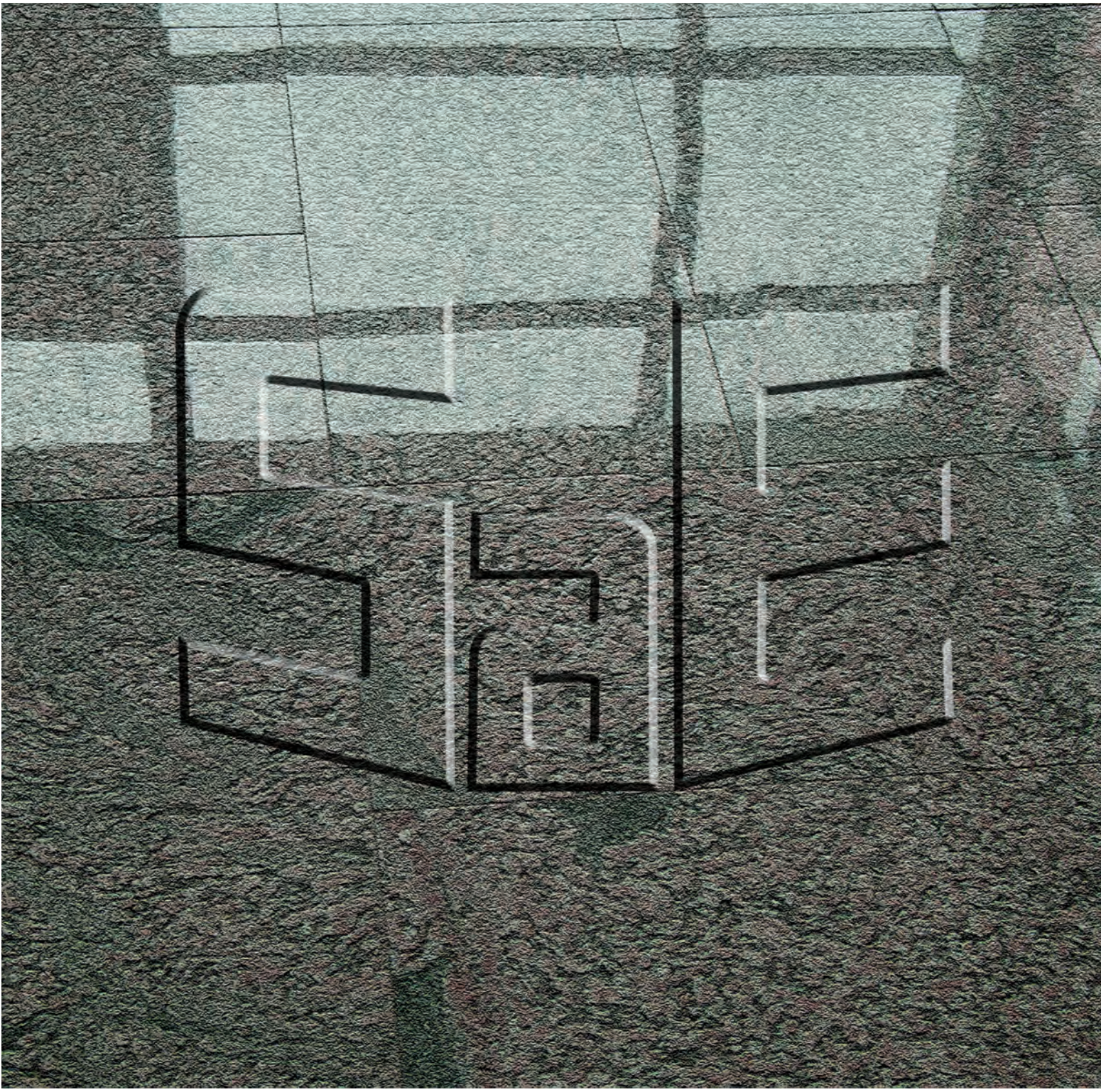
STRUCTURE AND ENVIRONMENT

KIELCE UNIVERSITY OF TECHNOLOGY

Quarterly
Vol. 13, No. 3, 2021

ISSN 2081-1500
e-ISSN 2657-6902

• Architecture and urban planning • Civil engineering and transport • Environmental engineering, mining and energy



Available online at: https://sae.tu.kielce.pl

Contents

structure

environment

General data:

Format of the journal – electronic form

Frequency of publication – quarterly

The quarterly issues of Structure and Environment are their original version

The journal published by the Kielce University of Technology and De Gruyter Polska

e-ISSN 2657-6902

ISSN 2081-1500

DOI: 10.30540/sae/

Journal Metrics:

Index Copernicus Value (IVC) 2020 = 100

The Polish Ministry of Education and Science 2021 = 40 pkt

Kielce University of Technology

2021

INDEX COPERNICUS INTERNATIONAL

structure

Dariusz Piotrowicz
Structure and Environment 2021, vol. 13, (3), pp. 71-82, Article number: el 008
https://doi.org/10.30540/sae-2021-008

Structure and Environment
ISSN 2081-1500
e-ISSN 2657-6902
https://content.sciendo.com/sae
https://sae.tu.kielce.pl

sciendo

Kielce University of Technology

DOI: 10.30540/sae-2021-008

DETERMINANTS OF THE LOCATION AND ARCHITECTURE OF THE PROVINCIAL OFFICE IN KIELCE

UWARUNKOWANIA LOKALIZACJI I ARCHITEKTURY URZĘDU WOJEWÓDZKIEGO W KIELCACH

Dariusz Piotrowicz*
Kielce University of Technology, Poland

Abstract

The article presents a very modest state of research on the, architecture of the then Presidium of the Provincial National Council in Kielce – currently the provincial and marshal's office. The research methodology was adopted to find new facts influencing the choice of place and the architectural form of the office. The study covered the period from the beginning of the 1950s to the end of the 1970s. An episode of socialist realism was shown, influencing its functionally and spatially planned location and the direction of modernism in architecture. Its similarity with the works of Le Corbusier was pointed out as a probable inspiration. As a result, a building was constructed that positively entered the postwar urban planning of the city. On the other hand, as an element of an unrealized modernist urban vision, it is a warning against the desire to irreversibly destroy the historic space of downtown Kielce.

Keywords: architecture, urban planning, Socialist realism, Modernism, Provincial Office in Kielce

Streszczenie

W artykule przedstawiono bardzo skromny stan badań architektury ówczesnego budynku Prezydium Wojewódzkiej Rady Narodowej w Kielcach – obecnie Urzędu Wojewódzkiego i Marszałkowskiego. Przyjęto metodykę badań w celu poszukiwań nowych faktów, mających wpływ na wybór miejsca i formę architektoniczną budynku. Badaniem objęto okres od początku lat pięćdziesiątych do końca siedemdziesiątych XX wieku. Ukazano wpływ socrealizmu na jego zaplanowaną funkcjonalnie i przestrzennie lokalizację oraz kierunku modernizmu na architekturę. Wskazano na dzieła Le Corbusiera jako prawdopodobną inspirację. W ich efekcie zrealizowano budynek, który pozytywnie wpisał się na karty powojennej urbanistyki miasta. Z drugiej strony, jako element niezrealizowanej modernistycznej wizji urbanistycznej, jest przestrogą przed chęcią nieodwracalnego zniszczenia historycznej przestrzeni śródmieścia Kielc.

Słowa kluczowe: architektura, urbanistyka, socrealizm, modernizm, Urząd Wojewódzki w Kielcach

1. INTRODUCTION

Kielce has a rich history, most of which is recognized. The exception is the period after World War II. Then the city began to modernize and expand. However, in the 1950s, the concept of ”modernity” was perceived politically, imposing the only correct architectural direction – socialist realism. It was followed by modernism, which rejected all conditions of the past in favor of modernity and functionality, as well as the opening of space and the play of light. Did these factors influence the modernization of the capital of Kielce Voivodeship and the seat of their authorities at that time?

*Kielce University of Technology, Poland, e-mail: dpiotrowicz@tu.kielce.pl

2. THE STATE OF RESEARCH

There are few publications on the architecture of Kielce offices and their space. Anna Cymer shows this as one of the examples of the evolution of postwar architecture [1]. Artur Hajdorowicz touched upon, inter alia, the complex of buildings of the Provincial Office in the context of the issues of protection and potential transformations of buildings important for the city space [2]. The Municipal Register of Monuments contains only the list of historic buildings and their locations. The conservationist *Address card of an immovable monument* for office buildings contains only its old and present name, time of creation, address, and administrative affiliation. Therefore, there is no broader knowledge about postwar town planning, from which one can learn about the reasons for the location of the Provincial Office and its architectural style. To obtain this knowledge, it was necessary to study the cartographic documents of its location and the analysis of iconography showing the planned and completed architectural forms of buildings.

3. RESEARCH METHODOLOGY

Two complementary methods were used in the study of the topic. The first is the geographic (cartographic, spatial) method used to establish facts or relationships between them in a geographical – historically shaped environment. In terms of cartography, manifestations of human activity are presented, which are suitable for spatial depiction. It consists, among other things, of associating and comparing cartographic materials of the same area from different time periods to determine changes in the area and its development. The second is the comparative (confrontational-contrastive) method, which is one of the most important tools of historical research. It is used not only to establish or reconstruct facts, but also to justify the hypotheses and their explanations. It consists in perceiving and associating various facts or phenomena and establishing their similarities or differences between them.

The research used archives from Archives of the Spatial Planning Office of the City Hall in Kielce, Museum of the History of Kielce, which have cartographic and iconographic resources, enabling the recognition of the determinants of urban composition and issues of architectural composition.

4. AN EPISODE OF SOCIALIST REALISM

The original development of the area was the result of the functioning of the Old-Warsaw Suburbs on the border of IX Wieków Kielc Avenue. Currently, it is illegible in the present city space. Construction of IX Wieków Kielc Avenue in the 1970s and numerous demolitions and new investments in this area practically obliterated the traces of the old layout.

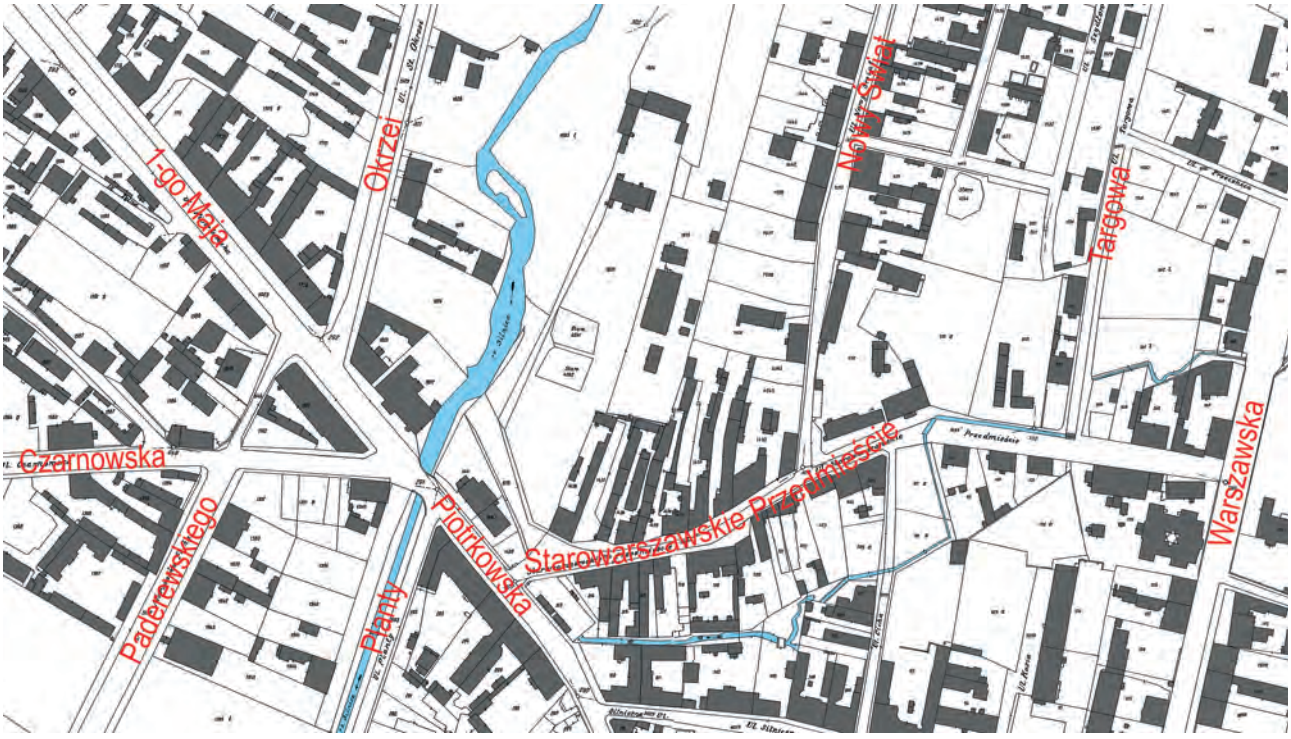


Fig. 1. Land development in 1927-1935 with contemporary street names
Source: Own study.

