevator in the building

Fig. 29. Vertical communication in the building

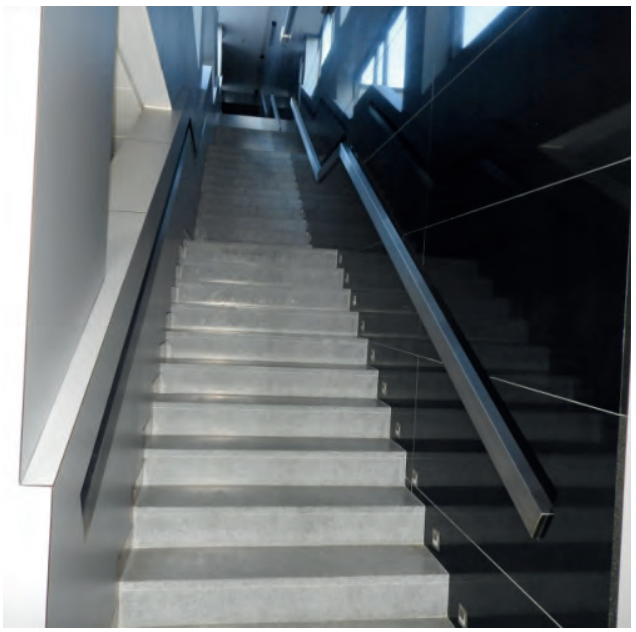

Fig. 30. Vertical communication in the building-stairs

Fig. 31. The main auditorium

Fig. 32. The main auditorium

Fig. 33. Information graphic in the building and patron

Fig. 34. Small Concert Hall

Photographs: the author, February 2023.

4.4. Poviat Starosty Office in Kielce,
year of establishment: 2013, designer: Team s.c. – Design Studio from Busko-Zdrój (Figs. 35-40)

Criterion No. 1
External access to the facility:
- parking spaces for people with disabilities closest to the building are located about 20 meters away,
- the pedestrian routes leading to the entrance are free of obstacles,
- the entrance for people with disabilities is the main entrance – directly from the ground level,
- the road that leads from the parking lot to the Starosty building has a smooth even surface,
- signage and information at the entrance to the building is clear and legible,
- in the area of the main entrance to the building there are sliding doors, wide enough, which significantly facilitates use,
- the space at the door is of adequate size and allows free manoeuvring for wheelchair users,
- the functional layout of the exterior is simple, logical and clear.

Criterion No. 2
Traffic in the interior space of the building:
- the functional layout is simple and clear, corridors and horizontal traffic spaces are wide and do not contain elements that impede traffic for people with disabilities, and have smooth non-slip surfaces,
- the floors are accessible to all users via elevators,
- the areas of vertical and horizontal traffic and toilets for people with disabilities are clearly and intuitively marked,
- traffic areas in the building have contrast elements for the visually impaired. Contrasts have been used on both walls and floors, which can be a significant convenience for the visually impaired,

- graphical solutions refer to the description of doors, toilets and main service areas in the building, as well as the directions of evacuation,
- fire escape routes are not cluttered with any obstacles,
- there are no elements of hearing support.

Criterion No. 3

Petitioner service area:

- access to the information points in the building is simple and clear,
- information desks are located at the main entrance to the building,
- the customer service area has been adapted for the disabled, with a lowered countertop for wheelchair users.

Conclusions: The building of the Poviat Starosty Office in Kielce is an accessible facility for people with disabilities. The building's big assets include a main entrance accessible to all, the legibility of the building's layout, spacious corridors, elevators and staircases, and accessible information areas at the building's entrance.

Fig. 35. Entrance to the Poviat Starosty on the front side

Fig. 36. Location of the Poviat Starosty Office building Source: https://www.4dkielce.eu, accessed on: 02.2023

Fig. 37. Entrance from the front side

Fig. 38. Horizontal communication in the building

Fig. 39. Lowered console table in the service area

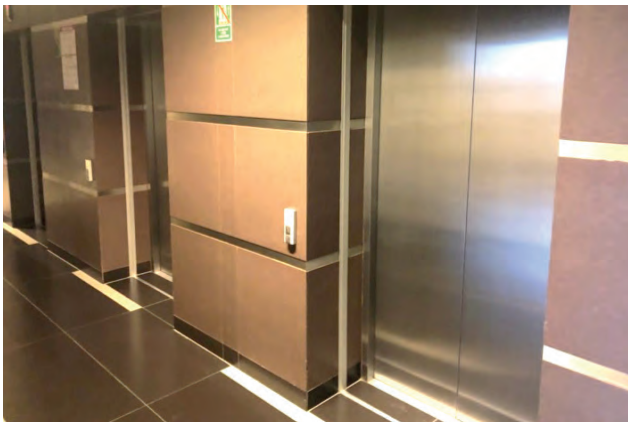

Fig. 40. Vertical communication in the building

Photographs: the author, February 2023.

5. SUMMARY AND CONCLUSIONS

A review of the proposed public facilities of Kielce allows us to conclude that these buildings mostly have architecture and interior space adapted for people with disabilities, but not to the full extent. This is due in large part to the period in which these buildings were designed and built (except the philharmonic). In the situation of some structures, it is often difficult or even impossible to meet all the requirements for full accessibility, due to the specificity of the structure. Then the situation forces the use of alternative solutions (e.g., Kielce Cultural Centre). In addition, the solutions that are introduced into the facilities at later stages of use are not exactly comfort solutions and those that should be considered equivalent to those envisioned at the stage of design or radical reconstruction of the facility. Based on the analysis, it should be concluded that the vast majority of the solutions and amenities introduced so far refer to conventional and formal solutions. These are more conservative concepts, with distinctive spaces and facilities that are usually introduced and dedicated specifically for the elderly and people with disabilities. With regard to the most recent buildings (the Philharmonic building) completed in Kielce in the 21st century, it should be emphasized that they constitute accessible space – based on the assumed evaluation criterion.

No criterion	Description of the criterion	Kielce Cultural Centre 1992	Public Library in Kielce 2007	Świętokrzyskie Philharmonic in Kielce 2011	Poviat Starosty Office in Kielce 2013
CRITERION No. 1 External access to the facility	designation of a motor vehicle parking system near one of the main entrances, including the location of traveller drop-off points	+	–	+	+
	unobstructed pedestrian routes leading to the entrance	+	+	+	+
	entrances and exits at ground level	–	+	+	+
	information at the entrance to the facility	+	+	+	+
	wide door openings and easy door operation	–	+	+	+
	sufficient space around the door to allow a person in a wheelchair to open and close the door	+	+	+	+
CRITERION No. 2 Traffic in the internal space of the building – reaching all necessary functions and zones in the petitioner/customer service area	organization and hierarchy of space – a simple and logical functional layout of the interior space	+	+	+	+
	available connections of the utility floors of the facility	+	+	+	+
	easy access to elevators and toilets, including those adapted to the needs of people with disabilities, intuitive, obvious and accessible fire escape routes	+	+	+	+
	spacious elevators equipped with access systems for people with limited perception, safe stairways that are convenient to use and will allow safe evacuation in emergency situations, non-slip surfaces for pedestrian routes	+	+	+	+
	appropriate height, location and easy operation of buttons (for example in elevators)	+	+	+	+
	the visual aspect, the appropriate contrast of walls, floors, doors and signage	–	+	+	+
CRITERION No. 3 Petitioner/customer service area	easy access to information points	+	+	+	+
	appropriate height of service points,	+	+	+	+
	clear and universally understandable signage	+	+	+	+
	the transmission of important information through two or more modalities – the senses of perception (touch, sound and visual content	+	+	+	+
	hearing support systems	–	–	–	–
	SUMMARY	14(+)/3(-)	15(+)/2(-)	17(+)	17(+)

In conclusion, the studies carried out have led to conclusions and recommendations to help in the design and management of facility spaces:

- An important aspect is to pay attention to innovation and consider the needs of future seniors, given the dynamic changes in the relationship between people and the virtual environment.
- Designing concepts with bold solutions, using the latest research advances related to design for seniors and people with disabilities, including: appropriate design of spaces that eliminate barriers related to sensory dysfunctions and minimize disabilities, i.e., functionality, clarity of layouts adapted for people with visual impairments.
- Using the achievements of progress and incorporating conteporary technologies that shorten the distance and save time determine greater efficiency and precision [5].

The research issues raised in the article, as well as the recommendations made, are undoubtedly interdisciplinary in nature. Therefore, the search for a new functional structure, universality of solutions and formal assumptions becomes an important challenge for architects and designers, both of existing and newly designed public facilities. In particular, the structures of newly constructed service buildings absolutely must be clear and intuitive to facilitate the functioning and spatial relationships in the facility for all users. Each space should allow all people to use it as independently and consciously as possible.

In conclusion, it should also be emphasized that awareness of universal accessibility of buildings and universal design has significantly increased in recent years, and those managing the presented public facilities are fully aware of the needs of people with disabilities. As it stands, the financial aspect remains an important issue to be resolved.

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NEW PROPOSAL FOR THE FORMER SYNAGOGUE IN KIELCE

NOWA PROPOZYCJA DLA BYŁEJ SYNAGOGI W KIELCACH

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Abstract

The current trend of conservation of immovable monuments is – in addition to ongoing maintenance and protection – adaptation. Simply taking care of a monument is not an effective way to keep it in good repair if it is not used. Utility is the primary function of architecture, as buildings are erected for this purpose only. No building can survive without function, especially a centuries-old one. This is because the lack of a user condemns any monument to destruction, which leads to ruin and, ultimately, to demolition. Therefore, proper adaptation to new functions and current technical conditions is necessary. In the process of adaptation, all the heritage values of the object should be brought out and only then should new ones be introduced, taking into account the integrity of the monument and ensuring authenticity. Sacred architecture has special cultural and historical values, both tangible and intangible, i.e. spiritual. Continually discussed adaptations of religious buildings in the case of Judaic religious buildings destroyed and abandoned after World War II proved to be the best way to reclaim synagogues. The Kielce synagogue is one of the early examples of adaptation to another function. The building, destroyed during World War II, was rebuilt in the 1950s in a different form than the original one, for use as an archive. This historic building, however, has been standing useless for more than a decade now, and this fact has a destructive effect on its heritage value, therefore it is necessary to take action as soon as possible. Numerous concepts for this building located in a prestigious area in Kielce can be produced, which will be presented and evaluated in terms of substantive potential of utilizing its value in a new incarnation.

Keywords: monument protection, conservation, adaptation, synagogue, Kielce

Streszczenie

Nurtem współczesnej ochrony zabytków nieruchomych jest nie tylko bieżąca konserwacja i ochrona, ale adaptacja. Samo dbanie o zabytek nie jest skuteczną metodą utrzymania w dobrej kondycji każdego obiektu, jeśli nie będzie użytkowany. Użyteczność to podstawowe zadanie architektury, ponieważ tylko z tego powodu tworzone są budowle. Żaden budynek nie przetrwa bez funkcji, a szczególnie wiekowy. Brak użytkownika skazuje bowiem każdy zabytek na zniszczenie, co doprowadza do ruiny, a z czasem skazuje na rozbiórkę. Dlatego konieczna jest właściwa adaptacja na nowe funkcje i do obecnych warunków technicznych. W procesie adaptacji powinno się wydobyć wszystkie wartości zabytkowe obiektu i dopiero wprowadzać nowe, uwzględniając integralność zabytku i wpisujące się w autentyczność. Szczególne wartości zabytkowe ma architektura sakralna, zarówno te materialne, jak i niematerialne – duchowe. Cały czas poddawane dyskusji adaptacje obiektów sakralnych w przypadku zniszczonych i opuszczonych po drugiej wojnie światowej budynków kultu religii judaistycznej okazały się najlepszą metodą na odzyskanie synagog. Kielecka synagoga należy do wczesnych przykładów adaptacji na inną funkcję. Budynek zniszczony w czasie drugiej wojny światowej odbudowano w latach 50. XX wieku, w innej formie niż pierwotna z przeznaczeniem na archiwum. Obecnie jednak ten historyczny budynek od ponad dekady stoi bezużyteczny, a fakt ten ma destrukcyjny wpływ na zabytkową substancję, dlatego konieczne jest jak najszybsze podjęcie działań. Pomysłów na ten obiekt w prestiżowej lokalizacji w Kielcach jest wiele, zostaną one przybliżone i ocenione pod względem możliwości merytorycznego wykorzystania jego wartości w nowym „wcieleniu".

Słowa kluczowe: ochrona zabytków, konserwacja, adaptacja, synagoga, Kielce

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1. INTRODUCTION

There were many Jewish communities in the Świętokrzyskie province before World War II, which it evidenced mainly by the remaining objects of worship – synagogues[1]. There are 14 synagogues[2] preserved in the Świętokrzyskie Voivodeship, and the fact that there were more is evidenced by written sources[3]. All masonry buildings[4] lost their original function after World War II and are now in various states of repair and serve a variety of functions. This is because some have been adapted for cultural functions (Chęciny, Chmielnik, Kielce, Pińczów, Połaniec, Sandomierz, Szydłowiec), some are privately owned and have a service/commercial function (Busko-Zdrój, Ożarów), but most fell into disrepair (Wodzisław, Działoszyce, Nowy Korczyn, Klimontów, Tarłów).

One of the synagogues dating back to the beginning of the 20th centuray can be found in Kielce, which is the capital of the Świętokrzyskie province, at 17 Warszawska Street, in the strip separating the road ways of IX Wieków Avenue Kielc (Fig. 1).

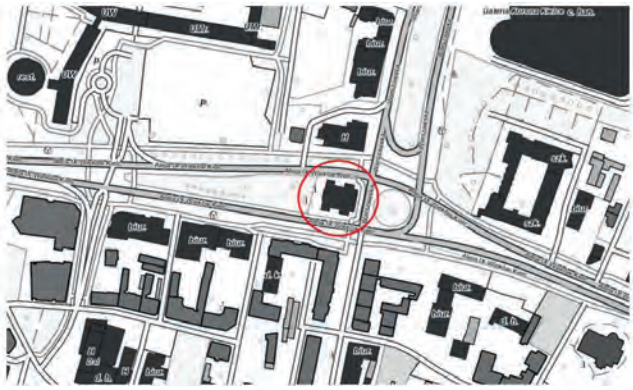

Fig. 1. Synagogue in Kielce. Current Situation. Base Source: [2]

As sources indicates, this detached building was erected on what was then called Nowowarszawska Street (Fig. 2), there was a wall with a gate between the synagogue and the street, and the plot also included the rabbi's house. The synagogue was taken over by the state treasury after the war, but the owner of the building was probably the Jewish Religious Community in Katowice. Currently, the city of Kielce is its owner. The synagogue building was entered in the register of monuments on 14/07/1987, under No. 1038, and has been legally protected ever since.