During the German occupation, the area was within the Jewish ghetto, established in 1941 by the staroste Drechsel's[1] order to establish a Jewish residential district in the city of Kielce. This area was delimited by the following streets: Orla, Piotrkowska, Nowowarszawska, Pocieszka, and Radomska, surrounding the so-called large ghetto. On the other hand, the area between St. Wojciech, Bodzentyńska, and Radomska Streets was called the small ghetto. The following streets were included in the ghetto: Piotrkowska, Jasna, Stolarska, Wąska, Krzywa, Zagnańska, Okrzei, Nowy Świat, Starowarszawskie Przedmieście, Przechodnia, Przecznica, Dąbrowska, Szydłowska, Targowa, Pocieszka, Nowowiejska, Silniczna, Kozia, Orla, Radomska, Cicha, Polna, St. Wojciecha (with the square), Bodzentyńska, Marszałkowska. The ghetto also included houses located to the west on Warszawska Street between Szydłowska, Pocieszka and Targowa Streets.

The main reason for the liquidation of Starowarszawskie Przedmieście and the remains of the ghetto was the functional and spatial transformations of the area and the demolition of buildings in poor technical condition. They took place mainly after World War II. At that time, Kielce retained the administrative statute of the voivodeship city. This prestige mobilized local authorities to improve the city's image. One of the activities directions was the reconstruction of the communication system and the modernization of the existing road and street network. The transit routes used so far ran through the center and even through the Old Town Square. The traffic in the north-south direction was partially relieved by Mielczarskiego (formerly Młynarska) and Paderewskiego (Focha, Buczka) Streets. There was no bypass of the center and the east-west connection. The city authorities outlined various communication variants in their urban planning plans. They were modeled on Soviet urban planning and the layout of Moscow and Leningrad (St. Petersburg). Their concept was based on the central downtown, from which roads radiated, connected by successive rings, relieving traffic from the center. Such a plan for Kielce was created in 1948 and was corrected several times in the 1950s.

Based on the general plan of Kielce, in 1953 a detailed development of the northern area of the city was created. The project was developed by a team of town planners led by Z. Sowala. Their composition implemented the assumptions of socialist realism in the form of representative public squares, traditional quarters of buildings with lots of internal greenery, instead of outbuildings. Despite these assumptions, this trend also referred to the slogans of modernists: more space, light and greenery.

Fig. 2. Development project from 1953
Source: Archives of the Spatial Planning Office of the City Hall in Kielce.

[1] The surname Drechsel appears on the document of the regulation, while Dreschel is mentioned in the literature on the subject.

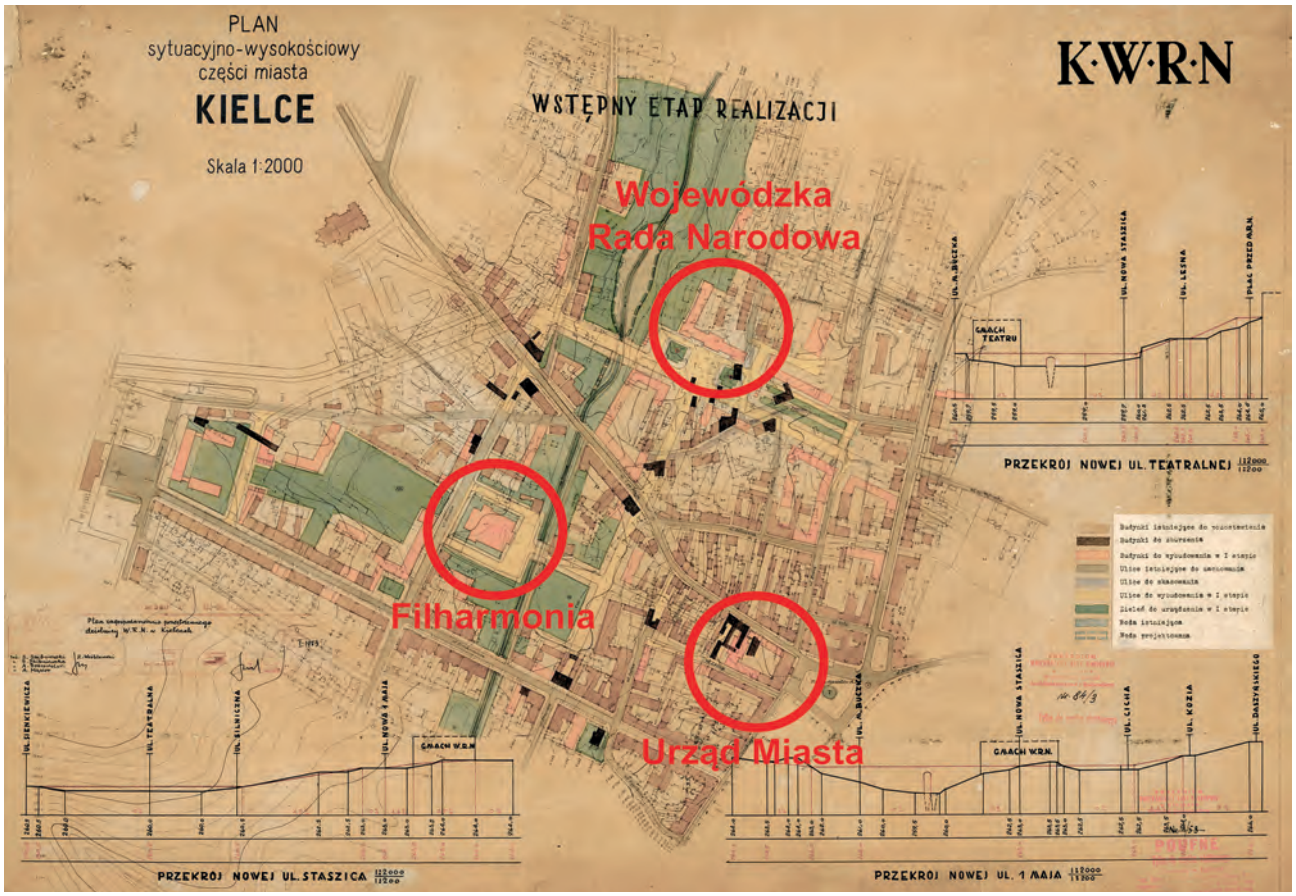


Fig. 3. Development plan for the WRN district (Provincial National Council) in Kielce
Source: Archives of the Spatial Planning Office of the City Hall in Kielce.

Another development plan for the district of the Provincial National Council, the authors of which were S. Skibniewski, S. Skibniewska, A. Dobrowolski, A. Mąsior, presented a different development concept. It was more ”conservative” than the earlier ”revolutionary”, which assumed numerous demolitions. Efforts were made to organize the existing space through selected demolitions and correction of communication.

As part of organizing the downtown space, three key urban investments were established that determined a new urban composition. It was the extension of the City Hall situated at the Market Square, the location of the philharmonic hall on the square at Paderewski (now the Irena Sendler Square) and the transfer of the seat of the Presidium of the Provincial National Council, located in the former bishop's[2] palace, to a complex of buildings in a new location. These four locations formed the composition of the cross for new development.

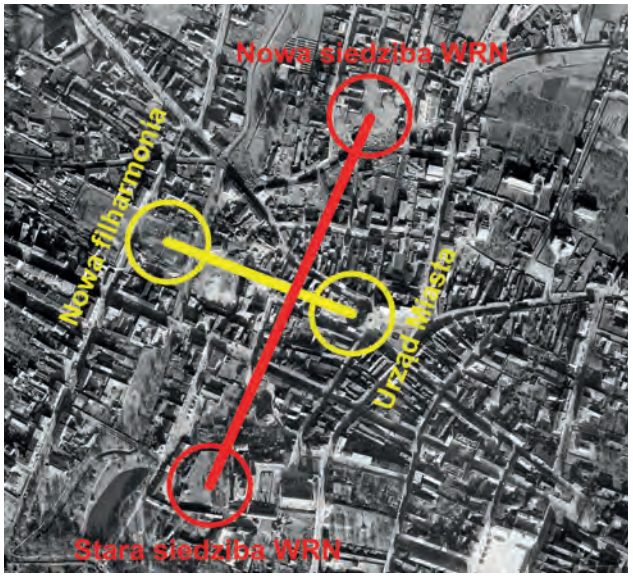


Fig. 4. New composition
Source: Own study. (Nowa siedziba WRN: The new headquarters of WRN; Stara siedziba WRN: Old WRN headquarters; Urząd miasta: City Hall; Nowa filharmonia: New Philharmonic)

[2] The seat of the office in the years 1945-1970.

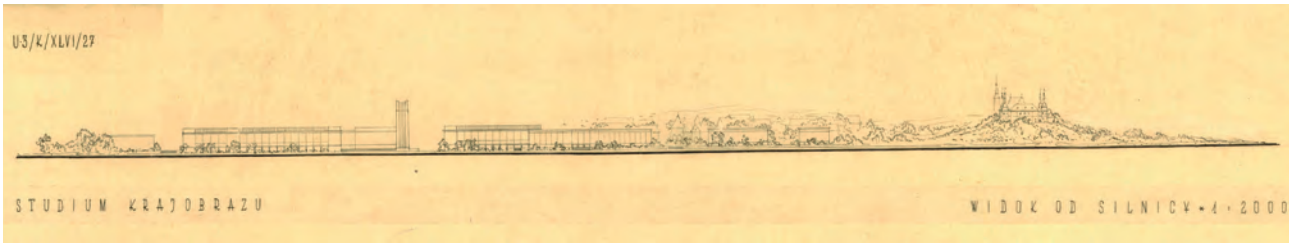


Fig. 5. Landscape study showing the potential impact of the new office of the Presidium of the Provincial National Council on spatial connections with the former seat
Source: Museum of the History of Kielce, ref. No. S-428.

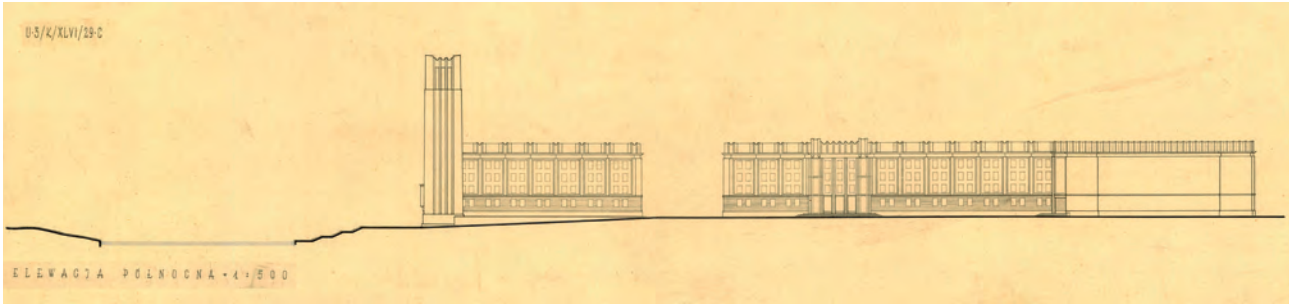


Fig. 6. The northern elevation of the buildings of the Presidium of the Provincial National Council
Source: Museum of the History of Kielce, ref. No. S-429.

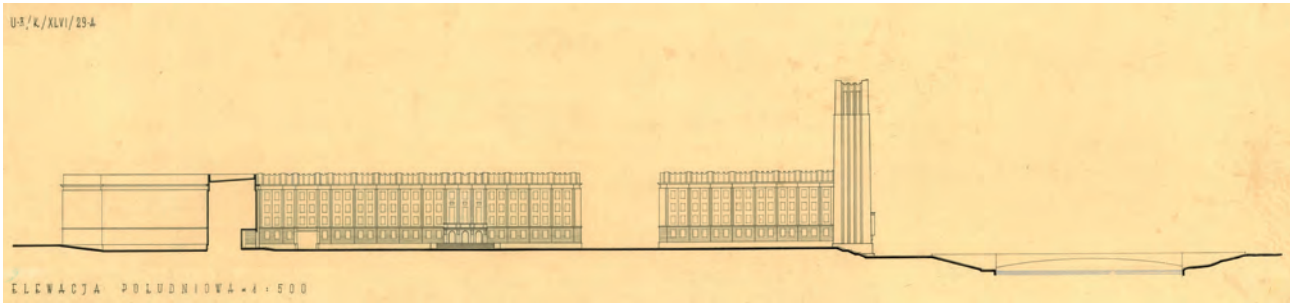


Fig. 7. South elevation of buildings
Source: Museum of the History of Kielce, ref. No. S-430.

This composition of the plan determined the location of the new seat of the Presidium of the Provincial National Council, which was completed in 1971. The original, unrealized design of the new office building has been preserved. Unfortunately, it has no date and no author. The building, designed in the style of socialist realism, proves that it was built in the 1950s on the basis of designated urban planning directions. The design includes a landscape study, which confirms the design relationship between the old palace and the new office as two dominants in the city silhouette.

In 1961, at the Miejska Pracownia Urbanistyczna, a team of architects consisting of H. Stawicki, T. Koralewicz, S. Godzic, and E. Dąbrowski developed another concept for the development of the city center. The aim of the study was to improve the image of the center of Kielce and its functioning. After the technical condition of the buildings was assessed, the necessary demolitions and modernization of the communication system were indicated. The priority was to move the burdensome traffic outside the downtown area by creating a new east-west line in the north.

Fig. 8. The target concept for the development of the city center of Kielce, study from 1962
Source: Archives of the Spatial Planning Office of the City Hall in Kielce, file no. 169.

Fig. 9. Development status in 1954
Source: Own archive.

Fig. 10. The beginning of the implementation of the new communication in 1967
Source: Own archive.

Fig. 11. Place of breakthrough of IX Wieków Kielc Avenue to Warszawska Street 1968
Source: Own archive.

5. THE STIGMA OF MODERNISM

The 1970s were a period of profound economic, political and social changes. The increase in population and the development of the automotive industry as the well as industrialized housing construction technologies have changed the perception of existing urban planning. This also applied to the city center. It was cramped and neglected. Therefore, it was necessary to improve sanitation and communication. The new spatial model was to create optimal conditions for a healthy life in the city. After Edward Gierek took power, there was a greater openness to Western solutions.

The basis of „new" urbanism was the Athens Charter adopted in 1933 at the International Congress for Modern Architecture. It states that after the mistakes of the past hundred years, the basic obligation of architecture is to come into accord with the fundamental needs of the individual and improve the quality of life. It must again serve people and be guided by humanistic values, providing them with more sunlight, space, and greenery. The representative of modernism, Tony Garnier, referring to the structure of cities at the end of the 19th century, wrote: "about narrow and winding streets, forming meanders which were never reached by a ray of sunshine, and which, as a result, not only presented a repulsive appearance, but also exerted a stigma on the psyche of the inhabitants, devoid of light and air" [3]. Le Corbusier, on the other hand, proclaimed that: "you must not dream of linking the city of the past with the present or the future (...) you have to redo everything, first destroying everything" [4]. A new issue raised was the hygiene of new residential districts and improving the functioning of the city, mainly in terms of communication and housing requirements.

Fig. 12. The modernist concept of the reconstruction of Paris by Le Corbusier
Source: https://www.businessinsider.com/le-corbusiers-plan-voisin-for-paris-2013-7?IR=T

Fig. 13. The office building of the Trade Unions at Piotrkowska 12 Street
Source: https://kielce.fotopolska.eu/1047976,foto.html; https://kielce.fotopolska.eu/foto/860/860747.jpg.

In the spirit of this idea, in the urban projects in the center of Kielce, "modern" buildings began to displace the still preserved historical tissue. The forerunner of the new urbanization is the former seat of the Trade Unions, and now the hotel at Piotrkowska 12 Street. This building is a witness to the unrealized project of a shopping and service center that was to be built near a medieval square. Despite the development of three variants of development, all of them transformed the historic space, leaving only its oldest fragment.

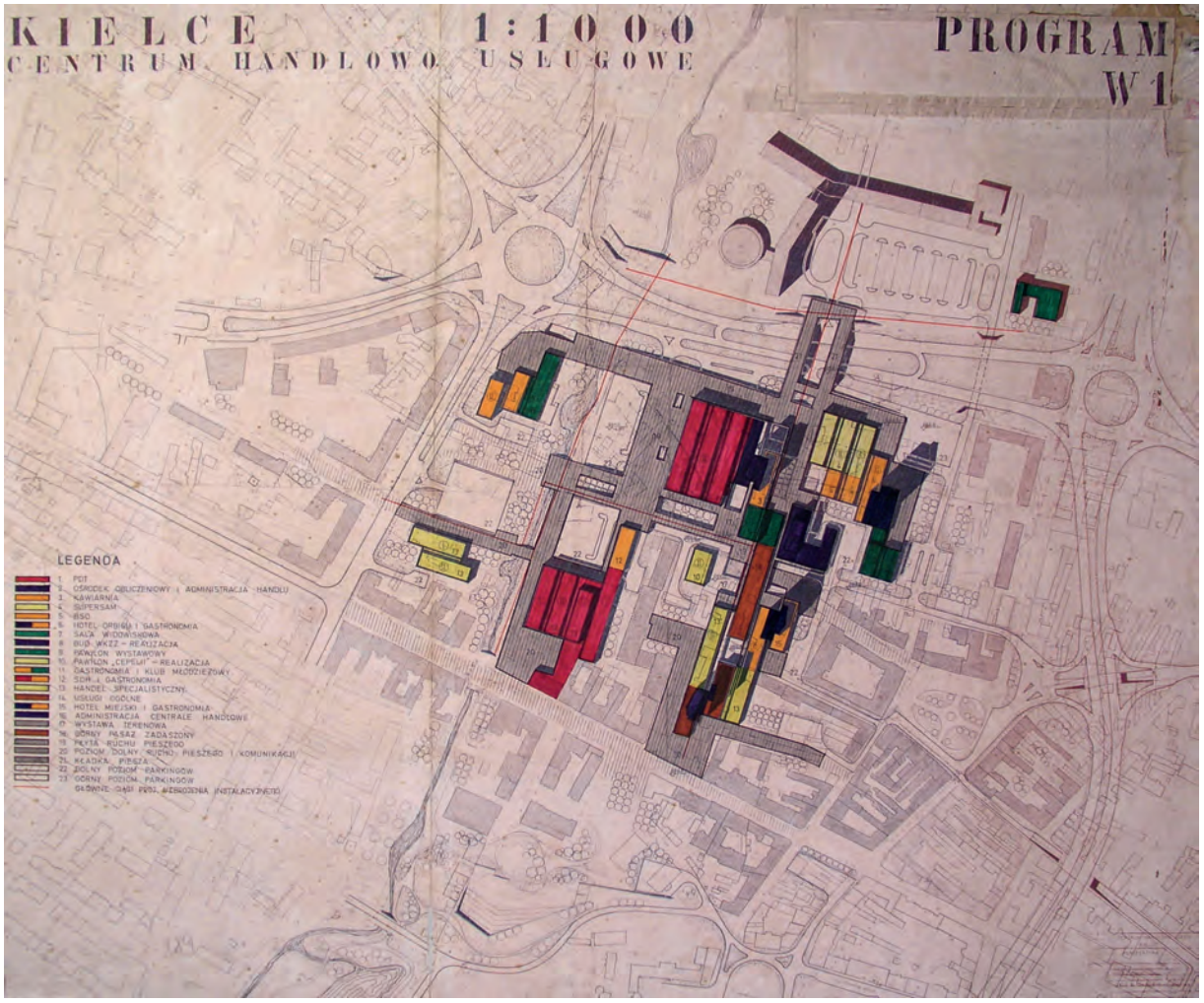


Fig. 14. Variant "W1" of a new shopping and service center in the center of Kielce
Source: Archives of the Spatial Planning Office of the City Hall in Kielce, file No. 334.

Fig. 15. Visualization of the "W1" variant of the new shopping and service center in the center of Kielce
Source: Archives of the Spatial Planning Office of the City Hall in Kielce, no reference number.

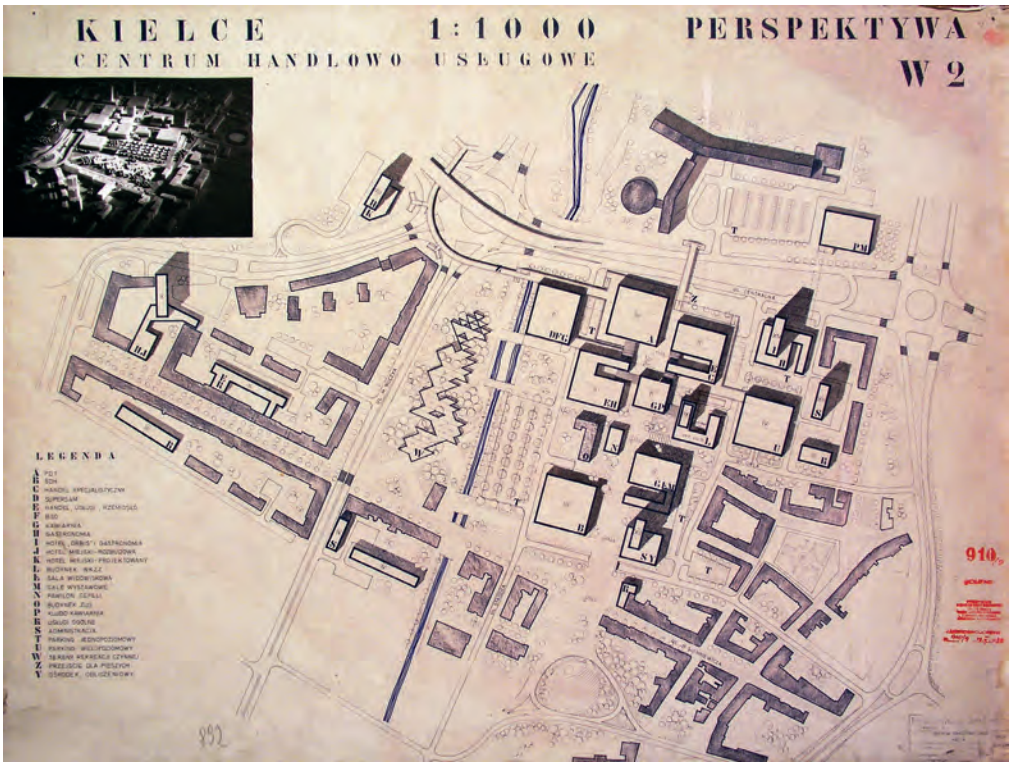


Fig. 16. Variant "W2" of a new shopping and service center in the center of Kielce
Source: Archives of the Spatial Planning Office of the City Hall in Kielce, file No. 337.

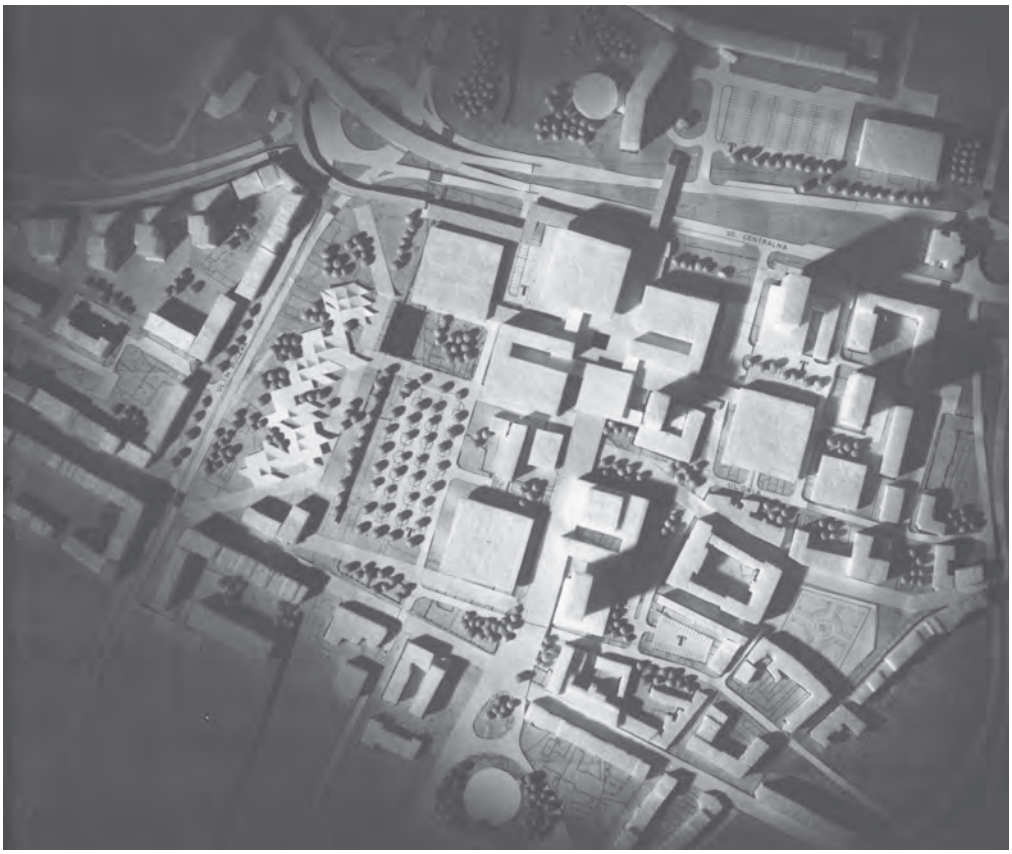


Fig. 17. Visualization of the "W2" variant of the new shopping and service center in the center of Kielce
Source: Archives of the Spatial Planning Office of the City Hall in Kielce, no reference number.