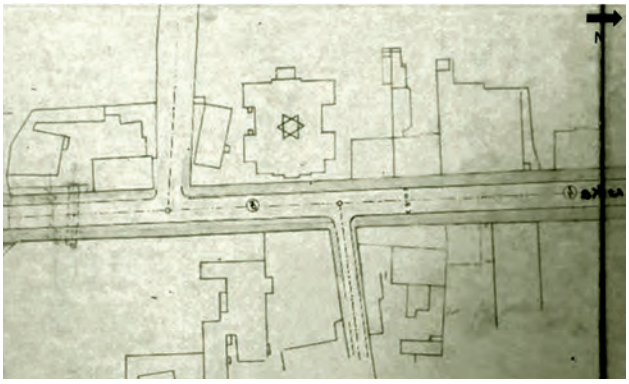

Fig. 2. Synagogue in Kielce. Location plan on a scale of 1:1000, 1919–1939 [3]

2. HISTORICAL OUTLINE OF THE OBJECT

The Kielce Synagogue was built in 1902–1903, but its history dates back to the late 19th century, or perhaps a bit earlier, when, under a tsarist decree in 1867, Jews were granted the right to settle in the city and began arriving in large numbers in Kielce. Earlier, they resided here "illegally"; despite a permit issued in 1833 for the Jewish worshipers to settle in the city, due to pressure from residents a decade later, an order was issued in 1843 to expel them from Kielce [4]. For, as a bishop's city, Kielce had the privilege of *Privilegium de non tolerandisjudaeis* (Latin: privilege of not accepting Jews), which was in effect until the reform of Alexander the Great. On 24 May 1862, a decree was issued which led to the full emancipation of Jews in the Kingdom [4]. In 1868, a new Synagogue District was approved in Kielce, as a result of which the Kielce Orthodox Jewish community organized a place for services in a private house on Bodzentyńska Street[5]. The concept of putting up an object of worship for Kielce's Jews – a synagogue – appeared in 1897. In order to permanently mark the presence of Jews in the city, a member of the board of directors of

[1] The synagogue was not a temple, although its space was considered sacred. It is a multifaceted establishment in which worship was held, it had the role of a school, shelter, court, charitable institution, and was a place for communal meals and meetings. See: [1].

[2] Kielce, Busko-Zdrój, Chęciny, Wodzisław, Działoszyce, Pińczów, Nowy Korczyn, Połaniec, Szydłowiec, Klimontów, Sandomierz, Ożarów, Tarłów, Chmielnik.

[3] Będzin, Bodzentyn, Bogoria (wooden), Końskie, Małogoszcz, Nowa Słupia, Oksa, Opatów, Radoszyce, Raków, Skarżysko-Kamienna, Starachowice, Staszów, Suchedniów, Wiślica, Włoszczowa.

[4] Wooden synagogues came before masonry ones in Będzin, Bodzentyn, Busk-Zdrój, Sandomierz.

[5] The synagogue was set up in a private house at Borzęcka Street (currently Bodzentyńska). See: [4].

the Jewish community in Kielce, Moses Pfeffer[6], along with his wife Esther, donated 20,000 rubles and their own square at 17 Nowowarszawska Street for the construction of the temple. Construction of the synagogue, designed by Stanisław Szpakowski[7], began in 1902, while a year later it was made available for use by the Jewish community.

In 1907–1908, with funds raised for paid seating in the synagogue, a wall, gate, rabbi's house, a modern brick mikvah – bathhouse – were erected, and the square around the synagogue was paved. Thus, in Kielce, alongside the cathedral and the Orthodox church, another religious building was erected, dominating the small, mostly wooden houses of the suburb of Nowy Świat, where there was the largest concentration of Jews in Kielce (Fig. 3a) [4]. The building served not only a sacred function, but was also a place for meetings of the Jewish community, the formation of certain social attitudes and decision-making of Jews living in Kielce.

The synagogue was first destroyed during World War I, when an artillery shell damaged the structure and fence. Nevertheless, the synagogue was bustling with activity, such as prayer and social meetings, a school for boys called 'cheder' and a men's choir. During World War I, also an "Affordable canteen" here and the "Society for the Relief of the Poor of the Mosaic Faith" functioned there. This was the case until the outbreak of World War II, at which time in 1940 the building was taken over by the German occupiers and used as a detention center and warehouse for stolen Jewish goods. At the end of the war, when the building was no longer needed, it was set on fire, and thus 70% destroyed along with all movable equipment, which made it unable to be operated according to its pre-war purpose.

The decision to rebuild the synagogue building was made in 1951, but the exact dates when the works were carried out, as well as the author of the design of the now-famous body of the building, are difficult to determine (Fig. 3b). Earlier studies pointed to Władysław Dmoch[8], while others to Jerzy Żukowski[9]. According to recent findings, the assumptions of the synagogue reconstruction plan were developed by engineer Stanislaw Skibniewski, while the design was drawn up by Dmoch in cooperation with B. Hermanowicz [10].

a)

b)

Fig. 3. a) Synagogue before World War II – reproduction of a postcard, 1913 or 1914, from the collection of the Kielce History Museum [7, 8]; b) Synagogue in Kielce. View of the northern and east facade from Warszawska Street, 2022, photo by M. Doroz-Turek

As a result of this post-war reconstruction, the synagogue lost its original architectural form, and with it the function was changed from sacred to secular. The State Archive was moved to the rebuilt building in 1955

[6] Moses Pfeffer (?–1920 Warsaw) – social and political activist, landowner, merchant. He gained considerable wealth by supplying materials for the construction of the Iwangorod-Dąbrowa railroad line (Dęblin-Dąbrowa Górnicza, with a branch line from Ostrowiec to Koluszki) in the 1st half of the 1980s, managed by J.B. Bloch. At the end of the 19th century, he was one of the leading personalities of the Jewish community in Kielce, a member of the local Synagogue Dispensary, co-founder of several charitable societies (including the Society for Aid to the Poor of the Mosaic Faith) [Polish name: Towarzystwo Pomocy Ubogim Wyznania Mojżeszowego]. He generously supported various social projects in Kielce, including the construction of a synagogue (1902) and the fight against typhus (1905–1907). He ran, unsuccessfully, in the State Duma elections. He was a member of the Agudat Yisrael, which he represented in the Council of State as a nominee of the Regency Council. See: [5].

[7] Stanislaw Szpakowski, a Kielce-based engineer-architect. Major projects, beside the synagogue, implemented by him in Kielce included: in 1902, St. Nicholas Orthodox Church – currently the Garrison Church of the Blessed Virgin Mary Queen of Poland; 1903 – Holy Cross Church; home-shelter for retired priests in Kielce. See: [6].

[8] It was restored in 1951–1955 to a design by W. Dmoch for use as an archive. See: [9].

[9] Jerzy Żukowski, architect, graduate of the Faculty of Architecture, Warsaw University of Technology. In Kielce, in 1944, he attended secret classes of the Architecture Department, led by Professor Bohdan Pniewski, teaching freehand drawing. Since then, he was active in the Kielce province and Kielce, where he carried out several projects, including the design of the building of the Central Committee of the Polish United Workers' Party in Kielce at S. Żeromskiego Street in 1952. See: [6].

Fig. 4. "Freedom Garden" – a proposal to develop the area in front of the former synagogue building – in the strip separating the roadways Aleja IX Wieków Kielc [13]

and the new function housed it for several decades. In the 1990s, on the occasion of the 50th anniversary of the Kielce pogrom[10], the former synagogue building was renovated [11]. Despite this, the building was still in a bad repair, as there was a lack of funds for ongoing repairs and maintenance, which was also related to the legal-ownership situation. The National Archives changed its location in June 2011. It was known beforehand that it was going to be relocated, and as a result, the city authorities were thinking of another use for the monument. In 2009, the then mayor of Kielce Wojciech Lubawski, who believed that the adaptation of the former synagogue building was very important for the city, invited Peter Zumthor[11] to cooperate. The Swiss architect was to take on the project of adapting the synagogue to a cultural function, making the building a center for the meeting of cultures and religions, where Jews who come to the city as tourists can pray and meet. The general concept for the transformation of the building was to house Grzegorz Artman's New Avant-Garde Theater and a public library with a reading room. The mayor emphasized the tradition of the building, the function it originally served, which he believed should be respected [12]. Unfortunately, the unregulated ownership of the building prevented the plan that the city authorities had with architect P. Zumthor, who wanted to create a modern building in the center of Kielce. Property ownership was clarified in May 2014, but unfortunately cooperation with P. Zumthor was not resumed. In the following years, a new idea was born to adapt the synagogue building into a Pałac Lalek [*Doll Palace*], but it did not come to fruition.

In February 2022, a proposal was announced to develop the space in front of the former synagogue, named "Freedom Garden"[12] with greenery, small architecture and educational paths. The project has been implemented since July 2023, and the work is scheduled to be completed in spring 2024. The space will be the first stage to create an Island of Understanding. Plantings will quiet and separate the entire area located between the road lanes of Aleja IX Wieków Kielc – the island – from heavy traffic. It is intended to be a separate enclave of park and garden space providing opportunities for recreation. The area is to be an introduction to the former synagogue building. Designed interactive educational sites with multimedia elements will inform about historical examples of the development of freedom in Europe. It will also serve the function of strengthening civic attitudes, building awareness of the freedom transition on the European continent and the values that have shaped Europe's cultural heritage (Fig. 4).

[10] The pogrom took place on 4 July 1946, in a tenement building at 7 Planty Street in Kielce.

[11] Peter Zumthor (born 1943) is ranked among the world's top contemporary architects. In 2009, he received the Jay Pritzker Prize in Buenos Aires, which is considered the Nobel Prize in architecture.

[12] The project would be implemented within the framework of the Polish Order program "Zielona rewitalizacja Śródmieścia Kielc – Skwer im. I. Sendlerowej, Rynku, ul. Bodzentyńskiej wraz z placem św. Wojciecha i terenem przed dawną Synagogą" [Green Revitalization of Downtown Kielce – I. Sendlerowa Square, Market Square, Bodzentyńska Street together with St. Adalbert Square and the area in front of the former Synagogue]. See: [13].

The synagogue building is currently unused, and public consultations on its new function are underway.

3. HISTORICAL AND CURRENT FORM OF THE BUILDING

Stanisław Szpakowski designed the synagogue in the Neo-Moorish style with oriental decorative motifs on the facade and a richly decorated interior. The architect was probably inspired by the architecture of the largest synagogues in Europe built in this style, i.e. in Budapest (1854–1859, rebuilt) and Vienna (1854–1858, no longer in existence), as well as in Berlin[13] (1866–1938). These structures made this style popular in the 19th century in the Austro-Hungarian Empire and in the Prussian partition. Unfortunately, most of these civil structures have not survived to this day. Almost all of those located within the German Reich, had already been completely destroyed during Kristallnacht in 1938.

Neither did the Kielce synagogue survive in its original style. The original synagogue building plans have also not survived, and the existing ones were drawn up in 1949, in connection with the planned reconstruction of the synagogue in its original form and purpose. Z. Wróblewski and P. Przybylski were the authors of the inventory plans [15]. Eventually, the building was rebuilt in the Socialist Realist style for use by the Provincial State Archive in Kielce [16].

3.1. The original form of the building

The building in Kielce was a classic example of synagogue architecture, built on a near-square plan, with a women's gallery located at the top. It was a detached building with a basement, set on stone foundations. The front was extended in relation to the main body by a lower extension and two symmetrically positioned annexes, in which staircases were located.

Originally, the building's facade was made of rough brick on lime mortar. In later years, probably in the interwar period, it was plastered over. The main entrance was on the east side hence the front facade was very ornate. The facades featured geometric and floral decorative motifs, including gables and frames for window and door openings, inspired by Romanesque, Arabic and even Orthodox church architecture. The two-story body of the temple was covered with a gable roof with a decorative attic on the east and west sides.

In 2020–2021, a member of the Jan Karski Association, Piotr Świerczyński, attempted to create visualizations depicting the synagogue building both from the outside – originally masonry (Fig. 5) and after plastering (Fig. 6), known from several iconographies, as well as its lesser-known interiors. The visualizations were based on the building inventory taken before the reconstruction, pictured above. Since no photographs depicting the synagogue's interior are known, its reconstruction is based on two post-war memoirs of Kielce Jews describing them, while the wall paintings, bimah and aron ha-kodesh are presented based on the appearance of these elements in synagogues decorated in a similar style.

Fig. 5. Synagogue in Kielce – originally masonry. 3D reconstruction of the former Kielce synagogue building, according to P. Świerczyński [7]

Fig. 6. Synagogue in Kielce – after plastering. 3D reconstruction of the former Kielce synagogue building, according to P. Świerczyński [7]

According to witnesses, the interior was richly decorated and had a clear layout. The main entrance, located in the western facade, was for men. The vestibule with two columns, where there was a bowl

[13] The Berlin architect Eduard Knoblauch (1801–1865), who designed the synagogue in Berlin, was inspired by the Moorish style of the Alhambra palace complex in Granada. See: [14].

or washbasin for washing hands before entering the main hall – the kijor, led straight to the main hall, to the right to the cheder – a Jewish religious school for boys or to the left to the Jewish Benevolent Society room. Women entered separately, through side entrances to balconies.

The main hall, the prayer room, was roughly square in shape and was divided by pillars into a nave and two aisles. Its interior was richly decorated. The 12 tribes of Israel were painted on the blue ceiling symbolizing the sky. There was the Wailing Wall to the right from the entrance, Rachel's tomb to the left, while in the center there was a richly decorated bimah – a lectern for reading Torah. Against the east wall, in a small apse, there was the altar closet – the aron ha-kodesh. To the right of the prayer hall there was a wide gallery for the choir. Women galleries were supported by pillars painted in the color of marble[14].

3.2. Present condition of the building

The current form of the former synagogue building is the result of the 1951–1955 reconstruction, during which its original exterior and partial interior layout were changed to accommodate the activities of the State Archives.