Fig. 18. Variant "W3" of a new shopping and service center in the center of Kielce.
Source: Archives of the Spatial Planning Office of the City Hall in Kielce, no reference number

The similarity of the variant "W3" to the Eastern Wall of the frontage of Marszałkowska Street in Warsaw is quite striking. At the intersection of Paderewskiego Street and IX Wieków Kielc Avenue, the rotunda building is planned just like in the capital at the intersection of Marszałkowska Street and Aleje Jerozolimskie. The composition of the longitudinal development is also similar. It is made up of a system of four horizontal buildings at the front, supplemented at the rear by four skyscrapers.

Fig. 19. South view of the "W3" variant of the new shopping and service center from the office
Source: Archives of the Spatial Planning Office of the City Hall in Kielce, no reference number.

Fig. 20. The frontage of Marszałkowska Street in Warsaw (1962-70), which was the inspiration for the Kielce concept of "W3"
Source: https://66.media.tumblr.com/7cf04b48774aa7be4439d9c2337c9522/tumblr_inline_opn3x4kDzV1tu5dp0_1280.jpg.

6. ARCHITECTURAL INSPIRATION

The designed complex of the buildings of the voivodeship and marshal offices is an example of a modernist way of thinking. It broke with the old

canons of shaping historical space and its architecture. On the other hand, in the 1950s it was a stigmatized enemy of the ”one right” idea of socialist realism as a post-war alternative that was intended to break with the interwar modernism of the West. Changes in politics and opening up to Western influences resulted in the creation of an object inspired by the works of one of the main representatives of modernism: Le Corbusier.

Fig. 21. Le Corbusier's Marseille housing unit built in 1947-1952
Source: https://img.kingandmcgaw.com/imagecache/4/3/bmwcm-5.0_fid-880611_fwcm-2.5_ihcm-70.0_iwcm-100.0_lmwcm-5.0_maxdim-1000_mc-fffffff_rmwcm-5.0_si-438086.jpg_tmwcm-5.0.jpg.

Fig. 22. Palace Assemble
Source: https://dwarchive.com/sites/default/files/resources/DWC2528.jpg.

Fig. 23. Le Corbusier's Villa Savoye built in 1928-1931
Source: https://upload.wikimedia.org/wikipedia/pl/thumb/a/af/Villa_Savoye_2015.jpg/1280px-Villa_Savoye_2015.jpg.

Figs. 24 and 25. Building complex of the Presidium of the Provincial National Council after completion of construction
Source: Own archive.

As you can see, the works of Le Corbusier were certainly a design inspiration for the designers of the office's architecture. Building ”A” refers to a housing unit in Marseille, ”B” to one of the facades of Palace Assembly, and ”C” to Villa Savoye. It should be emphasized that inspiration from the works of Le Corbusier is quite common. An example is the Central Department Store (Smyk) in Warsaw, put into use in 1951 at Bracka Street at the intersection of Krucza and Aleje Jerozolimskie Streets. The inspiration is the column structure, the horizontal arrangement of the windows and the partially usable roof. Another Warsaw example is the Za Żelazną Bramą estate, whose residential buildings refer to the Marseille Unit.

The general designer of the entire investment in Kielce with a total usable area of more than 20,000 m^2 was a team led by Eng. Stanisław Skibniewski, cooperating with the Design Studio „Miastoprojekt” under the direction of Eng. Wacław Hebda. The main designers were arch. Tadeusz Steiner and Stanisław Kawiorski. Construction was managed by Eng. Józef Kuciński from the Kielce Municipal Construction Company under the supervision of the Kielce Construction Association. In the summer of 1967,

the then chairman of the Provincial National Council, Antoni Mieśmieński, solemnly laid the cornerstone for the construction of the office.

The office complex consisting of three buildings was gradually put into use. In 1970, the main ten-story building ”A” was completed with an area of more than 10,000 m^2. A year later, a seven-story building ”C” with 8,000 m^2 of space, and in the following two years the smallest, but most characteristic of Kielce's inhabitants, part ”B”, called a „round log”, with more than 2,000 m^2. There are conference and training rooms and a canteen there. In addition to the usable space that was impressive for Kielce at that time, the cubature of these buildings was also substantial, amounting to over 80,000 m^3, of which nearly half is the main building.

7. CONCLUSIONS

The area of the former seat of the Presidium of the Provincial National Council is formally located outside the border of the historic urban layout. However, historically, in terms of composition and landscape, it is closely related to it. Its location is the result of the historical evolution of the city's layout and the implementation in the 1950s of a socialist realist functional and spatial composition, combining the former palace of Cracow bishops, then the seat of the office. The architectural form, on the other hand, was inspired by modernism and the works of Le Corbusier's works. While socialist realism was an imposed political direction, modernism was the choice of architects according to their individual preferences of ”modernity” and current ”fashion”.

The location of the object is not accidental. It is a fragment of the urban composition of the era of socialist realism. It consisted of two axes. One was to connect the City Hall and Irena Sendler's Square, where a philharmonic was planned to be located in the 1950s. The second axis connected the bishop's palace with the former seat of the Presidium of the Provincial National Council with the new office buildings. It was a symbolic axis, connecting at its ends the buildings of historical – church and contemporary – state power.

The construction of a complex of buildings for the Presidium of the Provincial National Council and the implementation of a new communication system around the city center of Kielce, on the one hand, spatially cut off the office buildings from the city center, but on the other hand gave a new investment impulse in the early 1970s. The assumption of the position of the first secretary of the Polish United Workers' Party by Edward Gierek broke with the current vision of a socialist city and opened a view to the world and the developed countries of the West. The correction of the current political thinking also changed the view of modernism, alien to Eastern Europe, which began to supersede the socialist realist style preferred by the political system for government buildings and public spaces. As a result, new visions of transforming the city and its center began to emerge in the Kielce urban planning studio, adopting the ideas of modernism and the motto: more space, light and greenery.

While the principles of modernism introduced into the Old Town structures are criticized in the circles of art historians, it should be said that the implemented architecture of the Kielce office complex replaced the concept of a building in the style of socialist realism, politically promoted in the 1950s. The rich history of the place and architectural values of the office buildings contributed to its protection under conservation, as an example of historical, compositional and architectural values.

Each building and its surroundings hide its history, which is closed or constitutes the basis for further continuation or inspiration to meet the needs of the next generation.

REFERENCES

[1] Cymer A., *Architektura w Polsce 1945-1989*, Centrum Architektury, Narodowy Instytut Architektury i Urbanistyki, Warszawa 2018, 476 s., ISBN 978-83-949185-9-0.
[2] Hajdorowicz A., *Dobra kultury współczesnej czy zabytki* [w:] *Renowacje i zabytki* nr 4, Wydawnictwo Agencja Informacyjno-Promocyjna „Raport”, Kraków 2014, s. 81-94.
[3] Pawłowski K.K., *Tony Garnier, pionier urbanistyki nowoczesnej,* Instytut Podstawowych Problemów Planowania Przestrzennego Politechniki Warszawskiej, Materiały i Studia Państwowego Wydawnictwa Naukowego, Warszawa 1972, s. 147.
[4] Małachowicz E., *Ochrona środowiska kulturowego,* t. 1, Państwowe Wydawnictwo Naukowe, Warszawa 1988, 379 s.

Karol Skowera, Anna Foksa
Structure and Environment 2021, vol. 13, (3), pp. 83-89, Article number: el 009
https://doi.org/10.30540/sae-2021-009

Structure and Environment
ISSN 2081-1500
e-ISSN 2657-6902
https://content.sciendo.com/sae
https://sae.tu.kielce.pl

sciendo

Kielce University of Technology

DOI: 10.30540/sae-2021-009

TECHNICAL ASPECTS OF MEASUREMENTS USING THE PULL-OFF METHOD

TECHNICZNE ASPEKTY POMIARÓW METODĄ PULL-OFF

Karol Skowera*, Anna Foksa
Kielce University of Technology, Poland

Abstract

The article presents an analysis of the technical use aspects of the pull-off method for testing the repair layers applied to concrete elements, based on the standards requirements. The use of non-destructive testing methods is the only option in some cases. However, it is very important to pay attention to their proper use or even preparation for research. The pull-off method requires just such diligence to be able to properly interpret the obtained results. The article compares the results of the research in which the pull-off method was used in various configurations. The obtained measurement results were compared with each other and analyzed in terms of their usefulness.

Keywords: pull-off method, tensile strength, reprofiling mortar, PCC layer, non-destructive metod

Streszczenie

W artykule przedstawiono analizę technicznych aspektów użytkowania metody pull-off do badania warstw naprawczych nakładanych na elementy betonowe w oparciu o wymagania norm. W niektórych przypadkach jedyną opcją jest zastosowanie nieniszczących metod badawczych. Bardzo ważne jest jednak, aby zwracać uwagę na ich właściwe stosowanie, a nawet samo przygotowanie do badań. Metoda pull-off wymaga właśnie takiej staranności, aby móc właściwie zinterpretować uzyskane wyniki. W artykule porównano wyniki badań, w których zastosowano metodę pull-off w różnych konfiguracjach. Otrzymane wyniki pomiarów porównano ze sobą i przeanalizowano pod kątem ich przydatności.

Słowa kluczowe: metoda pull-off, wytrzymałość na rozciąganie, zaprawa naprawcza, zaprawa PCC, metoda nieniszcząca

1. INTRODUCTION

From the moment the first buildings were erected, durability was the main factor taken into account. Over the years, the concept of durability has changed its essence, because nowadays buildings are not erected "for centuries" but for a specific period of time, called the period of use. The need to carry out all kinds of repairs and renovations is more and more frequent nowadays. Damage to buildings is completely natural. The important issue is finding the cause, solution and prevention. In order for the object to be preserved in the condition of its use as long as possible, it is first of all necessary to design it properly and then execute it. All maintenance procedures during use and protection against corrosion are also extremely important. If any element is damaged, it should be repaired immediately and then properly protected. In the initial stages, it is important to choose the right repair method and materials. For this purpose, repair mortars of the PCC type are used.

*Kielce University of Technology, Poland, e-mail: kskowera@tu.kielce.pl

PCC mortars are ready-made mortars (polymer cement concrete) manufactured at the factory, in which, apart from cement binder, aggregates and mineral additives or pigments, powdered polymers play an important role, playing the role of modifiers improving the adhesion of mortars to the substrate, bending and tensile strength, workability, tightness, chemical resistance [1].

The purpose of the performed tests and comparisons was to illustrate the results obtained in the pull-off tests carried out in accordance with the standards in question, and the results of tests that are often performed on construction sites under real conditions.

2. METHODOLOGY – PULL-OFF METHOD

When determining the strength of a concrete element, it is not always possible to rely on the test results of control elements, i.e. cubes and cylinders, due to the various conditions of their production and maturation, as well as the lack of appropriate control elements. Then, non-destructive methods of concrete strength testing are used, thanks to which additional information is obtained on the distribution of concrete strength in the analyzed element [2]. Non-destructive methods of concrete testing are very helpful in cases where taking samples for testing would damage the structure of the tested elements [3]. Because of non-destructive testing, it is possible to obtain information on the strength characteristics, homogeneity and moisture of the concrete built into the tested object, without disturbing its current structure and further usability. These tests are also widely used in quality control and detection of defects in concrete products during their production, as well as in experimental tests, such as the assessment of changes in concrete properties after a specific time or under the influence of specific external factors [4, 5].

As can be seen in the publications of other authors, the influence of tested variables is relatively large [6-8]. Based on the results of the pull-off test, the methods of repairing objects, the possibility of the repair itself or even the selection of appropriate repair materials are determined. However, in order for the test to obtain results appropriate for the analysis, particular attention should be paid to all factors related to it. This article only discusses two variables: different substructure (concrete and aerated concrete) and two ways of test preparation (notched and non-incised). Additional parameters that should also be taken into account when performing the pull-off test are, for example: the temperature of the substrate and measuring discs, their humidity, surface cleanliness, age, environmental conditions in which they work, etc. A large number of factors that directly or indirectly affect test result causes that the pull-off method – commonly recognized as relatively simple – gives appropriate results only for skilled engineers who are aware of the conditions that affect the obtained results [9, 10]. The authors are also aware of their importance, while the article focuses only on the two combinations presented.