The body of the building, the facades devoid of original detail, are significantly different from pre-war ones. The transformation of oriental motifs through the use of simple neoclassical divisions significantly simplified the building's form. The new form is dominated by an attic with narrow niches topped with a semicircle, being a reference to the details of the synagogue's original style, as well as classical divisions of the facade. The extensions have balustrades made of balusters, separated by low quadrilateral posts. The main entrance is preserved in its original location, on the west side, framed by a stone portal with a wooden double door with panels, with stone steps leading to it. The size and shape of the window openings were completely changed, from arched, characteristic of the Moorish style, to rectangular ones. Currently, the windows are wooden, double, with four (on the ground floor) and five (on the first floor) panes in the sash. In addition, metal bars have been installed in the windows of the ground floor. The building is fully plastered. Its color scheme has changed over the years, but in 1996 the original blue-gray color was restored.

The plan and cross-section of the building also show the changes made. On the ground floor, two staircases housed in symmetrically arranged annexes were eliminated, replaced by a single representative staircase. Two rows of columns to support the ceiling of the first floor, which was laid over the entire building (previously, the first floor had women's galleries located on both sides, and there was no ceiling over the rest of the hall – it was topped by an unusual wooden vault) were additionally designed in the main hall, the former prayer hall. The cross-section shows changes in the height of the floors. Originally, both the main hall, vestibule and annexes were located on the same level, while the women's balconies were located 5.4 meters higher. Currently the rooms are located on different levels. The entrance area in the vestibule is located higher than the level of the main hall. An additional level between the floors was also added, at a height of 2.7 meters running along the aisles. The entire height of the building has also changed. In the original design, the building was 19.75 m high (measured to the highest point), while measured to the ridge it was 17.4 m high. Currently, the building is much lower, and its height, measured to the top of the attic, is 14.9 m. The building has a partial basement on the west side.

In addition to the building, the development of the area around the former synagogue (Fig. 1) consists of a square with memorials and a green area. The square with memorials to the site is located on the west side, right at the entrance to the building. There is, among others, a stone with a plaque commemorating the victims of the Kielce ghetto and death camps, which bears the inscription: "Pamięci 27000 Żydów z kieleckiego getta zamordowanych przez Niemców w latach 1939–1944 w Kielcach, Treblince i innych obozach zagłady" [*To the memory of the 27,000 Jews from the Kielce ghetto murdered by the Germans in 1939–1944 in Kielce, Treblinka and other extermination camps*]. Next to it there is a monument with a large inscription SPRAWIEDLIWY WŚRÓD NARODÓW ŚWIATA [*To the rightous among the nations of the world]* commemorating Poles who died for helping Jews. It also features two plaques: "JA SŁYSZĘ TEN TYTUŁ I STARAM SIĘ O TYCH LUDZIACH MYŚLEĆ, CO CHRONILI MNIE. JA PYTAM I PYTAM: – O, NA MIŁY BÓG, CZY JA BYM NA ICH MIEJSCU TAK UCZYNIĆ MÓGŁ?" [*"I hear this title trying to think about these people who protected me, and I keep asking myself: Oh, for goodness' sake, would I in their place have done the same?"*] and "PAMIĘCI POLAKÓW ZAMORDOWANYCH PRZEZ NIEMCÓW

[14] Interiors description. See: [9].

W LATACH 1939–1945 ZA UDZIELANIE POMOCY ŻYDOM I RATOWANIE ICH PRZED ZAGŁADĄ" [*To the memory of Poles murdered by the Germans in 1939–1945 for helping Jews and saving them from extermination*].

The remaining area, from the square to the end of the plot, is a green area. It features irregularly spaced, sparse trees and shrubs, with no paths or sidewalks. The area is connected to the adjacent streets by pedestrian crossings located at the eastern and western sides of the plot.

4. ADAPTATION OF THE SYNAGOGUE AND ITS SURROUNDINGS ON THE EXAMPLES OF STUDENT PROJECTS OF THE KIELCE UNIVERSITY OF TECHNOLOGY

"As an architect you design for the present, with an awareness of the past, for a future which is essentially unknown" – applying Norman Foster's words to the analyzed area shows how important it is to be aware of the history of a place – *the past* – and how difficult a task the designer faces – *for the present*, whose goal is to design the *future* of the place in the context of its surroundings.

The interest of architecture students at Kielce University of Technology in the design activities related to the former synagogue shows how valuable this micro-area [22] is in the city of Kielce, as can be seen in selected course projects and theses. The creative insight of the young architects, their expression and attempt to search for solutions other than standard ones, shows new possibilities for the adaptation of the former synagogue and the development of the land next to the building located in a prestigious location in the median strip of Aleja IX Wieków Kielc near the intersection with Warszawska Street.

The authors of the projects presented below faced a major design challenge, difficulties and complexity of problems, such as:

– adaptation of the historic synagogue building, taking into account the history of the site and its importance not only for the Jewish people, but also for the city of Kielce, to a new utility function;
– difficult location – the plot is located in the median strip, with heavy traffic streets on each side, difficult access for pedestrians and vehicles;
– the shape of the plot – oblong, narrowing gradually as one moves away from the building;
– surrounding buildings – historical and modern, dominant buildings.

4.1. Student conceptual design for the adaptation of a former synagogue into a Museum of Jewish History and Culture [23]

The conceptual design for the adaptation of the former synagogue, the main goal of which was to restore interest in the building by giving it a new function – the Museum of Jewish History and Culture, as well as the development of the site (Fig. 7) in a way making it attractive to visitors, is an example of a student project carried out as part of the course in Conservation Design. The design objectives set by the authors of the concept include: partial restoration of the synagogue's original external appearance; development of the site in a way making it attractive and safe for users – linking the communication systems of the building, the plot and the surroundings, introducing an underground tunnel providing direct access to the building; adapting the interior of the building to modern needs and utility requirements,

Fig. 7. Land development [23]

adapting the rooms to the new functional program, introducing an underground story that will be a museum of Jewish history and proposing a new facility with the function of a café.

An important aspect of the project is an attempt to restore the memory of the site's history. According to the authors, the goal will be achieved by introducing a cultural function to the former synagogue building – the Museum of Jewish History and Culture. The functional program would include, among other things, a library and reading room, a conference and exhibition hall in the main hall, which would be restored to its former majestic appearance, along with mezzanine floors, a prayer room for worshipers of Judaism, in the south wing, and technical, administrative and sanitary rooms (Fig. 8). In addition, an underground story was introduced, housing a museum of Jewish history. This story is connected to Kozia and Targowa Streets with a tunnel, and is also a link to a new building with a café, whose interior and exterior design is full of symbols and references to Jewish culture.

In their concept, the authors also propose to show the changes that the former synagogue building has undergone over the course of history. An installation of mesh on a grid attached to the facade, molded to resemble the original Neo-Mauritanian style, was applied to the building's renovated Socialist Realist facade. With the superimposed images, it is possible to observe the elements that have been changed or removed (Fig. 9).

The concept is complemented by the development of the plot, through the introduction of a new building with a café function and a water reservoir integrated into an orderly low and high greenery, which will reduce the noise of the neighboring streets (Fig. 10).

Fig. 8. Synagogue in Kielce. Design. Ground and floor plan [23]

Fig. 9. Design visualizations – bird's eye view from the east [23]

Fig. 10. Design visualizations – view of the western facade including the surroundings [23]

4.2. The adaptation of the former synagogue building at Warszawska Street in Kielce to house a fringe theater [21]

The main assumption of the author of the diploma project was that the adaptation of the historic building of the former synagogue to the new function of a fringe theater should take into account the history of the place and its importance not only for the Jewish people, but also for the city of Kielce. Therefore, with the aim of respecting the historical and cultural context, the historic building was preserved in its existing state, providing for the renewal of the facade while maintaining the current color scheme. Taking into account the value of the monument, the author has proposed a cultural function – a theater, involving, in addition to the use of the existing building, upward and underground extension by two floors below ground level next to the existing building.

The project site is in a rather difficult location. Despite the advantages of being located in the city center, connecting the plot to the rest of the city is problematic. Although directly adjacent to the transportation system, access to the building is difficult, both for pedestrians and wheeled vehicles. The author proposed a solution for underground parking, with an entrance road planned from Targowa Street, while pedestrian access to the entrance area through a garden located on the west side of the plot, near the existing pedestrian crossing.

The author proposes to develop the area around the building with orderly plantings of trees and shrubs. Taller vegetation has a filtering and protective function – located at the border of the plot, it becomes a natural barrier against pollution and noise coming from the busy streets surrounding the development area (Figs. 11, 12). The concept also retains, slightly changing their location, the memorials. The stone with the plaque and the brick wall will be moved to the garden area, while the plaque on the building will be left in its current place.

The author proposes to adapt the former synagogue building into a theater. The former nave will house the stage and auditorium, while the aisles – facilities for both staff and actors. Former women's gallery will be transformed into audience balconies. The annexes will house toilets and dressing rooms, as well as scenery, costumes or stage equipment storerooms (Fig. 13).

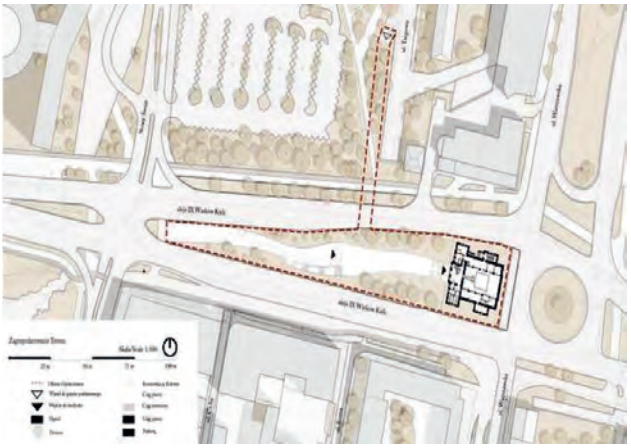

Fig. 11. Synagogue in Kielce. Design. Land development [21]

Fig. 12. Synagogue in Kielce. Design. Visualization – bird's eye view of the entire study area [21]

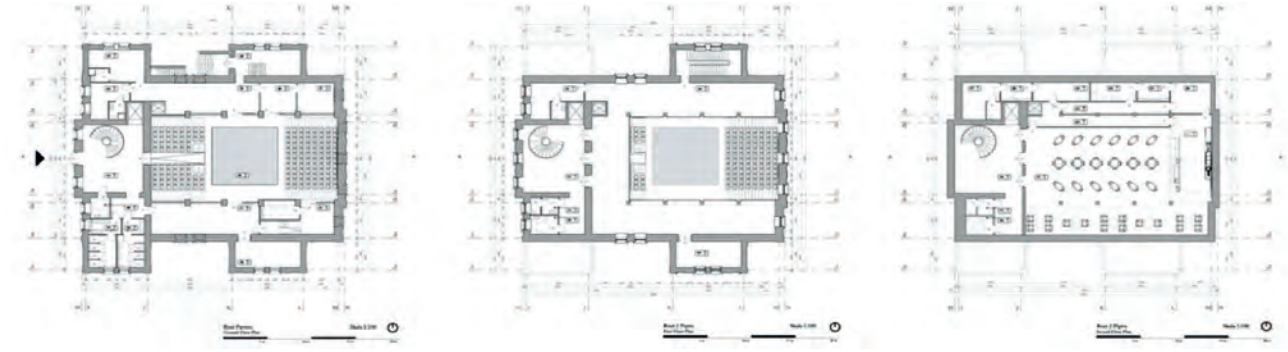

Fig. 13. Synagogue in Kielce. Design. Floor plans of the building (ground floor, first floor, second floor) [21]

The extension of the building proposed by the author involves a café designed on the top floor and its roofing. It was projected above the attic, thus increasing the height of the building aligning with the height of the contemporary frontage located on both sides of Warszawska Street (Fig. 14).

The entrance to the former synagogue building will be left in its original location and skylights will be located in the same axis to light up the entrance area from above, as well as supplementary functions for the theater in the new part of the building on level –1 (Figs. 15, 16). Underground parking lot has been envisaged on the lower floor, with access from Targowa Street. The proposed expansion is linked directly to the theater (Fig. 17).

A usable green roof has been designed over the new underground section to continue and complement the garden zone.

Symbolism also plays an important role in this project. The entire design was divided into 3 parts: the open zone – the garden, the semi-closed zone – the further part of the garden surrounded by a wall, and the closed zone – the existing building. The enclosed zone, due to the former function of the building, can be equated with the *sacred* zone. Thus, the garden and open part becomes the secular – profane zone.

Fig. 14. Synagogue in Kielce. Design. Warszawska Street frontage [21]

Fig. 15. Synagogue in Kielce. Design. Visualization – view of the entrance from the west, facing the garden [21]

Fig. 16. Synagogue in Kielce. Design. Visualization – view from the interior, showing illumination of the entrance area [21]

Fig. 17. Synagogue in Kielce. Design. Perspective cross-section [21]

In order to enter the very center, which is the theater, it is necessary to pass through all three zones, which can be compared to a kind of rite of passage and purification. This creates a certain mystique of place that influences the viewer through the space produced.

The project described above is an original student attempt to interpret the concept of adapting a former synagogue into a fringe theater according to P. Zumthor. Considerations on the form, functional solution, communication and development of a plot of land with an unusual shape, located in the center of the city, are presented. The multifaceted nature of the project stems primarily from the rich history of the site and its significant symbolism, which creates the ideological layer of the entire project assumption.

4.3. Revitalization of the synagogue at Warszawska Street in Kielce for a Multicultural Center [24]

In her work, the author of the diploma project set the goal of finding appropriate functional and aesthetic-design solutions for the currently unused building of the former synagogue. In addition, the project addresses the aspect of multiculturalism, concerning the past and present, and attempts to answer the question of how architecture can influence the aspect given.

The introduction of a new function – the Multicultural Center – would allow the building to provide an open space for dialog and allow individuals to find elements of their culture and the opportunity to learn about different cultures. Through such activities, the local community, which may feel lost in the flurry of information from different parts of the world, could understand the phenomena occurring in it.

The square next to the building is located on the west side and features a network of paths that symbolize the vicissitudes and windings of human life. Elements of an underground building poke out between the paths, indicating that something is hidden underground. The area is mainly covered with low greenery, grasses and herbs (Fig. 18). At the edge of the site to the west, a long tunnel can be seen. This is the entrance to the underground part of the designed architectural assumption, in which the main zone of the Multicultural Center is located (Fig. 19).