The pull-off method is classified as semi-destructive. It consists in measuring the tensile strength, which is necessary to tear off the metal disc glued to the tested surface. The disc diameter should be 50 mm, minimum thickness 20 mm – for steel discs, or 30 mm – for aluminum ones. The test area is determined by the appropriate drilling of the surface [11-13]. The peel-off adhesion test allows the peel strength of coatings, plasters, floors, plasters, weldable roofing membranes etc. on concrete and steel to be assessed. Thanks to this method, it is easy to estimate whether a given surface requires repairs. It is also used immediately before laying all types of repair layers, in order to check the quality of concrete substrate preparation, as well as after the application of repair layers [12, 14].

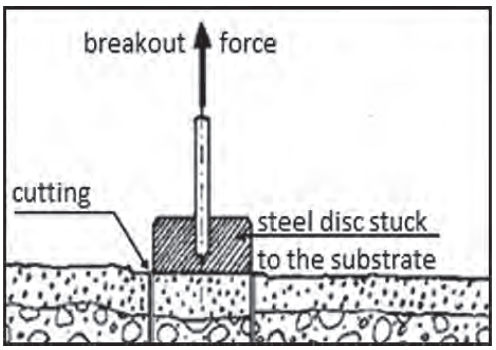


Fig. 1. Pull-off adhesion test – the essence of the measurement [14]

A detailed description of the course of the study is presented in the standard [15]. Before starting the test, the concrete sample should be cleaned of all kinds of dust, preferably with compressed air. According to the standard, the samples should have dimensions of 300 mm × 300 mm × 100 mm with the maximum grain size of the aggregate 8 mm or 10 mm. It is required to make five measurements of adhesion on at least one sample of a given product. The arrangement of the measuring discs is shown in Figure 2. A repair layer should be evenly applied to the concrete sample, prepared according to the manufacturer's

recommendations. After a three-day curing period, the sample should be additionally stored for a period of seven days under standard laboratory conditions. After this time, the specimen should be drilled with a diamond core bit at an angle (90 ±1)° to the surface. The borehole should be drilled to a depth of (15 ±5) mm into the concrete substrate. The next step is to glue the discs, which must be properly prepared by grinding and degreasing the surface that will be in contact with the adhesive. Then apply a thin layer of quick-drying two-component epoxy adhesive to the surface of the sample and place the disc so that its center is aligned with the center of the drilled cylinder. After the glue has hardened, you can start to tear off the discs. Various devices for pull-off testing are available on the market, devices with an automatic pump, such as DeFelsko PosiTest AT-A, Elcometer 510 or Proceq Dyna DY-2, are characterized by extremely high accuracy. The tear-off device should be used based on the manufacturer's recommendations. It is placed concentrically over the disk, perpendicular to the drilled surface. The disc should be torn off continuously and evenly, at a speed of (0.05 ±0.01) MPa/s, until failure occurs [15]. The result of the test measurement is the value expressed in MPa, determined from the strength at which the layer of the cut material is broken, to which the disc tearing off the sample fragment is glued, in relation to the surface of the cut layer. The test is reliable if the entire surface of the disc is covered with a stripped layer. The type of sample failure should be determined visually. If there are different types of damage on one sample, their percentage should be specified. Possible types of failure are presented below [15]:

- A: cohesive failure in concrete substrate,
- A/B: failure of the adhesive between the substrate and the first layer (e.g. primer or tie coat),
- B: cohesive failure in the first layer,
- B/C: adhesion failure between the first and second layer,
- C: cohesive failure in the second layer (etc. according to the type of product or system tested),
- – /Y: adhesive failure between the last layer and the adhesive layer (e.g. C/Y with a two-layer repair system),
- Y: cohesive failure in the adhesive layer,
- Y/Z: adhesive failure between the adhesive layer and the disc (marked as Z).

Of course, a completely unreliable result is the failure in the adhesive layer (Y) or between the adhesive and the disc (Y/Z). Obtaining such results proves only the incorrect preparation of the material for testing (bad mixing of the two-component adhesive, non-degreasing of the disc surface, ect). Destruction in the concrete layer (A) shows that the individual re-profiling or repair layers are sufficiently firmly bonded to the substrate. Damage between one of the layers requires additional analysis, e.g. the peel strength obtained in the measurements or even the test repeated.

The test result is influenced by: the type of tear-off device used; thickness, diameter and type of material from which the disc was made; well depth and angle; the method of attaching the holder to the disc; thickness of the substrate and top layer; sample moisture during measurement; the tearing speed [13].

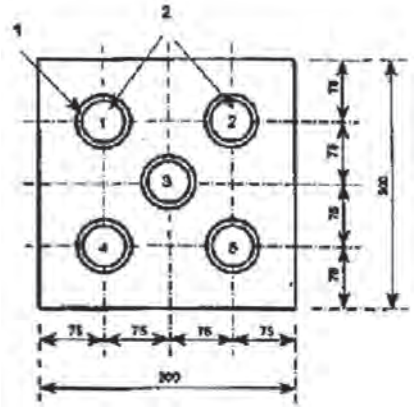


Fig. 2. View of the sample for testing with the arrangement of the discs, dimensions in millimeters; 1 – ring around the test site, formed during drilling, 2 – steel or aluminum discs with a diameter of 50 mm [15]

Fig. 3. Correctly performed adhesion measurement using the pull-off method [14]

3. MEASUREMENTS

The aim of the study was to compare the adhesion between concrete layer and re-profiling system on two variables: two types of substructure (strong, i.e.

concrete, and weak – aerated concrete), and two ways of test preparation (notched and non-incised). Adhesion tests are characterized by a large dispersion of results, therefore 20 tests were prepared and performed (the standard [15] indicates that a minimum of 5 tests should be performed) for each concrete.

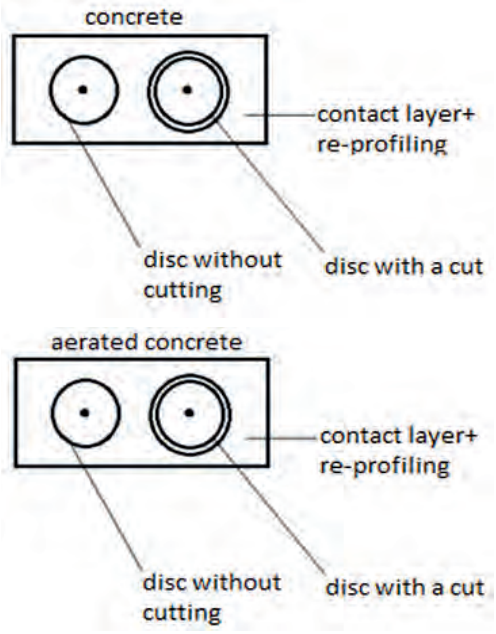


Fig. 4. Diagram showing the materials used and the method of performing the adhesion test (own elaboration)

Eight concrete slabs and eight aerated concrete slabs were used for the test. A mix was made, consisting of a ready-made dry mix of the contact layer of the PCC repair system. The mortar was evenly applied to the cleaned surface of the boards, then another layer of PCC re-profiling mortar was applied to it. The samples were left for 28 days. After this time, another stage of research took place – gluing metal discs. The specimens were trimmed according to the standard [16] with a distinction between non-notched and non-notched adhesion tests.

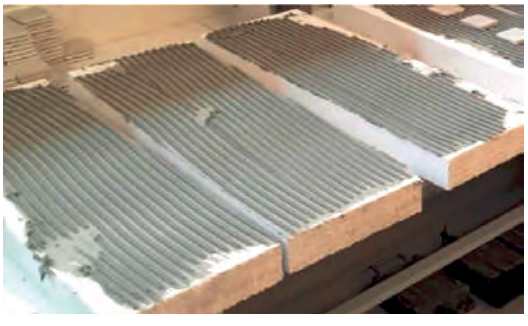


Fig. 5. Preparation of samples for adhesion tests – mortar application

The surface of the discs has been thoroughly polished and degreased. After applying the two-component epoxy glue, the discs were glued to the boards as shown in Figure 6. At this stage of the research, no drillings were made, and 4 concrete slabs and 4 aerated concrete slabs were used. The authors used the material without cutting in the research, because very often in real conditions on the construction site, during the pull-off tests, the substrate is not cut. This is due to various reasons, but often it is just ignorance.

The adhesion tests were performed with a Proceq dy-216 pull-off tester 72 hours after the metal discs had been glued.

Fig. 6. Metal discs torn off on the surface of the plates

The second stage of the research consisted in carrying out an adhesion test on the surface with making an incision. Before gluing the discs, 4 concrete slabs and 4 aerated concrete slabs were notched with a crown drill until the depth penetrated the concrete layer. On one of the aerated concrete samples, the structure of the material was damaged during cutting, which made it possible to stick only 3 discs. The further procedure is the same as for peeling discs without notches.

Fig. 7. Discs torn off from the aerated concrete surface with cuts

Fig. 8 Discs detached from the concrete surface with cuts

4. RESULTS

The Table 1 summarizes all the obtained results of PCC mortar adhesion tests to the surface of concrete samples and aerated concrete without incisions and with incisions.

Table 1. Results of adhesion tests

No.	Breakout strength in non-incised samples [MPa]		Breakout strength in not-ched samples [MPa]	
	concrete	aerated concrete	concrete	aerated concrete
1	2.04	1.47	1.54	
2	2.56	0.71	1.82	1.06
3	2.49	1.46	2.79	0.63
4	2.59	1.80	0.73	1.12
5	2.95	1.78	2.90	1.02
6	3.36	1.77	2.55	0.63
7	4.23	1.59	3.44	1.00
8	1.92	2.02	2.04	1.35
9	1.76	2.20	2.50	0.98
10	0.87	2.00	2.71	0.37
11	2.28	1.22	3.40	0.92
12	2.53	1.47	2.78	0.30
13	3.55	1.40	1.42	1.00
14	2.55	1.73	2.89	0.76
15	1.13	1.96	2.06	0.90
16	5.02	2.33	2.97	0.98
17	3.80	2.21	2.88	1.51
18	5.13	2.12	1.57	0.76
19	4.12	2.11	3.19	0.68
20	1.81	1.81	2.69	
avg.	2.83	2.44	1.76	0.89
standard deviation	1.1522	0.7065	0.3843	0.2951

For better understand the standard deviation, results are presented in Figure 9.

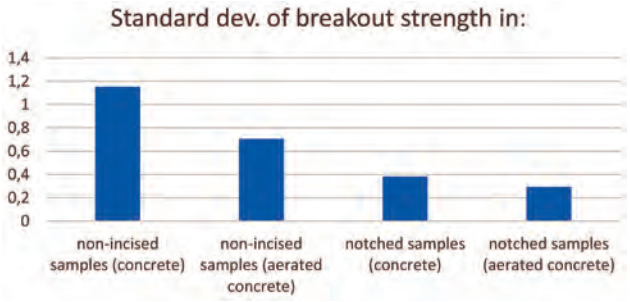


Fig. 9. Standard deviation of breakout strength in non-incised and notched samples

As can be seen in the diagram (Fig. 9), notching the coating before the measurement has a relatively large impact on the scatter of the obtained results.

Figures 10 and 11 presents a breakdown of the damage depending on the material and test method.

Fig. 10. Damage during adhesion tests on non-incised samples of concrete (left) and aerated concrete (right)

Fig. 11. Damage during adhesion tests on notched samples of concrete (left) and aerated concrete (right)

By analyzing the above photos, we can see differences in the way the material is detached. In the case of concrete, the damage occurs in the repair layers. In aerated concrete, which is a weak material, the measuring disc with repair layers also tears off a fragment of the substrate. In addition, during the

tests without cutting, the aerated concrete showed complete destruction of the material structure, as shown in the photo.

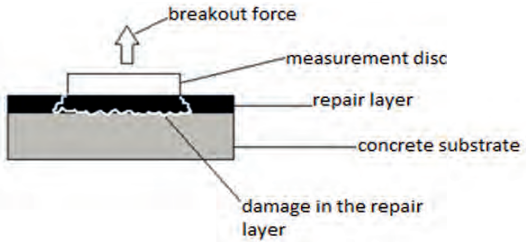


Fig. 12. Diagram showing the method of failure in a concrete sample without incising

The above figure shows the observed pattern of failure occurring in a concrete sample without an incision. The damage is visible in the repair layers, it extends slightly beyond the area where the measuring disc is attached and does not reach the concrete substrate, which is a strong material. The failure type that occurs is cohesiv e failure.

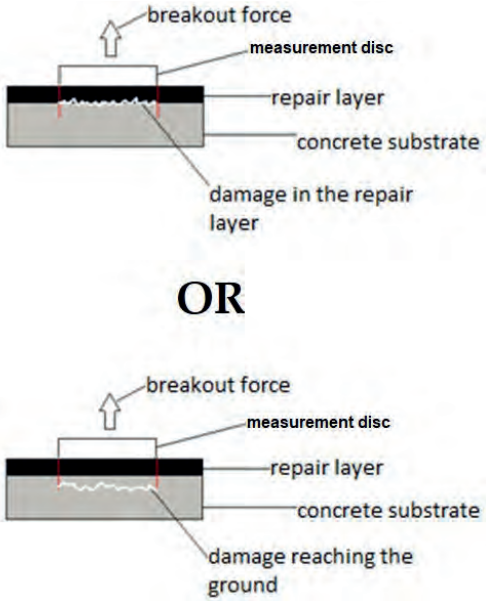


Fig. 13. Diagram showing the method of destruction in a concrete sample with an incision

Figure 13 shows the observed pattern of damage occurring in a concrete sample with cuts. Damage manifests itself in two ways. They can only occur in the repair layer as well as in the concrete layer at the depth of the cut. The types of failure are cohesive failure (first scheme) and adhesive failure (second scheme).

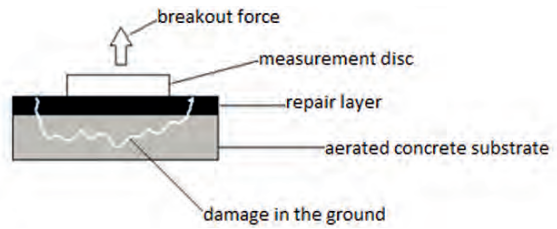


Fig. 14. Diagram showing the method of destruction in an aerated concrete sample without incision

Figure 14 shows the observed damage pattern in an aerated concrete sample without cuts. The damage goes deep into the layers of the material, damaging to a large extent the structure of the substrate and causing it to cracks all over the surface. The failure type that occurs is adhesive failure.

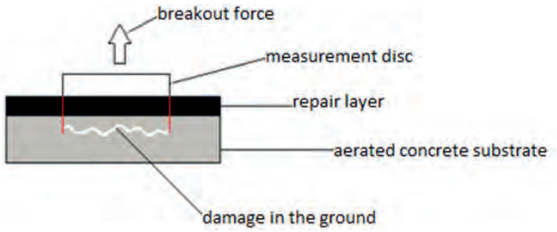


Fig. 15. Diagram showing the method of destruction in an aerated concrete sample with cuts

In Figure 15, the observed pattern of damage in an aerated concrete sample with notches is presented. The damages are visible in the substrate along the width of the previously made incision. The failure type that occurs is adhesive failure.

5. CONCLUSIONS

The test of adhesion without cutting gives results with a larger spread than in the case of notched materials.

By analyzing the results summarized in Table 1, it can be seen that the average adhesion on concrete samples is lower in the case of notched samples by 0.39 MPa (about 14%). The dispersion of the individual measurement results is significantly smaller in the case of notched concrete.

When analyzing the results summarized Table 1, it can be seen that the average adhesion on aerated concrete samples is much lower in the case of notched samples. The difference is 0.87 MPa (approximately 50%). The dispersion of the individual measurement results is slightly smaller in the case of incised aerated concrete.

The variety of results may indicate the heterogeneity of the substrate or the inaccuracy of the test itself due to the method of sample preparation or the uneven application of the detachable strength. It is more visible in the case of tests on concrete samples. The results contain information not only about adhesion to the substrate, but also about the cohesion, i.e. cohesion, of the repair material itself. The method of detaching the material from the tested samples shows a much greater cohesive effect in concrete particles compared to aerated concrete. The introduction of a cut with a diamond core drill simplifies the tested state of stress to uniaxial detachment, and the then observed nature of the damage allows to determine whether it was an adhesive or a cohesive failure.

From the point of view of ease of interpretation of the results, notching the substrate is desirable, however, testing without incision corresponds to the conditions in which the substrate and repair layers work. Because of that and in connection with the need for an appropriate interpretation of the results, in Authors opinion, it is recommended to incise the samples before pull-off testing.

REFERENCES

[1] Detailed technical specification for the execution and acceptance of construction works - Repair of concrete and reinforced concrete structures, type PCC I (surfaces on which traffic takes place, dynamically loaded) and type PCC II (surfaces on which there is no traffic, dynamically loaded), code: 4526330 Works in concrete repair – in Polish.
[2] http://home.agh.edu.pl/~dhajto/materialy/podst-4b.pdf (access on 09/12/2021).
[3] Dziewiecki A., *Technologies for testing concrete elements with particular emphasis on non-destructive methods of compressive strength estimation with the use of N-type Schmidt hammer*, Construction Survey Center, Warsaw, 2016 – in Polish.
[4] Śledziewski K., *Non-destructive testing of concrete strength in bridge structures – sclerometric method*, Lublin University of Technology, 2012 – in Polish.
[5] Brunarski L., Runkiewicz L., *Basics and examples of the use of non-destructive methods in the testing of concrete structures*, Scientific Work of the Building Research Institute, Series of monographs, Vol. 38, Warsaw 1983 – in Polish.
[6] Ramos N.M.M., Simoes M.L., Delgado J.M.P.Q., de Freitas V.P., *Reliability of the pull-off test for in-situ evaluation of adhesion strength*, Construction and Building Materials, 2012, Vol. 31, pp. 86-93.
[7] Sadowski Ł., *Non-destructive identification of pull-off adhesion between concreto layers*, Automation in Construction, 2015, Vol. 57, pp. 146-155.
[8] Cleland D.J., Long A.E., *The pull-off test for concreto patch repairs*, Structures and Buildings, 1997 Vol. 122, issue: 4, pp.: 451-460.
[9] Bungey J.H., Madandoust R., *Factors influencing pull-off tests on concrete*, Magazine of Concrete Research, 1992 Vol. 44, issue: 158, pp. 21-30.
[10] Bonaldo E., Barros J.A.O., Lourenco P.B., *Bond characterization between concreto substrate and repairing SFRC using pull-off testing*, International Journal of Adhesion and Adhesives, 2005 Vol. 25, issue: 6, pp. 463-474.
[11] Małolepszy J., *Concrete technology: test methods*, AGH University of Science and Technology Publications, Cracow 2000 – in Polish.
[12] Drobiec Ł., Jasiński R., Piekarczyk A., *Diagnostics of reinforced concrete structures, Methodology, field tests, laboratory tests of concrete and steel*, Scientific Publisher PWN, Vol. 1, Warsaw 2010 – in Polish.
[13] Chmielewska B., *Assessment of adhesion of repair materials to the base – laboratory and construction site methods*, Building Materials, Vol. 6, 2006 – in Polish.
[14] http://korbet.pl/ocena-jakosci-i-wytrzymalosci-betonu-w-konstrukcji/pull_off (access on 09/12/2021)
[15] PN-EN 1542:2000 Products and systems for the protection and repair of concrete structures. Test methods. Measurement of adhesion by tearing off – in Polish.
[16] PN-EN 1348:2008 Tile adhesives – Adhesion determination for cementitious adhesives – in Polish.


environment
environment

Robert Kowalik, Paulina Bąk-Patyna
Structure and Environment 2021, vol. 13, (3), pp. 90-95, Article number: el 010
https://doi.org/10.30540/sae-2021-010

Structure and Environment
ISSN 2081-1500
e-ISSN 2657-6902
https://content.sciendo.com/sae
https://sae.tu.kielce.pl

sciendo

Kielce University of Technology

DOI: 10.30540/sae-2021-010

ANALYSIS OF HEAT RECOVERY FROM WASTEWATER USING A HEAT PUMP ON THE EXAMPLE OF A WASTEWATER TREATMENT PLANT IN THE ŚWIĘTOKRZYSKIE VOIVODESHIP IN POLISH

ANALIZA ODZYSKU CIEPŁA ZE ŚCIEKÓW PRZY WYKORZYSTANIU POMPY CIEPŁA NA PRZYKŁADZIE OCZYSZCZALNI ŚCIEKÓW WOJEWÓDZTWA ŚWIĘTOKRZYSKIEGO

Robert Kowalik*, Paulina Bąk-Patyna
Kielce University of Technology, Poland

Abstract

Currently, sources from which renewable energy could be generated are being sought worldwide. One of these sources could be wastewater. This article shows how heat can be recovered from wastewater, using a small wastewater treatment plant in Świętokrzyskie voivodeship as an example. It analyses the temperature of wastewater in the reactor, in the sewage system and the ambient temperature for each month. The principle of heat pump operation was presented. Then, the amount of heat energy that can be recovered from wastewater was calculated for each month.

Keywords: heat pumps, heat recovery, waste water as a source of heat pump supply

Streszczenie

Obecnie na całym świecie poszukuje się źródeł, z których można by wytworzyć energię odnawialną. Jednym z takich czynników mogą być ścieki. W niniejszym artykule przedstawiono, jak można odzyskać ciepło ze ścieków na przykładzie niewielkiej oczyszczalni pracującej na terenie województwa świętokrzyskiego. Dokonano analizy temperatury ścieków znajdujących się w reaktorze, w kanalizacji oraz temperatury otoczenia dla każdego miesiąca. Przedstawiono zasadę działania pomp ciepła. Następnie policzono ilość energii cieplnej, jaka może być odzyskana ze ścieków dla każdego miesiąca.

Słowa kluczowe: pompy ciepła, odzysk ciepła, ścieki jako źródło zasilania pomp ciepła

1. INTRODUCTION

Energy is becoming more expansive and the burning of fossil fuels is accelerating global warming. Increased use of renewable energy is the best solution to conserve fossil energy sources, reduce or avoid carbon emissions and slow climate change. Recovering heat from wastewater for heating buildings is possible and has become cost-effective. Wastewater has significant heat energy potential. The temperature of wastewater varies between 7°C and 28°C throughout the year [1]. Even in winter, its temperature does not fall, or at most for a few days, below 7°C. For this reason, wastewater is an excellent heat source for the efficient and economical operation of heat pumps. The recovery and use of this heat is cost-effective for heating large buildings and

*Kielce University of Technology, Poland, e-mail: rkowalik@tu.kielce.pl

complexes. The recovered heat can also be fed into existing or planned district heating networks [2].

Heat can be recovered in sewage treatment plants. This is technically relatively simple, but wastewater treatment plants are often located far from buildings that could be heated with the recovered heat. Heat recovery from treated wastewater is the best solution where the treatment plant itself needs a lot of heat, e.g. for sludge drying. Recovered heat can also be supplied from the wastewater treatment plant to large nearby heat consumers such as construction sites, business parks or factories [2].

Alternatively, heat can be recovered from sewers and used to heat buildings in their vicinity. In this case, it is important to investigate the impact that wastewater cooling can have on the operation of wastewater treatment plants. Since the technological efficiency of heat pumps depends on the temperature of the heat source, wastewater is one of the most ideal heat sources to power heat pumps [2]. The use of wastewater as an energy source is not a completely new idea, and it is also very environmentally friendly and economical [3].

2. WORKING PRINCIPLE OF HEAT PUMPS

A heat pump is an appliance which extracts heat from the ground, air, water or another heat source with the aid of a small amount of electrical energy and transfers it to heat exchangers [4]. The transport of heat energy takes place in an evaporator and a condenser. The whole process of energy transfer is made possible by thermodynamic transformations (Linde cycle) occurring in a closed circuit [5].

Traditional heat sources such as gas, oil or solid fuel boilers generate heat by burning fuel. The efficiency of such an installation is mainly affected by the calorific value of the fuel used. The efficiency of such boilers varies between 70-110% [5]. Heat pumps are devices that transfer energy from one source to another instead of producing it, thanks to which their efficiency can be as high as 500% [5].

Heat pump components:

- compressor – is used to compress the working medium circulating in the pump circuit. The compression of the vapour causes an increase in pressure and temperature. The compressor is the most energy-intensive component in the system;
- evaporator – is a heat exchanger in which the process of absorbing heat from the environment takes place;
- condenser – is a heat exchanger in which the process of condensation of the working fluid takes place. The change of state of aggregation from vapour to liquid results in an increase in volume, which simultaneously increases the temperature. Thanks to this process in the condenser we obtain high temperature, which can be further transferred to the installation.

Expansion valve – serves to expand the working medium in the heat pump circuit from liquid to steam. Its two most essential functions are throttling of the working medium so that the compressor can reach the required working pressure in the condenser, and expansion when the thermodynamic cycle is required to be repeated [5].

Figure 1 shows a simplified schematic of an effluent heat pump installation.