The structure of the entrance to the building is reinforced concrete, and in the southern facade there are openings of 20 x 20 cm, which symbolize the number of lives that were taken during World War II. Inside the tunnel on the left, photos and short films showing the beauty of different parts of the world and their cultures

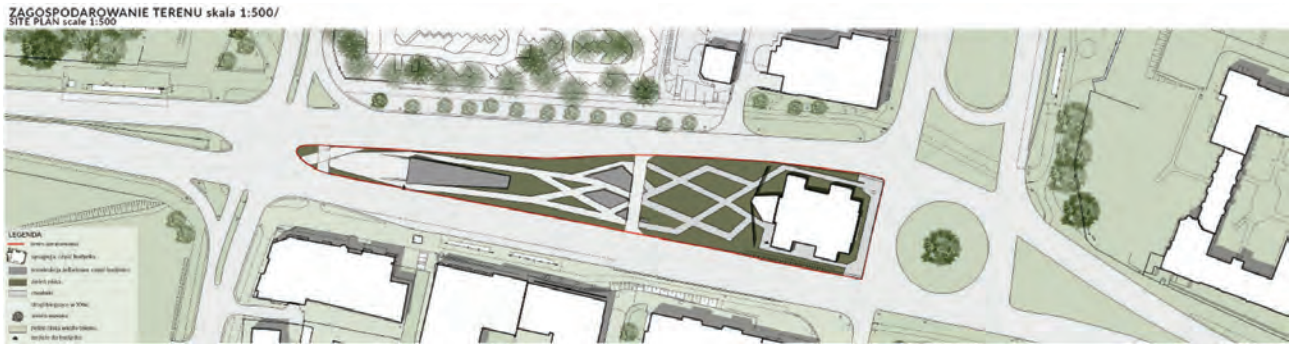

Fig. 18. Synagogue in Kielce. Design. Land development [24]

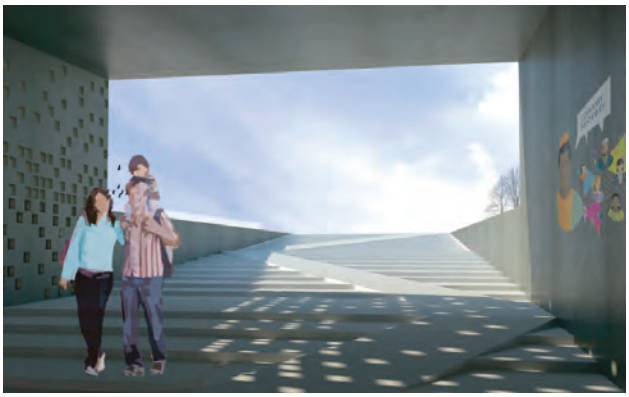

Fig. 19. Synagogue in Kielce. Design. Visualization – entrance area on the west side [24]

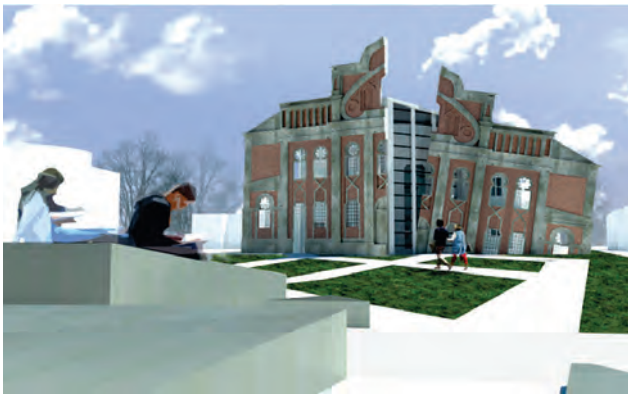

Fig. 20. Synagogue in Kielce. Design. Visualization – view of the building from the west [24]

will be displayed. This part of the building also features a huge open space that can be developed in any way, including integration meetings of organizations working for intercultural tolerance with residents of the city and province, as well as food court.

The design did not transform the exterior form of the building on the north, east and south sides. The plasterwork and details were restored, and kept in the current color scheme. The most visible changes were made to the building on the west side. This façade took the form of a pastiche, imitating the past form of the synagogue. And while it is not a faithful reproduction of the building's original façade, the author shows her own interpretation of history and reference to it. The main structural element is concrete, and is complemented by brick, as this is the material that the building was constructed from. The form is intended to remind the local community what the building looked like in its first version and what history it represents through "break ups" and asymmetry. Adjacent to the building is an attached staircase that further "breaks up" the western facade (Fig. 20).

Significant changes are proposed by the author inside the existing building to restore the original layout of the building. The ceiling that made up the +1 floor and the mezzanine at the +0.5 level have been eliminated. As a result of these changes, a mezzanine floor was created on the +1 level. The staircase from the vestibule is moved to the southern annex, and an elevator is placed in the vestibule, connecting all floors. The floor level was leveled all the way from the entrance to the main hall, to provide free access to the entire building for people with disabilities.

In the former synagogue building, the former main hall will host exhibitions and vernissages on the history of the site and Kielce. Other rooms in the building will be used for administrative, technical and sanitary functions. The new staircase connects the existing building to the newly designed underground part of the building (Figs. 21, 22).

Looking at the definition of revitalization and components thereof (community, space and infrastructure, economy), it can be seen that the proposed changes fit into this concept. Through the extensive process of area revitalization, we are able to change local environments, not only in a visual way, but we can also influence education and change the mindset of the people affected. The project responds to all these problematic issues. Through the development of the former synagogue building, which will be restored to its former life, it will be possible to remind current and future generations of past events

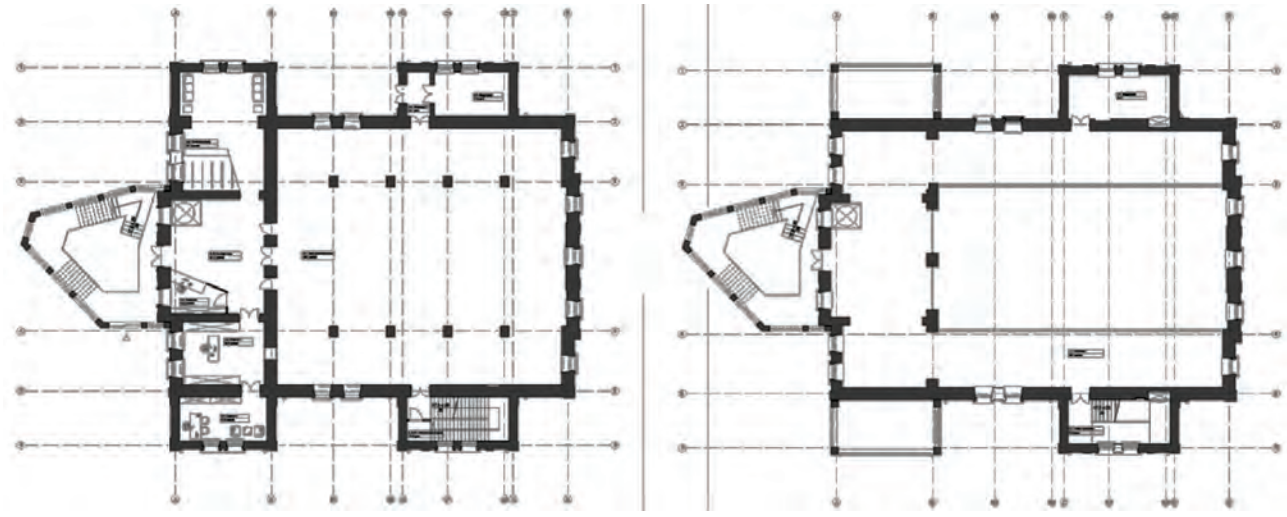

Fig. 21. Synagogue in Kielce. Design. Drawings of individual floor plans of the building (ground floor, first floor) – design [24]

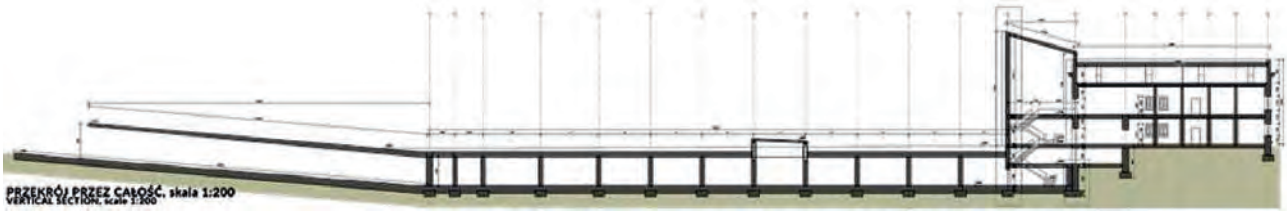

Fig. 22. Synagogue in Kielce. Design. Cross-section through the adapted and newly designed building [24]

and give the synagogue and the culture it represents due tribute. Through expansion of its functions and creation of a Multicultural Center, this place will have an impact on the local community.

5. CONCLUSIONS

Adaptation aims to save the historic building by adapting it to serve a new function or restore the original one, bringing it up to current technical conditions and meeting the needs of modern users, while preserving its most important values. These activities should be preceded by historical, architectural and conservation studies, taking into account the existing condition and historic values, which will help in making the right decisions in the selection of functions and related steps. The adaptation process should bring out all the historic values of the building, strive to preserve the authenticity and integrity of the monument when introducing a new function, both in the strict senses and in the largo sense. Sacred architecture holds significant historical and cultural value, both tangible and intangible, and the inherent sacral value [25]. The adaptation of historic religious buildings, including synagogues, has been the subject of much discussion for a long time. However, despite the often many doubts surrounding adaptation work on this type of buildings, preservation is what ultimately justifies their adaptation. A particularly appropriate and most commonly introduced function is the cultural, museum one [26], but they are increasingly being adapted to other functions, especially in Western European countries [27].

The paradox of the building of former Kielce synagogue is that despite its history and the importance it has not only for the Jewish community, but also for the city of Kielce, it is now an abandoned place. Despite the many ideas for the adaptation of this monument, none have come to fruition. Thus, the building has stood useless for almost two decades.

The concepts created by students of the Architecture Department at the Faculty of Civil Engineering and Architecture, Kielce University of Technology demonstrate the potential of this building. The presented designs show that the best solution for this former synagogue would be to introduce cultural and scientific functions along with a complementary function for ex. a cafe. Due to the multidimensional significance of the original object, not only sacred, the best concept would be a center of Jewish culture and dialogue with other cultures, where integration through art of the people meeting there would be possible. The presented projects show that the introduction of a cultural and scientific function along with a complementary function – a café – is considered most appropriate. The concepts shown are an attempt to answer the problematic issues, taking into account the history of the site and preserving the current form of the building with reference to the original façade of the building and to the contemporary architecture surrounding the synagogue. A common factor in the projects is the improvement of transportation aspects given the difficult location of the plot in the median strip of high-traffic streets, the landscaping of the space around the building through numerous, orderly green plantings, and the establishment of paths inviting to the site and the building, especially on the west side. A positive proposal is to connect this place with Kozia Street through an underground passage that could connect with Targowa Street. On the other hand, when it comes to the building interiors, the authors of the solutions shown propose to restore the original appearance of a large room with mezzanine floors open at the height of two floors (the former main hall with a choir and women's galleries) and to adapt the building in accordance with current guidelines.

It would be advisable to discuss design concepts among the inhabitants of Kielce. Conducting public consultations would allow for listening to their voices on this subject and for the active participation of the local community and other users (Jewish community) in shaping an important place for Kielce and changing the functioning of the former synagogue facility. Solutions developed together with the residents would complement the process of shaping the new space, fully revealing the potential of both the place and the people. In the processes of revitalization of city areas and adaptation of facilities to a new function, the participation of residents is particularly important and should play an important role at the design stage. Architecture is created for people for their use, so it would be good for the future adaptation of the synagogue to also meet their expectations and needs.

Creative solutions to the presented requirements and assumptions, as well as student insights, show new possibilities and solutions for the analyzed building and site. The projects presented include a variety of solutions, which gives a choice for the investor interested in adapting this structure. By implementing the project of adapting this building along with its surroundings, the site's appeal would be enhanced, and the potential of this exceptional place in Kielce could be fully exploited.

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THE INFLUENCE OF TOTAL WATER-TO-CEMENT RATIO ON THE MECHANICAL PROPERTIES OF CEMENTITIOUS COMPOSITES INTERNALLY CURED WITH POLYACRYLIC SUPERABSORBENT POLYMERS (SAP)

WPŁYW CAŁKOWITEGO WSPÓŁCZYNNIKA WODA-CEMENT NA WŁAŚCIWOŚCI MECHANICZNE KOMPOZYTÓW CEMENTOWYCH PIELĘGNOWANYCH WEWNĘTRZNIE POLIAKRYLOWYMI POLIMERAMI SUPERABSORPCYJNYMI (SAP)

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Warsaw University of Technology, Poland

Abstract

Superabsorbent polymers (SAP) allow for the introduction of changes to the pore network characteristics in cementitious composites and the course of binder hydration. Therefore, SAP addition contributes to significant changes in multiple properties of concrete. The effect of internal curing differs depending on its design process – the initial content of curing water in the concrete mix, polymer characteristics and water absorption properties, the state in which it's added (non-saturated/hydrogel), and the design method regarding curing water content in the entire water content. The authors investigated those variables' influence on selected concrete properties – compressive strength, water absorption, and shrinkage. All independent variables significantly influenced the studied properties of concrete. The increase in the total water-to-cement ratio led to a significant decrease in the mechanical properties of cementitious composites. Modification with the use of SAP added in the form of hydrogel had the most positive influence on the properties of concrete..

Keywords: concrete internal curing, superabsorbent polymers, cementitious composites, hydrogel, SAP

Streszczenie

Polimery superabsorpcyjne (SAP) umożliwiają wprowadzenie zmian w charakterystyce sieci porowej kompozytów cementowych i w przebiegu hydratacji spoiwa. W efekcie dodatek SAP przyczynia się do znaczących zmian w wielu właściwościach betonu. Efekt pielęgnacji wewnętrznej różni się w zależności od metody jej zaprojektowania – początkowej zawartości wody pielęgnacyjnej w mieszance betonowej, właściwości fizycznych polimeru, w tym zdolności do absorpcji wody, stanu, w jakim jest on wprowadzony (nienasycony wodą/hydrożel), oraz metody uwzględnienia wody pielęgnacyjnej w całej zawartości wody zarobowej. Autorzy zbadali wpływ tych zmiennych na wybrane właściwości betonu, w tym na wytrzymałość na ściskanie, nasiąkliwość i skurcz całkowity. Wszystkie zmienne niezależne w istotny sposób wpływały na badane właściwości betonu. Wzrost całkowitego współczynnika woda-cement spowodował istotne pogorszenie właściwo-

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ści mechanicznych kompozytów cementowych. Najbardziej pozytywnym wpływem na właściwości betonu charakteryzowała się modyfikacja za pomocą dodatku SAP wprowadzonego w postaci hydrożelu.

Słowa kluczowe: pielęgnacja wewnętrzna betonu, polimery superabsorpcyjne, kompozyty cementowe, hydrożel, SAP

1. INTRODUCTION

Internal curing of cementitious components presents an interesting approach to shaping the properties of hardened concrete. With its significant influence over hydration dynamics and pore network characteristics, internal curing affects the mechanical properties of concrete and its resistance to different corrosive agents and, therefore, concrete's durability. The idea of internal curing, introduced decades ago using water-saturated lightweight aggregate, focuses on limiting the negative effects of the hydration process – self-desiccation of the hardening cement matrix, and its most visible impact – autogenous shrinkage [1, 2]. Although this issue can be neglected in regular concrete, properties of cementitious composites of low and very low water-to-binder ratios can be significantly impacted by the aforementioned phenomenon [3].

During the hydration of the binder, mixing water in the hardening composite is slowly used to form hydrates, making a cement matrix. During this transition, as the overall volume of hydration products is smaller than that of substrates, the difference in volume marks the creation of a pore network. Due to ongoing hydration, those gel pores gradually contain less water and subsequently collapse due to pressure differences as the composite has not gained its designed stiffness. The scope of those changes is most visible during the first 24 hours of hydration when the skeleton of the cement matrix is still forming.

The idea behind internal curing was to introduce another material in the mix, which would not participate in the hydration process but instead allow a portion of mixing water to be stored in its structure [2]. Initially, it would not be used for hydration purposes but rather for maintaining high relative humidity during the initial formation of the pore network, preventing or reducing the scope of pore collapse, causing volumetric changes, and, therefore, decreasing autogenous shrinkage [4, 5].

Different agents can provide internal curing of cementitious composites and can be divided into two main groups differing in the phenomena linked to water absorption potential [6]. The first includes materials with an extensive pore network – mainly lightweight aggregates (LWA) and organic fillers (sawdust, wood pellets, etc.). In their case, the water absorption mechanism is purely physical and consists of water adsorption due to high specific external and internal surfaces. During hydration, as the access to stored water within the internal curing agent is limited, the decrease in relative humidity within the composite can be prolonged, and, therefore, the scope of negative aspects associated with hydration is limited. Due to its grain structure, although a modification of concrete with that type of material allows for mitigation of autogenous shrinkage, high porosity and below-average mechanical properties of the modifier often result in an overall decrease in mechanical properties of concrete as a side effect.

The other group of modifiers consists of superabsorbent materials. Although those have some potential for surface water adsorption, the main cause of their ability to absorb water is electrochemical in nature. As such materials are introduced into the water environment, the absorption process occurs within the entire volume of the modifier [7]. Due to its structure, consisting of long and entangled polymeric chains and a high content of ions (sodium, potassium, etc.), to reduce the initially high osmotic pressure, water molecules are absorbed in its structure and non-permanently entrained in it [8]. The efficiency and scope of that process can depend on various factors, among others, on the chemical composition of any given superabsorbent polymer and the properties of the environment in which the absorption process takes place [9]. The absorption capacity of any given SAP varies in different environments, as the absorption process ceases to occur once the equilibrium state is reached between osmotic pressure within the polymer, its polymeric structure strength, and external pressures of various origins. Different manufactured and natural polymers have such properties – the most commonly used are polyacrylic polymers (artificial) and cellulose-based ones (natural).

The effect of cementitious composites' internal curing varies significantly in using SAP compared to other internal curing methods [7, 10, 11]. The effect regarding self-desiccation of cement matrix is more effective, as the granulation of SAP used in concrete technology can be much finer than in the case of LWA and can ensure access to stored water

throughout the volume of the cement matrix. Also, due to the much higher water absorption capacity, changes to the pore network characteristics of a cementitious composite (mainly its total volume and median pore diameter) can be introduced after its desorption from the polymer structure [12]. Those can positively or negatively impact concrete's durability and mechanical properties and depend heavily on the design process of internal curing. Modification with SAP introduces an additional phase to cementitious composite, sometimes referred to as 'quasi-pores' [13], which, after water desorption from SAP structure, transitions towards the regular pore phase, influencing both mechanical properties of the composite, as well as its resistance towards aggressive environmental factors, freeze-thaw or carbonation for instance [14, 15]. The influence over the pore network of the composite due to internal curing can result in a significant deterioration of the mechanical performance of concrete. Methods presented in this paper focus on exploiting SAP properties in different water absorption environments to reduce negative effects associated with internal curing methods, both for fresh and hardened concrete.

2. RESEARCH SIGNIFICANCE

The effects of internal curing with superabsorbent polymers can vary significantly over numerous properties of cementitious composites [16-18]. SAPs of varying origins and properties have different water absorption and desorption potentials in different environments. Also, as the proposed modification usually includes adding extra mixing water, its presence in the composite impacts the hardened composite's pore network characteristics. To investigate this issue, the authors compared and analyzed the properties of internally cured concretes differing in the polyacrylic SAP mass content in the concrete mix. Also, the influence of its dosing method was investigated. SAP can be added to other ingredients in different states regarding its initial water saturation: in a non-saturated state (the process of water absorption takes place while mixing with other ingredients phase – in cement paste environment), saturated/hydrogel state (the process of water absorption takes place prior to mixing SAP with other ingredients in water environment), and a superposition of both (SAP is pre-saturated not to full capacity with water prior to its addition to other ingredients of concrete mix). All those variants have a different effect on one of the essential characteristics of an internal curing agent – the dynamics of water desorption from its structure and, therefore, the effectiveness of internal curing.

Except for the type, amount and addition method, the influence of additional curing water (water absorbed by superabsorbent polymer) increasing the total water-to-cement ratio was determined as one of the critical factors impacting the effect of SAP on various concrete properties. As curing water is introduced into the concrete mix, its water-to-cement ratio changes. In internally cured composites, its three variants can be distinguished: total water-to-cement ratio – $(w/c)_{tot}$; effective water-to-cement ratio – $(w/c)_{eff}$; entrained water-to-cement ratio – $(w/c)_e$. The dependence between them can be described as:

$$(w/c)_{tot} = (w/c)_{eff} + (w/c)_e \quad (1)$$

Determining the actual value of the entrained water-to-cement ratio is burdensome. It includes mainly the analysis of water absorption test results of any given internal curing agent in the environment simulating cementitious composite or changes in the consistency of SAP-modified and reference concrete mixes. Based on that information, the amount of water stored in the internal curing agent at the time of the test can be estimated, and therefore, $(w/c)_e$ can be calculated. Usually, as in the case of other types of internal curing agents (for example, LWA), additional water is included in the mix to compensate for water stored in the internal curing agent to prevent consistency loss. In previous work, authors investigated and described a significant negative effect of this method on the mechanical properties of concrete and its resistance to corrosive agents. The authors determined the influence of those four variables to be crucial to the effectiveness of internal curing in concrete technology and designed an experiment plan to verify its influence over selected concrete properties.

The use of internal curing agents in concrete technology usually contributes to a deterioration in the workability of fresh concrete. Although there are multiple methods to increase mix fluidity, in the case of modification with the use of SAP, it is still most common to counteract those changes through the addition of extra water (curing water) to the mix. Authors believe and wanted to confirm it through experimental means, that any changes to the water-to-cement ratio have a statistically significant impact on the performance of hardened concrete.

3. MATERIALS AND METHODS

In total, 20 series of concrete samples were prepared. Eighteen of those were modified with superabsorbent polymers. Modified series varied in SAP type, amount, dosing method, and the designed total water-to-cement ratio. The range of each quantitive variable was set to mimic cementitious composite in which internal curing would have merit. It was decided to simplify the composition of the mix to reduce the probability of unintended interactions between its different ingredients. The concrete mix consisted of cement CEM I 42.5 R as a binder, river sand 0/2, gravel coarse aggregate 2/4, 4/8, and 8/16, PCE superplasticizer (2.3% m.c.), and mixing water. No other additions or admixtures were used (Table 1).

Table 1. Composition of reference series

Material	Mass per 1 m³ [kg]	
	REF 0.30	REF 0.36
River sand 0/2	668	643
Gravel 2/4	95	91
Gravel 4/8	477	459
Gravel 8/16	668	643
CEM I 42.5 R	450	
Total water	135	162
$(w/c)_{tot}$ [-]	0.30	0.36

Two superabsorbents of different material characteristics were used, varying in polymer composition and water absorption properties (Table 2). SAP A represented a fine-graded SAP of high water absorption capacity and rapid character of the water absorption process (up to 15 min from an introduction into absorption environment). On the other hand, SAP B granulation in a non-saturated state ranged from 2 mm to 2.5 mm (Fig. 1), its absorption capacity was much lower than SAP A's, and its water absorption took up to 24 hours. Due to a prolonged water absorption process, it was decided not to include in the experiment the variant of concrete modification with SAP B added in a non-saturated state to the mix.

Table 2. Material characteristics of polyacrylic superabsorbent polymers

Grain size in a non-saturated state [µm]	SAP A	SAP B
<90	<8%	0%
90-150		0%
150-750	86-95%	0%
750-2000	≤6%	0%
2000-2500	0%	100%
Water absorption capacity in mixing water environment [g/g]	160.0	69.2
Water absorption capacity in cement paste environment [g/g]	16.0	7.5
Grain morphology	Irregular	Spherical

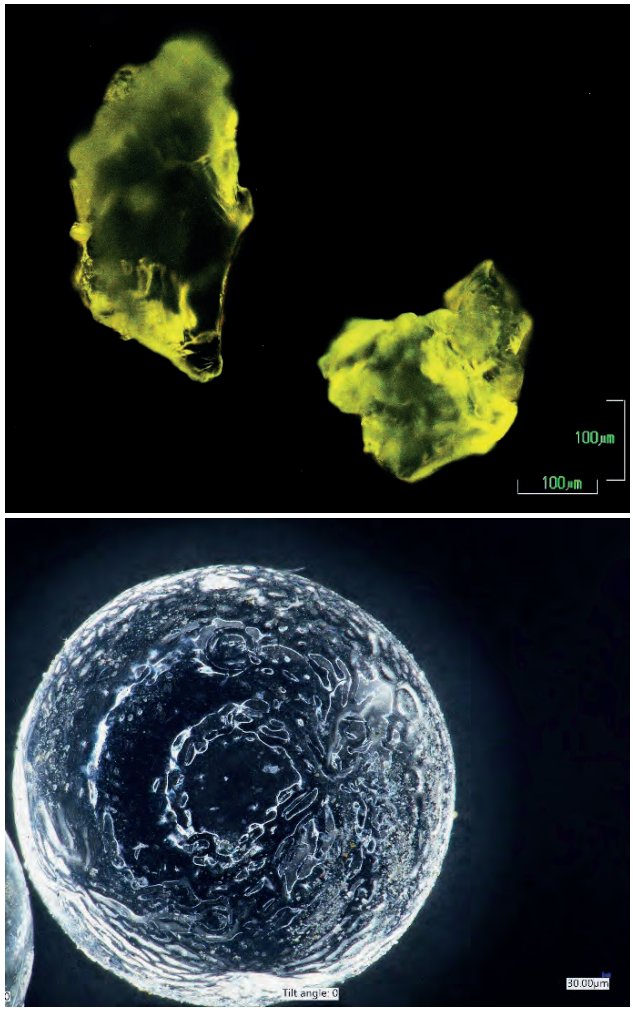

Fig. 1. Morphology of SAP A (irregular) and SAP B (spherical) grains in a non-saturated state

The water absorption capacity of superabsorbent polymers was determined via the commonly used "teabag method", which consists of placing a sachet with a known mass non-saturated SAP in the water absorption environment and its mass measurements after time spent in the water absorption environment. Based on that information, it is possible to calculate water absorption capacity in different environments (the maximal mass of water that SAP can absorb into its structure). The presented research determined water absorption capacity for two environments – mixing water and cement paste of water-to-cement ratio equal to 0.50 (simulating water absorption capacity in concrete mix). The maximal SAP mass increase caused by water absorption was determined – water absorption capacity in each of those environments was determined.

The analysis of obtained test results was conducted via screening design. The designed experiment included four independent variables – $(w/c)_{tot}$, polymers type, amount of mixing water absorbed initially by SAP, and dosing method of SAP into the mix (Table 3). The total water-to-cement ratio of SAP-modified cementitious composites ranged from 0.30 to 0.36. Polymer type variable was varied through its granulation (parameterized – 0 for fine granulation, 1 for coarse granulation). The dosing method was varied through the part of SAP introduced in a hydrogel form (100% for the hydrogel dosing method, 0% for the non-saturated method). The last variable was the initial amount of mixing water absorbed by the internal curing agent in relative units (%). The mass content of SAP was calculated based on its water absorption capacities in different environments and assumed portion of mixing water that was to be absorbed according to formula (2), where m_{SAP} – mass content of SAP [% m.c.], β – designed portion of mixing water to be absorbed by SAP [%], α – water absorption capacity of SAP in water absorption environment (in the case of conducted study, either mixing water environment or concrete mix environment), (w/c) – water-to-cement ratio (in the conducted research is equaled to 0.30).

$$m_{SAP} = \frac{\beta \cdot \left(\frac{w}{c}\right)}{\alpha} \qquad (2)$$

The mass of additional water increasing the total water-to-cement ratio in AW was determined experimentally by testing the consistency of individual concrete mixtures using the slump test method – $(w/c)_{tot}$ was raised until the same consistency as in the case of REF 0.30 was reached. This method was used to determine the effect of the additional water in the mix composition of the properties of hardened concrete.