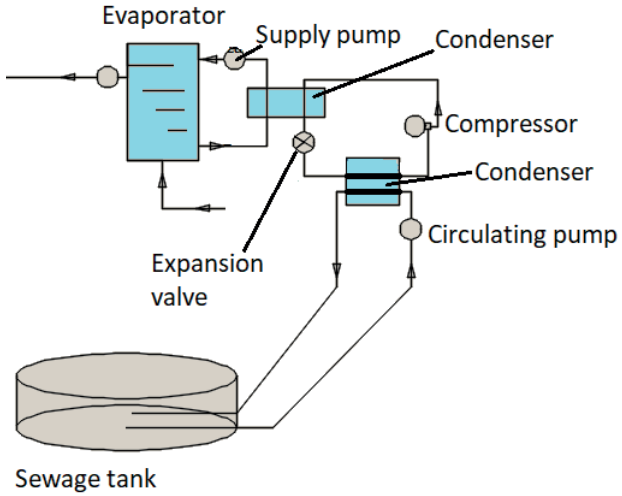


Fig. 1. Schematic of the operation of a heat pump fed with wastewater (own study)

The COP (coefficient of performance) is the basic performance parameter of a heat pump. It defines the ratio of the amount of heat delivered to the amount of energy (usually electrical) consumed during a given operating point. The higher the coefficient, the cheaper the pump is to operate as it uses less energy to produce the same amount of heat. The COP is calculated based on the EN 255-3 standard. The higher the COP value, the higher the heat pump efficiency [5, 6].

3. CASE STUDY

Typically, modelling heat recovery from wastewater presents several difficulties. Firstly, appropriate input data has to be generated or obtained based on the highly variable wastewater temperature statistics [7]. Since wastewater heat is

Table 1. External temperature values for location of wastewater treatment plant X [°C] [8]

	January	Fabruary	March	April	May	June	July	August	September	October	November	December
Avarge Temperature (°C)	– 5.8	– 4.3	1.8	8	12.5	15.5	17.3	16.7	13.1	8.8	2.8	– 2.5
Min. Temperature (°C)	– 8.8	– 7.5	– 2	3.1	7.2	10.3	12.1	11.5	8.3	4.5	0	– 5
Max. Temperature (°C)	– 2.8	– 1.1	5.7	13	17.8	20.7	22.5	21.9	18	13.1	5.7	0.1

almost never taken into account, there are very few statistics available for wastewater temperature data. In order to implement wastewater temperature data, the sewage system at wastewater treatment plant X operating in the Świętokrzyskie Province was analysed and monitored.

At the site of the analysed facility in 2020, the average annual ambient air temperature was 7°C. Temperature values for the location are presented in Table 1.

As an example, wastewater treatment plant X operating in a mechanical-biological system, located in the Świętokrzyskie voivodeship, was taken for calculation. The plant operates with a sequencing batch reactor (SBR) system. The facility serves 890 inhabitants. Wastewater temperature was measured in the sewerage system supplying wastewater to the plant, and inside the SBR reactor, in which wastewater was subjected to biological treatment processes using the activated sludge method. Measurements were taken periodically at the beginning of each month of 2020. The result sarepre sented in Figure 2.

As can be seen, the effluent temperature correlates strongly with the outdoor temperature, but is significantly higher for the coldest months. It ranges from 7.5°C to 18.4°C for the temperature in the reactor. It can therefore be seen that when the outside temperature is high, the effluent maintains a similar value, while at minus temperatures the effluent remains positive and oscillates between 7°C and 8°C.

Figure 2 shows a graphical plot of wastewater temperatures in the sewer and in the reactor during the different periods of the study.

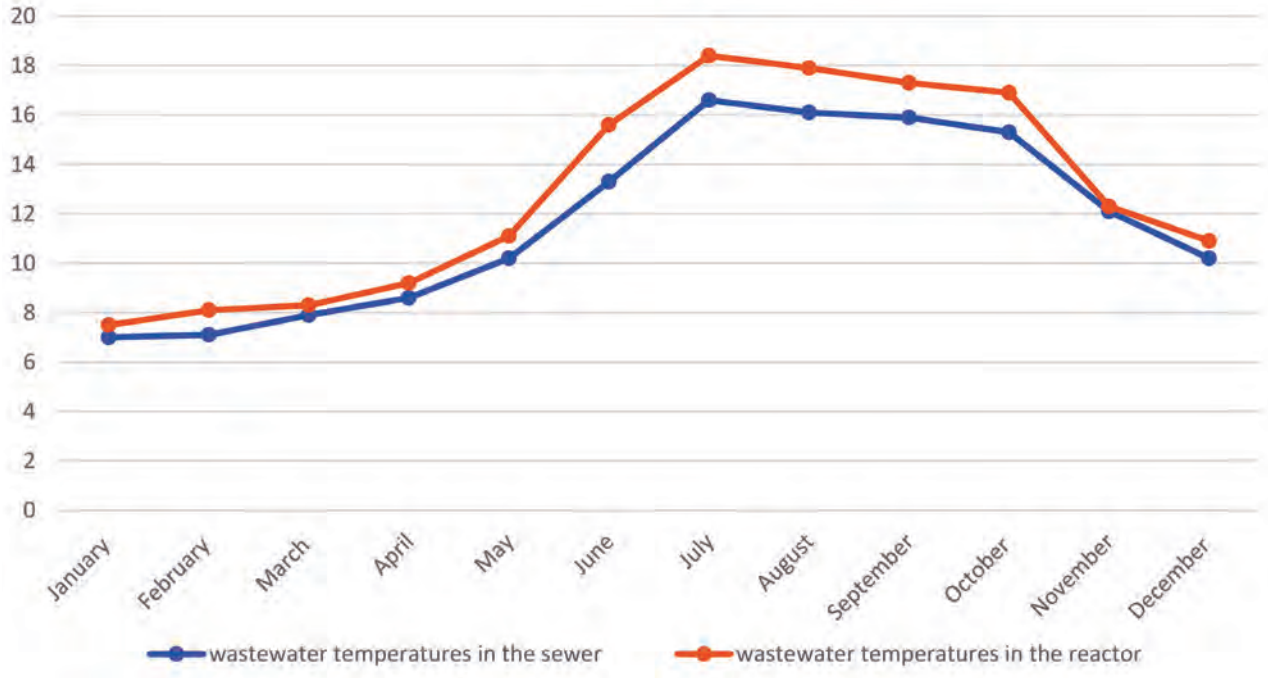


Fig. 2. Graph of wastewater temperature values at treatment plant X

4. CALCULATION OF HEAT OUTPUT FROM WASTE WATER

This paragraph presents an example of the calculation of the extracted heat power from wastewater for the temperature data analysed. The input data come from a statistical analysis carried out for wastewater treatment plant X in the Świętokrzyskie region. The principle of operation is as follows: a waste water heat exchanger extracts heat from municipal waste water filtered through a block filtration unit (to reduce corrosion and extend the life of the waste water heat exchanger) and sends it to the evaporator side of a heat pump as a low grade heat source. The compressor side of the heat pump system extracts heat from the condenser side and sends it to the heat supply system [9]. The design of the system starts with setting the inlet (*Tc*) and outlet (*Tz*) temperatures and the effluent flow rate [6].

The determination of the heat output extracted from the grey sewage flow rate, can be determined by the following formula [6]:

$$Q_F = q_{hśr} \cdot c_{ść} \cdot \rho_{ść} \cdot (Tc - Tz) \quad (1)$$

where:

$q_{hśr}$ – average flow of grey sewage assumed 8000 dm^3/h,
$c_{ść}$ – specific heat of grey sewage: assumed 4.186 kJ/(kg·K);
$\rho_{ść}$ – density of grey sewage, assumed 1.15 kg/dm^3;
Tc – temperature at inlet, °C;
Tz – outlet temperature, °C.

Table 2. Obtained thermal power from wastewater for individual months

Month	T [°C]	T [K]	ΔT [K]	Q_F [KW]
January	7.5	280.5	1.5	16.05
Fabruary	8.1	281.1	2.1	22.47
March	8.3	281.3	2.3	24.61
April	9.2	282.2	3.2	34.23
May	11.1	284.1	5.1	54.56
June	15.6	288.6	9.6	102.70
July	18.4	291.4	12.4	132.66
August	17.9	290.9	11.9	127.31
September	17.3	290.3	11.3	120.89
October	16.9	289.9	10.9	116.61
November	12.3	285.3	6.3	67.40
December	10.9	283.9	4.9	52.42

The above formula shows that to increase the available power, the flow rate or the temperature difference must be increased. In this example, the available wastewater flow rate was assumed to be about 8000 dm^3/h, (average flow rate generated by about 1000 inhabitants) [10]. It was also assumed that the wastewater will cool to a temperature of 6°C. It is therefore possible to recalculate the heat output for different variants of effluent temperature depending on the season, as shown in Table 2.

The wastewater heat output ranged from 16.05 kW for January to 132.66 kW for July. Retrofitting the wastewater treatment plant with a heat pump reduces maintenance and operating costs, with the least possible impact on the environment.

5. HEAT PUMP EFFICIENCY

To evaluate the performance of a heat pump, the *COP* (coefficient of performance) was introduced. It describes the ratio of the heating power to the electrical power input required for the pump operation and is expressed by the formula [11];

$$COP = \frac{Q_F}{Q_E}[-] \quad (2)$$

where:

Q_F – heating capacity of the heat pump, kW;
Q_E – electrical power needed to drive the compressor, kW.

The efficiency coefficient of a heat pump can also be calculated using the reverse Carnot cycle [11]:

$$COP = \frac{Tg}{Tg - Td} = \frac{Tg}{\Delta T} \quad (3)$$

where:

Td – temperature of the lower heat source, K;
Tg – temperature of the upper source (heating system) K;
ΔT – temperature difference between the upper source temperature and the lower source temperature, K.

A COP = 5 therefore means that the pump gives back as heat five times the electrical energy that was supplied to the pump. The lower the temperature difference between the heating water and the lower heat source, the higher the COP and the efficiency of the heat pump [4]. Depending on the heat source, modern heat pumps achieve an efficiency ratio of between 3.5 and 5.5 [3]. This means that for every kilowatt hour of electricity consumed, 3.5 to 5.5 kWh of heating heat will be generated.

So a heat pump using 1000 watts of electrical power to absorb 4000 watts of heat from the external environment, and then adding 1000 watts of heat to that total, for a total of 5000 watts of heat transferred to the building, with only 1000 watts of electrical power actually being used by the heat pump to facilitate this transfer. The *COP* in this example will be 5:1, or 5, meaning, for every 1000 watts of electrical input power supplied to the heat pump, the heat pump transfers 5000 watts of heat output power to the house, or 5:1 – output power divided by input power. This is the ideal *COP* value that can be obtained using heat pumps calculated from the $Tg/(Tg - Td)$ equation.

6. OTHER METHODS BASED ON MEASUREMENT

The measurement-based approach relies on measurements and mathematical models to capture the relationship between the relevant input and output parameters. Various measurements, such as waste water temperature, ambient temperature, waste water discharge, etc., were made over a period of time and the relationships between these variables were established using mathematical tools. Between these variables using mathematical tools such as correlation analysis. An example of such an approach can be found in the work of Escalas-Cañellas et al. [12]. The authors used the method of time series modeling in which the future temperature of the wastewater is predicted on the basis of historical temperature, average daily ambient temperature and rainfall. Modeling error A modeling error of 0.5°C (RMSE) was found between the predicted and measured temperature. Abdel Aal et al. [13] used a different approach in which the wastewater temperature was modeled using the inductive abduction mechanism (AIM), a supervised learning technique. Two parameters were used as input, the sewage temperature at the top and the air temperature at the bottom of the channel. The study compares it with the model developed by Abdel et al. [14] and it has been shown that the proposed AIM estimates the temperature of waste water with greater accuracy. In a recent study by Golzar et al. [15] used an artificial neural network to predict the temperature of the wastewater flowing into the treatment plant. The model included as input parameters the ambient temperature, temperature and flow rate of waste water from the building, storm water flow rate, infiltration water flow rate, hour of day and day of the year [12, 15].

7. CONCLUSIONS

The paper analysed the seasonal variation of wastewater temperature in the sewage system of wastewater treatment plant X in the Świętokrzyskie Province, and analysed the amount of power extracted using a heat pump. Studies of this type can be useful in designing heat recovery systems, which require the knowledge of temperature trends. Special attention was paid to the seasonal value of waste water temperature and outdoor temperature. During the coldest period, the heat pump was able to generate 16.05 kW of power to heat the building. In contrast, during the summer periods, the power was as high as 132.66 kW, where this power could be used for drying the sludge.