Table 3. Plan of the experiment in the conducted research with its independent variables – total water-to-cement ratio, SAP type, SAP dosing method, and designed amount of mixing water to be initially absorbed by SAP

Series ID	$(w/c)_{tot}$ [–]	SAP content [% m.c]	Mixing water absorbed by SAP [%]	SAP type	Dosing method
a	b	c	d	e	f
AH 25	0.30	0.047	25	SAP A	Hydrogel
AH 50		0.094	50		
AH 75		0.141	75		
AH 25 AW	0.32	0.047	25		
AH 50 AW	0.34	0.094	50		
AH 75 AW	0.36	0.141	75		
AN 2.5	0.30	0.047	2.5		Non-saturated
AN 5.0		0.094	5.0		
AN 7.5		0.141	7.5		
AN 2.5 AW	0.32	0.047	2.5		
AN 5.0 AW	0.34	0.094	5.0		
AN 7.5 AW	0.36	0.141	7.5		
BH 12.5	0.30	0.054	12.5	SAP B	Hydrogel
BH 25		0.108	25		
BH 50		0.216	50		
BH 12.5 AW	0.32	0.054	12.5		
BH 25 AW	0.34	0.108	25		
BH 50 AW	0.36	0.216	50		

The effect of designed internal curing of different intensities over various concrete properties was investigated. The total shrinkage of concrete was tested according to PN-84/B06714/23 and ITB instruction nr 194 [19, 20]. In concrete beams (100 x 100 x 500 mm), measurement units were installed, and using the Amsler apparatus, the relative change in sample length was measured. Tests began one

day after sample preparation and lasted for 480 days. Samples were stored in a climatic chamber in a controlled humidity and temperature environment (RH above 95% and T = 21 ±2°C).

Water absorption of concrete was tested based on PN-88/B-06250 [21]. Cubic samples (100 x 100 x 100 mm) were stored in water for 28 days after forming. Afterward, samples were moved to air-dry conditions for 24 hours to remove excess water from concrete surfaces. In the next step, samples were dried at 105°C until their mass stabilized. The result of the test – water absorption of concrete – was then calculated as a quotient of the difference in wet mass and dry one to dry mass, multiplied by 100 [%].

Compressive strength was investigated according to PN-EN 12390-3 [22] on cubic samples (150 x 150 x 150 mm). Samples were cured in the same climatic chamber for 28 days. After that time, they were compressed in a hydraulic press using the aforementioned standard.

The consistency of fresh concrete mix was determined via the slump test method according to PN-EN 12350-2 [23].

4. RESULTS

Consistency was determined using the slump test method. The consistency test was used in the series with additional water (AW) to determine the mass of extra water that should be introduced into the mixture to maintain the mix's rheological properties at a level similar to the reference series (REF 0.30). The results of the tests carried out are presented in Table 4. As the mass of water initially absorbed by the SAP increases, the fluidity of the mixture significantly decreases. This phenomenon is caused by the reduced mass of water available to liquify the cement paste in the concrete mix. It can be solved by introducing additional water into the system, increasing the total water-cement ratio. For series of concrete mixes to which extra water was added to counteract the decrease in the mix's workability, its amount was determined experimentally and presented as a new total water-cement ratio $(w/c)_{tot}$: 0.32, 0.34, and 0.36, respectively. Although this is a design method commonly used for internal curing, it contributes to a change in the proportions between all ingredients in the mixture – the additional volume of water is introduced at the expense of the volume of the remaining ingredients, making the final composition of the mix different from the composition of the reference series.

Table 4. Slump test results for fresh concrete mixes

Series ID	Total water-to-cement ratio [-]	Slump [mm]
REF 0.30	0.30	65
REF 0.36	0.36	125
SAP AH 25	0.30	60
SAP AH 50		40
SAP AH 75		30
SAP AH 25 AW	0.32	70
SAP AH 50 AW	0.34	65
SAP AH 75 AW	0.36	70
SAP AN 2.5	0.30	60
SAP AN 5.0		50
SAP AN 7.5		20
SAP AN 2.5 AW	0.32	60
SAP AN 5.0 AW	0.34	65
SAP AN 7.5 AW	0.36	65
SAP BH 12.5	0.30	30
SAP BH 24		15
SAP BH 50		0
SAP BH 12.5 AW	0.32	60
SAP BH 25 AW	0.34	65
SAP BH 50 AW	0.36	70

The effects of internal curing significantly varied depending on all assumed quantitative variables. In all prepared concrete series, internal curing met its goal of reducing linear changes caused by shrinkage deformations. An empirical model of linear changes caused by shrinkage deformations was developed (3), where ε_t – linear changes caused by shrinkage deformations [10^{-6} m/m], t – time from sample preparation after which linear changes were measured [day], c – asymptote of the model (maximal linear changes caused by shrinkage [10^{-6} m/m], d – correction coefficient [$\sqrt{\text{day}}$].

$$\varepsilon_t = c \cdot \operatorname{tgh}\left(\frac{\sqrt{t}}{d}\right) \tag{3}$$

In all analyzed variants of internal curing, its effects contributed to a reduction in linear changes caused by shrinkage deformations (Fig. 2).

The scope of those changes varied – the most positive effect was observed for modification with SAP A added in hydrogel state, in mass content, allowing for an initial absorption of 75% of mixing water, with an additional volume of water added to

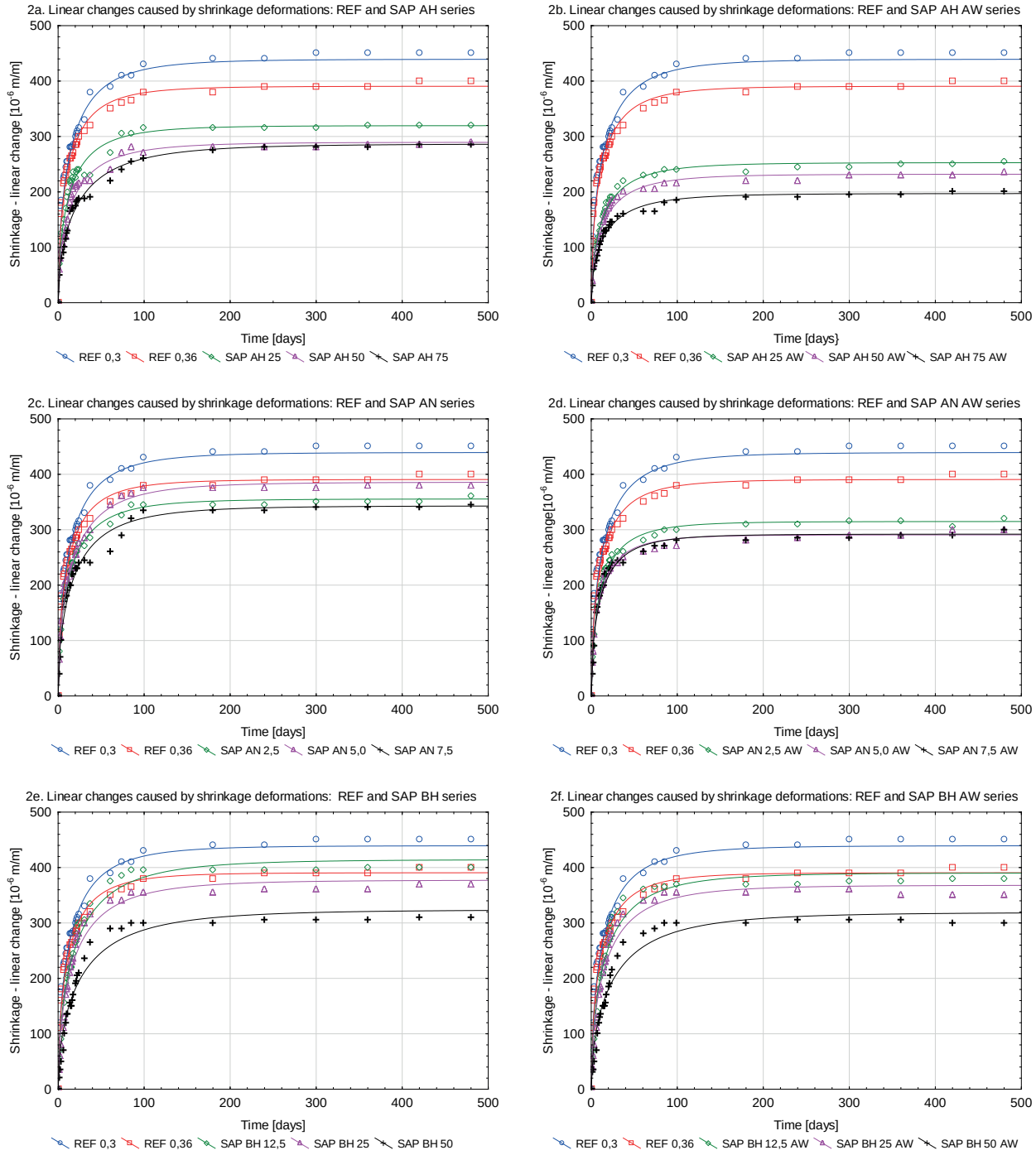

Fig. 2. Aggregated test results for linear changes caused by shrinkage deformations carried out for cement composites modified with superabsorbent polymers in various variants and reference compositions: 2a) SAP A added as a hydrogel; 2b) SAP A added as a hydrogel with additional water to maintain reference consistency; 2c) SAP A added in a non-saturated state; 2d) SAP A added in a non-saturated state with additional water to maintain reference consistency; 2e) SAP B added as a hydrogel; 2f) SAP B added as hydrogel with additional water to maintain reference consistency

the concrete mix to compensate for the consistency loss. The least efficient was modification with SAP B, regardless of its dosing method. In most cases, linear changes for internally cured series of total water-to-cement ratio equal to 0.30 were lower than for reference concrete with a total water-to-cement ratio of 0.36.

The influence on the concrete's water absorption wasn't that unambiguous (Fig. 3). Water absorption is one of the properties that allow estimating the

continuity of the capillary network in the cement matrix. For reference series, water absorption was determined at 4.04% for REF 0.30 and 4.56% for REF 0.36. Concretes modified with SAP A in a hydrogel state were characterized by significantly lower water absorption than the reference series. In the case of SAP AH 75 was nearly 50%. The effect of reducing water absorption was not observed in the case of concretes in which SAP A was added in a non-saturated state to the remaining ingredients of the concrete mix. Concretes modified with SAP B polymer, with a grain size unsaturated with water of 2-2.5 mm, were characterized by a significant increase in water absorption compared to the reference series, up to 25%.

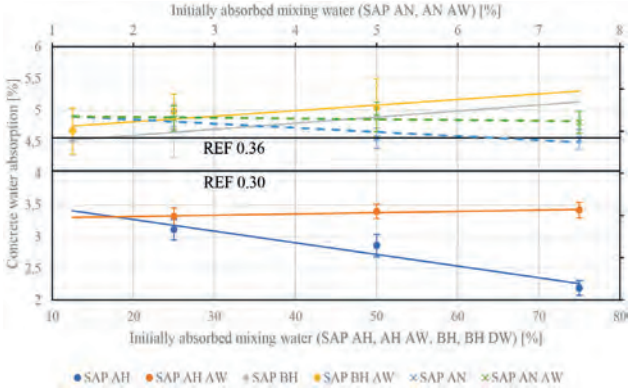

Fig. 3. Concrete water absorption for internally cured hardened concrete samples. SAP A was added to the concrete mix in different states (non-saturated/hydrogel). Due to differences in water absorption capacity in different environments, the same mass of polymer led to varying amounts of water that could be absorbed into the polymer structure, hence two axes of abscissae

In most cases, the compressive strength of concretes modified with superabsorbent polymers was lower than that of the reference series (REF 0.30) (Fig. 4). This effect was intensified by increasing the total water-to-cement ratio with additional curing water to maintain concrete mix consistency. Concretes modified with SAP A in a hydrogel state and added in the amount allowing for initial absorption of 25% and 50% of mixing water, were the exception – an increase in the mechanical performance of concrete was observed in those cases.

The influence of superabsorbent polymers on the strength characteristics of concrete is associated with the formation of SAP agglomerates, contributing to changes in the composite's pore network. This effect disappears in the case of fine-grained SAP (SAP A), added in the form of a hydrogel. Changing the method of adding SAP (SAP AO series) caused an almost 10% increase in compressive strength compared to the reference series REF 0.30. There are several reasons for this phenomenon. If SAP is introduced in a hydrogel form into the concrete mix, the SAP particles are characterized by the lowest electrochemical activity. Osmotic pressure reaches the lowest possible level due to water absorption in a mixing water environment before SAPs mix with the other ingredients. This significantly reduces the intensity of agglomeration of SAP particles, contributing to their more even distribution in the cement matrix. Therefore, the internal curing performed this way leads to more effective binder hydration.

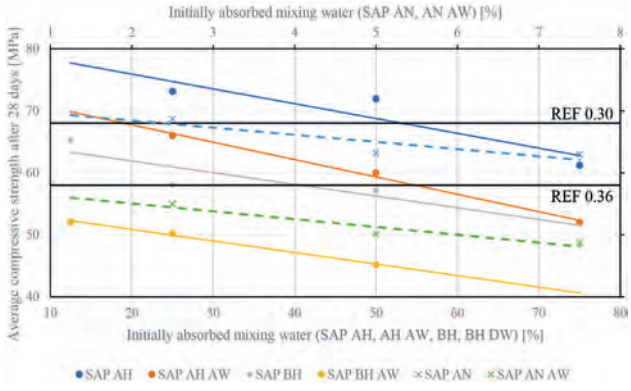

Fig. 4. Average compressive strength for internally cured concrete after 28 days of curing in a climatic chamber. SAP A was added to the concrete mix in different states (non-saturated/hydrogel). Due to differences in water absorption capacity in different environments, the same mass of polymer led to varying amounts of water that could be absorbed into the polymer structure, hence two axes of abscissae

The negative impact of increasing the total water-to-cement ratio $(w/c)_{tot}$ on the compressive strength of internally cured concretes was significant. The introduction of additional water to the concrete mix (increase $(w/c)_{tot}$) to maintain the consistency at a level similar to the reference series (REF 0.30) contributed to a significant decrease in compressive strength, in the extreme case by up to 33% (SAP BO DW50 series). An important issue is the problem of determining the reference level for internally cured concrete to which water has been added that is not included in the effective water-to-cement ratio. The REF 0.36 reference series was prepared to demonstrate the impact of SAP at different $(w/c)_{tot}$. However, the reference level to which the results of all series modified with superabsorbent polymers refer was concrete with a specific initial water content $w/c_{tot} = 0.30$ (REF 0.30).

Internal curing aims to improve the material's durability and reduce the material's susceptibility to linear changes caused by shrinkage deformations. The impact on the strength characteristics of the material is not the primary purpose of using internal curing of cementitious composites using SAP, but designing it to limit the negative impact on strength is desirable and expedient.

5. DISCUSSION

Internal curing is usually considered a way of modyfing concrete to prolong its durability and impact shrinkage behavior due to the binder's hydration. However, its addition to the concrete mix can have an unintended negative influence on the mechanical performance of the composite and its other properties. In conducted research main variables that can manifest during internal curing design were considered. The analysis parameterized two independent variables: SAP grain size and the addition method. Each of these variables was considered at two levels.

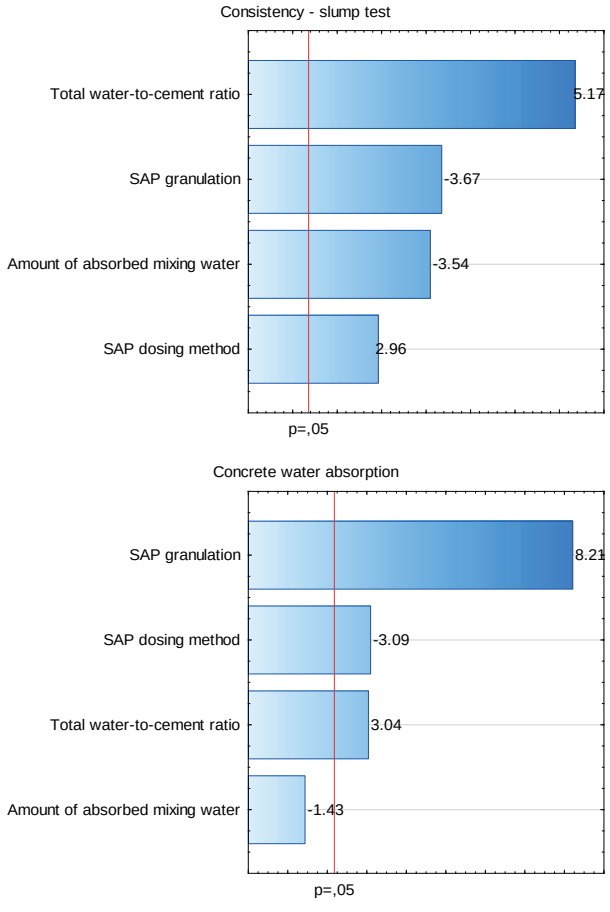

Fig. 5. Pareto chart of the absolute value of standardized effect estimate of variables considered in the study on the consistency of fresh concrete mix and hardened concrete's water absorption

All of the investigated properties were influenced by internal curing. Assumed independent variables had a statistically significant impact on the properties of the fresh mix (Fig. 5). In this graph, the effect ratings obtained by the ANOVA procedure are ordered from the highest absolute value to the lowest. The value of each effect is represented by a bar and a line that indicates how large the effect should be to be statistically significant (in the conducted research, the p-value was chosen at a standard value of 0.05). It was observed that with an increase in the internal curing agent's content, the concrete mix's rheological properties changed significantly, reducing the fluidity of the mix. The granulation of SAP in a non-saturated state most influenced concrete water absorption as it most certainly contributed to significant changes in the pore network, the effect of which can also be observed in the mechanical properties of concretes modified with SAP B.

In the case of compressive strength, a significant effect of all adopted variables can be observed (Fig. 6). A negative effect (decrease in compressive strength) was observed when increasing the total water-cement ratio, using SAP B (with a larger size of polymer particles in the water-unsaturated state), and increasing the percentage of mixing water absorbed by SAP. Introducing SAP into the mix in a hydrogel state was the only variable positively influencing concrete's mechanical performance.

In the case of linear changes caused by shrinkage deformations, the significant variables were polymer grain size (increase in linear changes with increasing grain size in the non-saturated state), total water-to-cement ratio (reduction of linear changes with increasing w/c), and the percentage of mixing water initially absorbed by the SAP (reduction of linear changes with the increase in the mass of water trapped in the SAP). It should be noted that in the research carried out, the percentage of initially absorbed mixing water was related to the method of adding SAP to the mixture concrete – concretes containing SAP added in a non-saturated state in an amount allowing for the absorption of 25%, 50% or 75% of the mixing water were not investigated. A modification of this type would result in an overestimation of the mass SAP content by approximately ten times compared to other cases, disturbing the analysis. For this reason, the only compositions with a much higher initial percentage absorbed mixing water were compositions to which SAP was added as a hydrogel, in the same mass amount as in the case of it being added in a non-saturated state.

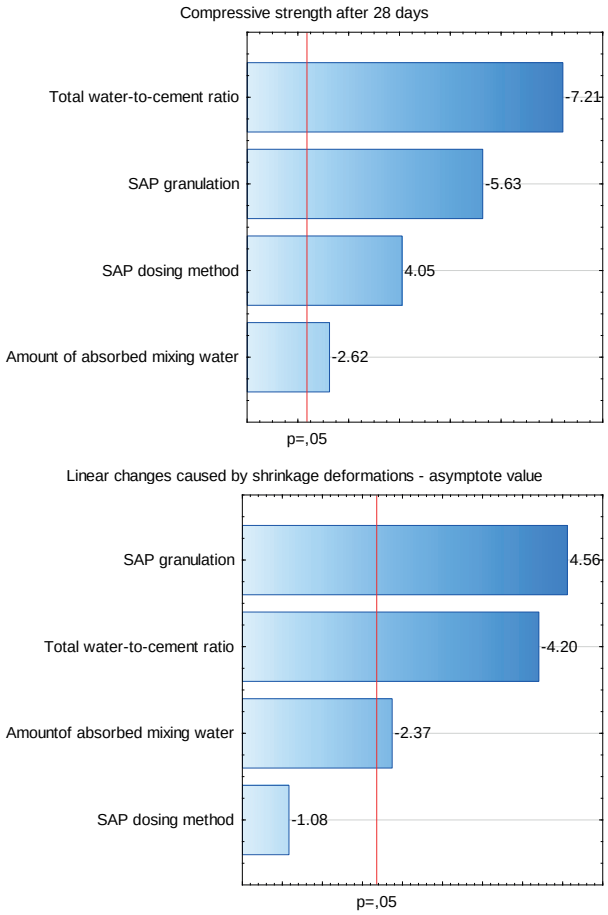

Fig. 6. Pareto chart of the absolute value of standardized effect estimate of variables considered in the study on concrete's compressive strength after 28 days of curing and asymptote value from the proposed model on the linear changes caused by shrinkage deformations

After their addition to the cementitious environment (cement paste, concrete mix), SAP grains are distributed within the cement matrix. It was proven in [24], that depending on the SAP state in which it is added to the mix, different phenomena impacting the quality of the aforementioned distribution occur. Entangled polymeric chains that make SAP's structure allow it to increase volume during water absorption while maintaining grain shape. This behavior is possible due to the elongation of the entire polymeric skeleton of SAP. However, in such a state, it is possible to fragment SAP grains by external forces.

This phenomenon can be observed as SAP is added to the concrete mix in hydrogel form. Water content in such a state exceeds 99% of SAP grain volume – polymeric skeleton expands to its limits. Under such conditions, when introduced to an environment with a high content of grains of different origins (cement, fine, and coarse aggregate), during the mixing phase of concrete mix, hydrogel SAP grains change their granulation – a mechanical fragmentation occurs.

Hydrogel fragmentation can have different impacts on the properties of SAP and concrete modified with it. As this phenomenon occurs, SAP structure can be damaged to the extent that its water absorption capacity in different environments is detrimented, which has a negative effect on the efficiency of internal curing. In the research, neither SAP A nor SAP B manifested changes in water absorption properties due to fragmentation.

On the other hand, as SAP is introduced in a non-saturated state, water absorption occurs in the cementitious environment. In the case of polyacrylic polymers, due to high ionic strength in the water absorption environment, SAPs' water absorption capacity is severely impaired (approx. ten times lower than in the case of a tap water environment). The less water SAP absorbs, the less its volume increases; therefore, the less its polymeric skeleton is susceptible to fragmentation. It can be assumed that this phenomenon occurs to a minimal extent if SAP water absorption occurs directly in the concrete mix environment.

The change in the way SAP is introduced into the mix has a significant impact on concrete properties. Fragmentation aside, due to a different initial water content stored in SAP grains, the dynamics of its desorption (the main SAP property affecting properties of internally cured concrete) varies. In the previous study by the authors, due to a different initial water content and fragmentation phenomenon, the difference in the volume of curing water used can vary 10-fold for the same mass of SAP introduced to the concrete mix in different states [9].

The other issue associated with the efficiency of internal curing is the distribution of SAP grains within the cement matrix. The phenomenon of SAP agglomeration, while added in a non-saturated state, is often described in the literature on the subject [25-27]. As SAP is introduced in a non-saturated state, all phenomena associated with water absorption occur during and straight after the mixing process. With significantly lesser volumetric increase caused by reduced water absorption capacity in an alkaline concrete mix environment, the osmotic pressure within polyacrylic SAP grains remains relatively high. The properties of the absorption environment affect the agglomeration risk of SAP grains. In this case, an additional water absorption environment can be distinguished – the outer layer of SAP grain,

constituting an interim layer between the absorption environment and SAP internal structure (Fig. 7).

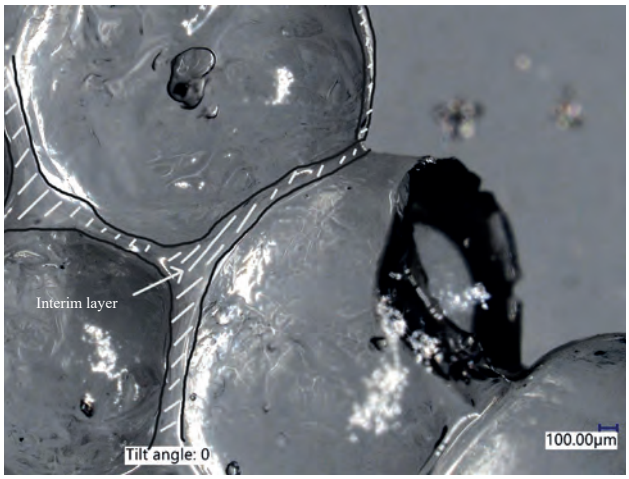

Fig. 7. The interim water layer on the outside of the water-absorbing SAP grains contributing to an increased risk of SAP grain agglomeration

Both physical and electrochemical aspects influence the aforementioned behavior. Surface tension and ionic strength due to high osmotic pressure in SAP grain are potent enough to attract water from the outer layer of neighboring SAP grain, therefore causing grain agglomeration.

As SAP grains agglomerate, the internal curing agents cease to be distributed evenly within the entire volume of the composite. As this occurs, the effectiveness of internal curing significantly reduces. Also, it contributes to forming a network of large pores in the cement matrix once water is removed after water desorption from agglomerated grains. Therefore, a deterioration in the mechanical properties of such concrete is highly probable. It has been reported that the aforementioned phenomena can contribute to significant deterioration in the mechanical performance of internally cured cementitious composites [28]. In the case of fresh concrete mix properties, SAP addition contributes to a significant deterioration in the workability of the fresh composite [29]. Due to this, it is common to counteract the aforementioned effect with an increase in total water content in the composition of concrete [30-32]. Although the exact interaction mechanisms between superabsorbent polymers of different origins and superplasticizing admixtures are still elusive, disregarding that method of controlling the rheology of the mix and including an additional volume of water in the composition to counteract SAP influence over viscosity leads to an increase in the porosity of the cement matrix. With introduced changes, the deterioration in the mechanical performance of the cementitious composite is expected, even if internal curing allows for a local increase in the degree of hydration of the binder. The effect of reduced mechanical performance with an increase in total water-to-cement content was also true in the case of concretes that are not subject to internal curing (in the case of the performed research, series REF 0.30 and REF 0.36). The increase in total water-to-cement ratio caused by increased water content in the mix that is added to counteract SAP's influence over concrete mix rheology also contributes to other, more mundane issues. With its introduction, the mass content of all ingredients per m^3 changes. In the performed research, the additional water volume was compensated through changes in the aggregate content in the mix. However, any non-intended changes between reference and modified series can deteriorate the quality of performed experiments and introduce additional variables influencing studied properties.

The SAP addition method isn't the only factor influencing the effectiveness of internal curing. Both the type and internal curing agent's properties significantly impact the characteristics of fresh concrete mix and hardened concrete properties. Any superabsorbent polymer's water absorption capacity depends on its chemical composition. SAP consists of polymeric chains interconnected via crosslinker. Its quantity indicates the level of entanglement between independent chains, its potential for volumetric change, and, therefore, its water absorption potential. As a polymeric network is less susceptible to elongation, it is also less prone to be impacted by mechanical fragmentation. Due to this, after water desorption, a network of large pores (defects) can be observed in the cement matrix, deteriorating the overall properties of concrete. It is the main reason behind recommendations for limiting the maximal grain size to be useful from the perspective of internal curing if added in a non-saturated state.

6. CONCLUSIONS

Conducted research allowed to determine the influence of variables related to designing internal curing using superabsorbent polymers on the properties of cementitious composites. It was found that:

- Pre-saturation of fine-graded SAP A in the tap water environment before its addition to other ingredients of the concrete mix contributed to an increase in the efficiency of internal curing – a more significant reduction in linear changes caused by shrinkage deformation was observed

while reducing the negative impact on the mechanical properties of concrete.
- Regardless of the type of SAP used, its mass content, the amount of mixing water initially absorbed by SAP, and its addition method to other ingredients, internal curing leads to a decrease in linear changes caused by shrinkage deformations in relation to reference series.
- Internal curing's side effects affecting the mechanical properties of concrete were avoided only in the case of particular modification using SAP A – an increase in mechanical properties of concrete (or no influence at all) was observed in the case of modifying concrete with fine-graded SAP A added in a hydrogel form to the concrete mix. Its effect on mechanical performance was dependent on the amount of initially absorbed mixing water by the internal curing agent.
- An increase in the mass content of SAP contributed to a significant decrease in the fluidity of concrete mix.
- Modification of concrete with SAP of coarse granulation (SAP B), regardless of the design method, contributed to a significant deterioration in the mechanical performance of concrete caused by its non-homogenous distribution within the cement matrix.
- An increase in the total water-to-cement ratio allowed the consistency of concrete mixes to be maintained on a level of a reference series; however, it contributed to a significant deterioration of the mechanical performance of concrete.

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DETERMINATION METHODS OF BOILING HEAT FLUX

METODY WYZNACZANIA GĘSTOŚCI STRUMIENIA CIEPŁA DLA WRZENIA

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Abstract

Boiling is a phase-change phenomenon, which is of significant practical application potential due to large heat flux values exchanged in the process. The paper provides an overview of calculation methods that enable to determine the values of pool boiling heat flux on smooth surfaces. The most commonly used correlations were analysed and the boiling phenomenon occurring on smooth surfaces has been discussed based on the experimental data. A modification of the Rohsenow model has been proposed with the values of the constants determined experimentally.