REFERENCES

[1] Elmitwalli T.A., Zandvoort M., Zeeman G., Bruning H., Lettinga G., *Low temperature treatment of domestic sewage in upflow anaerobic sludge blanket and anaerobic hybrid reactors*, Water Sci. Technol, 1990.
[2] Brodowicz K., Dyakowski T., *Pompy ciepła*, PWN Edition, Warsaw 1990.
[3] Górski J., Matuszewska D., *Possibility of obtaining precipitation heat from wastewater and sewage systems*, Industrial Furnaces & Boilers, VII-VIII, 2013, pp. 21-28.
[4] Rubik M., *Heat pumps. Guidebook. Ośrodek Informacji „Technika instalacyjna w budownictwie"*, Warszawa 1990.
[5] Viessemann, *Wytyczne projektowe, Systemy pomp ciepła, Project guidelines, heat pump systems*. 2008. available online: http://www.viessmann.com/http-svc/web/poland/PDF-90.nsf/908EEE0A83B2E007C1257B490010C7ED/$FILE/WP%20Vitocal%20300-G%20(04,2008).pdf?OpenElement
[6] Cipolla S., Maglionico M., *Heat recovery from urban wastewater: analysis of the variability of flow rate and temperature in sewer of Bologna, Italy*, Energy Procedia 45, 2014, pp. 288-297.
[7] Czarniecki D., Pisarev V., Dziopak J., Słyś D. 2014. *Technical and financial analysis of installation for heat recovery from wastewater in multi-family buildings*. [w:] Traczewska T., Kaźmierczak B. (red.) *Interdisciplinary Issues in Environmental Protection Engineering* 4, Publishing Office of Wrocław University of Technology, Wrocław. 2014.
[8] https://pl.climate-data.org/europa/polska/swietokrzyskie-voivodeship/kielce-764743/.
[9] Gu Y., Deng H., Zhuang Z., Weng W., *The potential of urban wastewater heat: the feasibility analysis of using wastewater source heat pump*, International Symposium on Water Resource and Environmental Protection (ISWREP), Vol. 2, 2011. pp. 1481, 1484.

[10] Qian J., *Heating performance analysis of the direct sewage source heat pump heating system*, International Conference on Mechanic Automation and Control Engineering, 2010.
[11] Rubik M., *Heat pumps. Guidebook, Information Centre: "Installation Technology in Construction"*, 2000.
[12] Escalas-Cañellas A., Ábrego-Góngora C.J., Barajas-López M.G., Houweling D., Comeau Y., *A time series model for influent temperature estimation: Application to dynamic temperature modelling of an aerated lagoon*, Water Res. 2008, 42, pp. 2551-2562.
[13] Abdel-Aal M., Mohamed M., Smits R., Abdel-Aal R., De Gussem K., Schellart A., Tait S., *Predicting wastewater temperatures in sewer pipes using abductive network models*, Water Sci, Technol, 2015, 71, pp. 89-96.
[14] Abdel-Aal M., Smits R., Mohamed M., De Gussem K., Schellart A., Tait S., *Modelling the viability of heat recovery from combined sewers*, Water Sci, Technol, 2014, 70, pp. 297-306.
[15] Nagpal H., Spriet J., Murali M., McNabola A., *Heat Recovery from Wastewater – A Review of Available Resource*, Water, 13, (9), 2021.

DETERMINANTS OF THE LOCATION AND ARCHITECTURE OF THE PROVINCIAL OFFICE IN KIELCE

UWARUNKOWANIA LOKALIZACJI I ARCHITEKTURY URZĘDU WOJEWÓDZKIEGO W KIELCACH

Dariusz Piotrowicz*
Kielce University of Technology, Poland

Structure and Environment vol. 13, No. 3/2021, p. 71 DOI: 10.30540/sae-2021-008

Abstract

The article presents a very modest state of research on the, architecture of the then Presidium of the Provincial National Council in Kielce – currently the provincial and marshal's office. The research methodology was adopted to find new facts influencing the choice of place and the architectural form of the office. The study covered the period from the beginning of the 1950s to the end of the 1970s. An episode of socialist realism was shown, influencing its functionally and spatially planned location and the direction of modernism in architecture. Its similarity with the works of Le Corbusier was pointed out as a probable inspiration. As a result, a building was constructed that positively entered the postwar urban planning of the city. On the other hand, as an element of an unrealized modernist urban vision, it is a warning against the desire to irreversibly destroy the historic space of downtown Kielce.

Streszczenie

W artykule przedstawiono bardzo skromny stan badań architektury ówczesnego budynku Prezydium Wojewódzkiej Rady Narodowej w Kielcach – obecnie Urzędu Wojewódzkiego i Marszałkowskiego. Przyjęto metodykę badań w celu poszukiwań nowych faktów, mających wpływ na wybór miejsca i formę architektoniczną budynku. Badaniem objęto okres od początku lat pięćdziesiątych do końca siedemdziesiątych XX wieku. Ukazano wpływ socrealizmu na jego zaplanowaną funkcjonalnie i przestrzennie lokalizację oraz kierunku modernizmu na architekturę. Wskazano na dzieła Le Corbusiera jako prawdopodobną inspirację. W ich efekcie zrealizowano budynek, który pozytywnie wpisał się na karty powojennej urbanistyki miasta. Z drugiej strony, jako element niezrealizowanej modernistycznej wizji urbanistycznej, jest przestrogą przed chęcią nieodwracalnego zniszczenia historycznej przestrzeni śródmieścia Kielc.

TECHNICAL ASPECTS OF MEASUREMENTS USING THE PULL-OFF METHOD

TECHNICZNE ASPEKTY POMIARÓW METODĄ PULL-OFF

Karol Skowera, Anna Foksa
Kielce University of Technology, Poland

Structure and Environment vol. 13, No. 3/2021, p. 83 DOI: 10.30540/sae-2021-009

Abstract

The article presents an analysis of the technical use aspects of the pull-off method for testing the repair layers applied to concrete elements, based on the standards requirements. The use of non-destructive testing methods is the only option in some cases. However, it is very important to pay attention to their proper use or even preparation for research. The pull-off method requires just such diligence to be able to properly interpret the obtained results. The article compares the results of the research in which the pull-off method was used in various configurations. The obtained measurement results were compared with each other and analyzed in terms of their usefulness.

Streszczenie

W artykule przedstawiono analizę technicznych aspektów użytkowania metody pull-off do badania warstw naprawczych nakładanych na elementy betonowe w oparciu o wymagania norm. W niektórych przypadkach jedyną opcją jest zastosowanie nieniszczących metod badawczych. Bardzo ważne jest jednak, aby zwracać uwagę na ich właściwe stosowanie, a nawet samo przygotowanie do badań. Metoda pull-off wymaga właśnie takiej staranności, aby móc właściwie zinterpretować uzyskane wyniki. W artykule porównano wyniki badań, w których zastosowano metodę pull-off w różnych konfiguracjach. Otrzymane wyniki pomiarów porównano ze sobą i przeanalizowano pod kątem ich przydatności.

ANALYSIS OF HEAT RECOVERY FROM WASTEWATER USING A HEAT PUMP ON THE EXAMPLE OF A WASTEWATER TREATMENT PLANT IN THE ŚWIĘTOKRZYSKIE VOIVODESHIP IN POLISH

ANALIZA ODZYSKU CIEPŁA ZE ŚCIEKÓW PRZY WYKORZYSTANIU POMPY CIEPŁA NA PRZYKŁADZIE OCZYSZCZALNI ŚCIEKÓW WOJEWÓDZTWA ŚWIĘTOKRZYSKIEGO

Robert Kowalik, Paulina Bąk-Patyna
Kielce University of Technology, Poland

Structure and Environment vol. 13, No. 3/2021, p. 90 DOI: 10.30540/sae-2021-010

Abstract

Currently, sources from which renewable energy could be generated are being sought worldwide. One of these sources could be wastewater. This article shows how heat can be recovered from wastewater, using a small wastewater treatment plant in Świętokrzyskie voivodeship as an example. It analyses the temperature of wastewater in the reactor, in the sewage system and the ambient temperature for each month. The principle of heat pump operation was presented. Then, the amount of heat energy that can be recovered from wastewater was calculated for each month.

Streszczenie

Obecnie na całym świecie poszukuje się źródeł, z których można by wytworzyć energię odnawialną. Jednym z takich czynników mogą być ścieki. W niniejszym artykule przedstawiono, jak można odzyskać ciepło ze ścieków na przykładzie niewielkiej oczyszczalni pracującej na terenie województwa świętokrzyskiego. Dokonano analizy temperatury ścieków znajdujących się w reaktorze, w kanalizacji oraz temperatury otoczenia dla każdego miesiąca. Przedstawiono zasadę działania pomp ciepła. Następnie policzono ilość energii cieplnej, jaka może być odzyskana ze ścieków dla każdego miesiąca.

Uniform requirements for manuscripts submitted to "Structure and Environment"

All manuscripts should be submitted in English.

Given name(s) and surname(s) of each author
Institutional affiliation(s)
Author's e-mail

Title

Format for the paper:

- Abstract
- Keywords
- Introduction
- Subsequent headings
- Summary
- References

The text should be single-spaced throughout. The font should be 11 pt Times New Roman. All paragraphs should be indented 0.5 cm.

Formulas, tables, figures and photographs should be numbered consecutively

Figures and photographs with a resolution of 300 dpi or higher must be submitted in *.TIFF, *.EPS, *.JPG, *.WMF format.

Figures, photographs and tables should be in English, but their captions should be given in English and Polish.

References: The paper submitted for publication must comply with copyright law provisions. Authors have to document sources of the photographs, figures, quotes and borrowings used in the article. References should be cited in square brackets through the text. The full list of references arranged in the citing order as they appear in the text should be placed at the end of the paper (with one language version only). The reference style is defined by the standard PN-ISO 690:2012 Information and documentation. Guidelines for bibliographic references and citations to information resources.

Examples

Whole books

[1] Author's surname followed by the initials: Title of the book. Place of publication: Publisher, Year of publication, ISBN number.

Edited books

[2] Surname and initials of the editor (Ed.): Title of the book. Place of publication: Publisher, Year of publication, ISBN number.

Chapters in edited books

[3] Author's surname followed by the initials: Title of the charter. (in): Title of the book. Place of publication: Publisher, Year of publication, page numbers (for example: pp. 10-20), ISBN number.

Journal articles

[4] Author's surname followed by the initials: Title of the article. "journal title" Year, Number, page numbers (for example: pp. 10-20), ISSN number

Web references

[5] Author's surname followed by the initials: Title of the work. [type of the source, for example: online]. [date when the reference was last Accessed: …]. Available online: web page

Podstawowe wymagania edytorskie dotyczące pisania artykułów do czasopisma „Structure and Environment”

Artykuł powinien być napisany w dwóch wersjach językowych: angielskiej oraz polskiej.

Imię i nazwisko autora
Nazwa uczelni
e-mail autora

Tytuł artykułu

Struktura artykułu:
- Streszczenie
- Słowa kluczowe
- Wprowadzenie
- Kolejne podtytuły
- Podsumowanie
- Bibliografia

Tekst artykułu powinien być napisany czcionką Times New Roman 11, interlinia pojedyncza, wcięcie akapitowe 0,5 cm.

Wzory, tabele, rysunki oraz zdjęcia powinny być ponumerowane zgodnie z kolejnością ich występowania w tekście.

Rysunki oraz zdjęcia o rozdzielczości 300 dpi lub wyższej, format *.TIFF, *.EPS, *.JPG, *.WMF.

Rysunki, zdjęcia oraz tabele zamieszczamy w wersji angielskiej, a ich tytuły podajemy zarówno w języku angielskim, jak i języku polskim.

Bibliografia: Artykuł przeznaczony do publikacji musi być przygotowany zgodnie z postanowieniami ustawy „Prawo autorskie”, które nakłada na autora obowiązek wykazania źródeł wykorzystanych zdjęć, rysunków cytowań, zapożyczeń. Źródła takie należy umieszczać w tekście w nawiasach kwadratowych. Zbiorcze zestawienie bibliografii umieszczamy na końcu artykułu w kolejności cytowania (tylko przy jednej wersji językowej).

Styl bibliograficzny definiuje norma: **PN-ISO 690:2012** *Informacja i dokumentacja. Wytyczne opracowania przypisów bibliograficznych i powołań na zasoby informacji*.

Przykłady

Pozycje książkowe

[1] Nazwisko i inicjały imion autora: *Tytuł: podtytuł*. Miejsce wydania: Wydawca, Rok, Numer ISBN.

Praca zbiorowa

[2] Nazwisko i inicjały imion redaktora (red): *Tytuł: podtytuł*. Miejsce wydania: Wydawca, Rok, Numer ISBN.

Rozdziały książek

[3] Nazwisko i inicjały imion autora: *Tytuł: podtytuł rozdziału*. [w]: *Tytuł publikacji*. Miejsce wydania: Wydawca, Rok, Strony (np. s. 10-20), Numer ISBN.

Artykuły w czasopismach

[4] Nazwisko i inicjały imion autora: *Tytuł artykułu.* „Tytuł czasopisma” Rok, Numer, Strony (np. s. 8-27), Numer ISSN.

Strony internetowe

[5] Nazwisko i inicjały imion autora: *Tytuł.* [typ nośnika (np. online)]. [data dostępu: ...]. Dostępny w internecie: Adres strony internetowej

THE REVIEW PROCESS

The following requirements need to be met by the paper:
- the title should reflect the content of the paper
- the content should be within the thematic scope of the journal
- the paper should be properly and clearly divided into paragraphs
- original elements need to be part of the paper
- the research method should be properly selected
- adequate references need to be cited
- interpretation and conclusions should match the presented test results
- the paper should not contain parts indicating commercial use