Streszczenie

Wrzenie to zjawisko związane ze zmianą fazy czynnika, które ma znaczny potencjał praktyczny z uwagi na wymianę dużych gęstości strumienia ciepła. Artykuł przedstawia metody wyznaczania gęstości strumienia ciepła wymienianego przy wrzeniu. Analizuje najczęściej stosowane korelacje i opisuje zjawisko wrzenia, odbywające się na powierzchniach gładkich, w oparciu o badania eksperymentalne. Zaproponowano modyfikację modelu Rohsenowa zawierającą nowe wartości stałych eksperymentalnych.

TASSESSING THE IMPACT OF LAND COVER AND LAND USE CHANGE ON URBAN INFRASTRUCTURE RESILIENCE IN ABUJA, NIGERIA: A CASE STUDY FROM 2017 TO 2022

OCENA WPŁYWU ZMIAN POKRYCIA I UŻYTKOWANIA GRUNTÓW NA ODPORNOŚĆ INFRASTRUKTURY MIEJSKIEJ W STOLICY NIGERII, ABUDŻY: STUDIUM PRZYPADKU Z LAT 2017-2022

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Abstract

The remarkable feature of rapid urbanisation, which has fundamentally altered the distribution of land cover and land use (LULC), is what sets the contemporary era apart. The impact of these modifications on the resilience of Abuja's metropolitan infrastructure from 2017 to 2022 is examined in this study. Our study examined the dynamic changes in LULC using information from remote sensing, geospatial analysis software, and land cover categorization techniques. The findings indicate major changes in Abuja's topography, including a decrease in the number of water bodies, a decrease in the number of trees, the expansion of urban areas, changes in agricultural land use, and fluctuations in the amount of grazing land. The previously mentioned changes have significant consequences for urban infrastructure resilience, affecting various sectors such as water supply, transportation, housing, utilities, and food distribution systems. The infrastructure supporting water supply and sanitation may be severely stretched as the number of water bodies decreases, affecting the quantity and quality of accessible water supplies. As metropolitan areas expand, greater strain is placed on transportation infrastructure, exacerbating traffic congestion and complicating road maintenance difficulties. Changes in agricultural land use can have an impact on food production and distribution, hence affecting food security. Deforestation can cause ecological deterioration, affecting a variety of aspects such as temperature regulation, biological diversity, and atmospheric purity. Adaptive approaches, green infrastructure, and adopting sustainable urban design can all strengthen the resilience of urban infrastructure, according to this study. The significance of renewable energy adoption, community participation, green building laws, the establishment of public-private partnerships, integrated water resource management, and data-driven decision-making is

Streszczenie

Współczesną erę wyróżnia niezwykle szybka urbanizacja, która zasadniczo zmieniła rozkład pokrycia terenu i użytkowania gruntów (LULC). W niniejszym badaniu przeanalizowano wpływ tych zmian na odporność infrastruktury metropolitalnej Abudży w latach 2017-2022. Dynamiczne zmiany LULC zbadano przy użyciu informacji z teledetekcji, oprogramowania do analizy geoprzestrzennej oraz technik kategoryzacji pokrycia terenu. Wyniki wskazują na poważne zmiany w topografii Abudży, w tym spadek liczby zbiorników wodnych, spadek liczby drzew, ekspansję obszarów miejskich, zmiany w użytkowaniu gruntów rolnych i wahania w ilości pastwisk. Zmiany te mają znaczące konsekwencje dla odporności infrastruktury miejskiej, wpływając na różne sektory, takie jak zaopatrzenie w wodę, transport, mieszkalnictwo, usługi komunalne i systemy dystrybucji żywności. Infrastruktura wspierająca zaopatrzenie w wodę i urządzenia sanitarne może być poważnie obciążona, ponieważ malejąca liczba zbiorników wodnych odbija się na ilości i jakości dostępnych zasobów wody. Wraz z rozwojem obszarów metropolitalnych rośnie obciążenie infrastruktury transportowej, co zwiększa natężenie ruchu i komplikuje utrzymanie dróg. Zmiany w użytkowaniu gruntów rolnych wpływają na produkcję i dystrybucję żywności, a tym samym na bezpieczeństwo żywnościowe. Wylesianie może powodować pogorszenie stanu środowiska, wpływając na regulację temperatury, różnorodność biologiczną i czystość atmosfery. Według naszych badań podejście adaptacyjne, zielona infrastruktura i przyjęcie zrównoważonego projektowania urbanistycznego mogą wzmocnić odporność infrastruktury miejskiej. Podkreśla się znaczenie energii odnawialnej, udziału społeczności, przepisów dotyczących zielonego budownictwa, ustanowienia partnerstw publiczno-prywatnych, zintegrowanego zarządzania zasobami wodnymi i podejmowania decyzji w oparciu o dane. Kluczowe znaczenie ma poprawa ram

emphasised. Improving legal frameworks that prioritise resilience and sustainability is critical. It is critical to have a complete grasp of the complicated links between changes in LULC, and the resilience of urban infrastructure in order to enable educated urban design and decision-making processes. Policymakers and urban planners may address and minimise the negative consequences of climate change while improving the overall quality of life in cities by using sustainable development practises. The findings of this study have the potential to dramatically improve Abuja's people's well-being and sustainability, especially given the variety of urban difficulties they encounter.

prawnych, które powinny priorytetowo traktować kwestie odporności miejskiej oraz zrównoważonego rozwoju. Świadome projektowanie urbanistyczne i procesy decyzyjne możliwe są jedynie przy zrozumieniu skomplikowanych powiązań między zmianami w LULC a odpornością infrastruktury miejskiej. Zastosowanie praktyk zrównoważonego rozwoju umożliwi decydentom i urbanistom zminimalizowanie negatywnych konsekwencji zmian klimatycznych oraz podniesienie ogólnej jakości życia w miastach. Wyniki tego badania mogą potencjalnie znacznie poprawić dobrobyt i zrównoważony rozwój mieszkańców Abudży, zwłaszcza biorąc pod uwagę różnorodność napotykanych przez nich trudności miejskich.

MULTI-CRITERIA EVALUATION OF ACCESSIBILITY OF CONTEPORARY PUBLIC UTILITY BUILDINGS – ON THE EXAMPLE OF KIELCE

WIELOKRYTERIALNA OCENA DOSTĘPNOŚCI WSPÓŁCZESNYCH BUDYNKÓW UŻYTECZNOŚCI PUBLICZNEJ – NA PRZYKŁADZIE KIELC

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Abstract

The article analyzes the accessibility of selected examples of public utility buildings, implemented at the end of the 20th century and at the beginning of the 21st century, in the structures of the conteporary city of Kielce. In order to learn about the functioning and architectural solutions of buildings that are among the most frequented by the general public, an in situ study was conducted, using a multi-criteria method that allows comparative analysis and is an effective tool in making an accurate assessment. The selection of the most relevant evaluation criteria was based on the actual needs and psychophysical condition of today's society. The research was locationally focused on the Kielce city area, taking into account current reports and statistics indicating the largest increase in the number of people over 65 in the Świętokrzyskie voivodeship. The studies carried out have led to conclusions and recommendations to help in the design and management of facility spaces.

Streszczenie

W artykule dokonano analizy dostępności wybranych przykładów obiektów użyteczności publicznej, zrealizowanych pod koniec XX i na początku XXI wieku w strukturach współczesnego miasta Kielce. W celu zapoznania się z funkcjonowaniem oraz rozwiązaniami architektonicznymi budynków, należących do najczęściej uczęszczanych przez ogół ludzi, przeprowadzono badania in situ, wykorzystano metodę wielokryterialną, umożliwiającą przeprowadzenie analiz porównawczych i stanowiącą skuteczne narzędzie w dokonaniu precyzyjnej oceny. Wyłonienie najistotniejszych kryteriów oceny oparto na rzeczywistych potrzebach oraz kondycji psychofizycznej dzisiejszego społeczeństwa. Badania skoncentrowano lokalizacyjnie na obszarze Kielc, mając na uwadze aktualne raporty i statystyki wskazujące na największy przyrost liczby osób powyżej 65 lat w województwie świętokrzyskim. Przeprowadzone studia pozwoliły na sformułowanie wniosków i zaleceń pomocnych w projektowaniu i zarządzaniu przestrzeni obiektów.

NEW PROPOSAL FOR THE FORMER SYNAGOGUE IN KIELCE

NOWA PROPOZYCJA DLA STAREJ SYNAGOGI W KIELCACH

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Abstract

The current trend of conservation of immovable monuments is – in addition to ongoing maintenance and protection – adaptation. Simply taking care of a monument is not an effective way to keep it in good repair if it is not used. Utility is the primary function of architecture, as buildings are erected for this purpose only. No building can survive without function, especially a centuries-old one. This is because the lack of a user condemns any monument to destruction, which leads to ruin and, ultimately, to demolition. Therefore, proper adaptation to new functions and current technical conditions is necessary. In the process of adaptation, all the heritage values of the object should be brought out and only then should new ones be introduced, taking into account the integrity of the monument and ensuring authenticity. Sacred architecture has special cultural and historical values, both tangible and intangible, i.e. spiritual. Continually discussed adaptations of religious buildings in the case of Judaic religious buildings destroyed and abandoned after World War II proved to be the best way to reclaim synagogues. The Kielce synagogue is one of the early examples of adaptation to another function. The building, destroyed during World War II, was rebuilt in the 1950s in a different form than the original one, for use as an archive. This historic building, however, has been standing useless for more than a decade now, and this fact has a destructive effect on its heritage value, therefore it is necessary to take action as soon as possible. Numerous concepts for this building located in a prestigious area in Kielce can be produced, which will be presented and evaluated in terms of substantive potential of utilizing its value in a new incarnation.

Streszczenie

Nurtem współczesnej ochrony zabytków nieruchomych jest nie tylko bieżąca konserwacja i ochrona, ale adaptacja. Samo dbanie o zabytek nie jest skuteczną metodą utrzymania w dobrej kondycji każdego obiektu, jeśli nie będzie użytkowany. Użyteczność to podstawowe zadanie architektury, ponieważ tylko z tego powodu tworzone są budowle. Żaden budynek nie przetrwa bez funkcji, a szczególnie wiekowy. Brak użytkownika skazuje bowiem każdy zabytek na zniszczenie, co doprowadza do ruiny, a z czasem skazuje na rozbiórkę. Dlatego konieczna jest właściwa adaptacja na nowe funkcje i do obecnych warunków technicznych. W procesie adaptacji powinno się wydobyć wszystkie wartości zabytkowe obiektu i dopiero wprowadzać nowe, uwzględniając integralność zabytku i wpisujące się w autentyczność. Szczególne wartości zabytkowe ma architektura sakralna, zarówno te materialne, jak i niematerialne – duchowe. Cały czas poddawane dyskusji adaptacje obiektów sakralnych w przypadku zniszczonych i opuszczonych po drugiej wojnie światowej budynków kultu religii judaistycznej okazały się najlepszą metodą na odzyskanie synagog. Kielecka synagoga należy do wczesnych przykładów adaptacji na inną funkcję. Budynek zniszczony w czasie drugiej wojny światowej odbudowano w latach 50. XX wieku, w innej formie niż pierwotna z przeznaczeniem na archiwum. Obecnie jednak ten historyczny budynek od ponad dekady stoi bezużyteczny, a fakt ten ma destrukcyjny wpływ na zabytkową substancję, dlatego konieczne jest jak najszybsze podjęcie działań. Pomysłów na ten obiekt w prestiżowej lokalizacji w Kielcach jest wiele, zostaną one przybliżone i ocenione pod względem możliwości merytorycznego wykorzystania jego wartości w nowym „wcieleniu".

THE INFLUENCE OF TOTAL WATER-TO-CEMENT RATIO ON THE MECHANICAL PROPERTIES OF CEMENTITIOUS COMPOSITES INTERNALLY CURED WITH POLYACRYLIC SUPERABSORBENT POLYMERS (SAP)

WPŁYW CAŁKOWITEGO WSPÓŁCZYNNIKA WODA-CEMENT NA WŁAŚCIWOŚCI MECHANICZNE KOMPOZYTÓW CEMENTOWYCH PIELĘGNOWANYCH WEWNĘTRZNIE POLIAKRYLOWYMI POLIMERAMI SUPERABSORPCYJNYMI (SAP)

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Abstract

Superabsorbent polymers (SAP) allow for the introduction of changes to the pore network characteristics in cementitious composites and the course of binder hydration. Therefore, SAP addition contributes to significant changes in multiple properties of concrete. The effect of internal curing differs depending on its design process – the initial content of curing water in the concrete mix, polymer characteristics and water absorption properties, the state in which it's added (non-saturated/hydrogel), and the design method regarding curing water content in the entire water content. The authors investigated those variables' influence on selected concrete properties – compressive strength, water absorption, and shrinkage. All independent variables significantly influenced the studied properties of concrete. The increase in the total water-to-cement ratio led to a significant decrease in the mechanical properties of cementitious composites. Modification with the use of SAP added in the form of hydrogel had the most positive influence on the properties of concrete.

Streszczenie

Polimery superabsorpcyjne (SAP) umożliwiają wprowadzenie zmian w charakterystyce sieci porowej kompozytów cementowych i w przebiegu hydratacji spoiwa. W efekcie dodatek SAP przyczynia się do znaczących zmian w wielu właściwościach betonu. Efekt pielęgnacji wewnętrznej różni się w zależności od metody jej zaprojektowania – początkowej zawartości wody pielęgnacyjnej w mieszance betonowej, właściwości fizycznych polimeru, w tym zdolności do absorpcji wody, stanu, w jakim jest on wprowadzony (nienasycony wodą/hydrożel), oraz metody uwzględnienia wody pielęgnacyjnej w całej zawartości wody zarobowej. Autorzy zbadali wpływ tych zmiennych na wybrane właściwości betonu, w tym na wytrzymałość na ściskanie, nasiąkliwość i skurcz całkowity. Wszystkie zmienne niezależne w istotny sposób wpływały na badane właściwości betonu. Wzrost całkowitego współczynnika woda-cement spowodował istotne pogorszenie właściwości mechanicznych kompozytów cementowych. Najbardziej pozytywnym wpływem na właściwości betonu charakteryzowała się modyfikacja za pomocą dodatku SAP wprowadzonego w postaci hydrożelu