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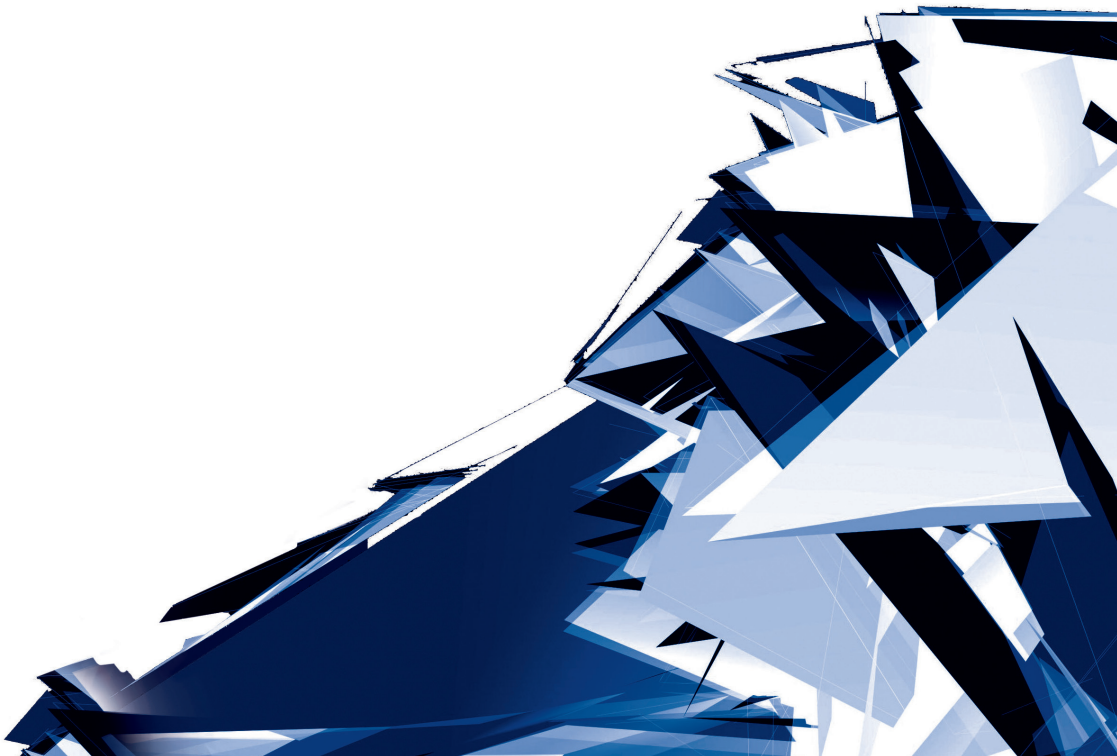

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"As masterly as very few others are …" – the Polish gardens of Peter Joseph Lenné. An example of Polish-German study into the history and maintenance of historical garden

„Mistrzowskie jak rzadko które …" – ogrody Petera Josepha Lenné w Polsce. Przykład polsko-niemieckich badań w zakresie historii i konserwacji zabytkowych ogrodów

Abstract

In 2016, on the sesquicentennial anniversary of the death of Peter Joseph Lenné, an exhibition, entitled *"Mistrzowskie jak rzadko które…". Ogrody Petera Josepha Lenné w Polsce*, was presented. It constituted the conclusion of a joint Polish and German academic project. As a part of the research project, a comprehensive review of garden and park layouts was performed and the degree to which Lenné himself and his associates had been involved in the design of the gardens was verified. It was also determined whether the projects had been carried out in accordance with the original assumptions of their authors. The projects were assessed on the basis of surviving garden plans and drawings from the collection of the Stiftung Preußische Schlösser und Gärten (SPSG), as well as data obtained during a query of archival materials and field studies carried out in the years 2014–2015.

Keywords: Peter Joseph Lenné, historical gardens, research in Poland

Streszczenie

W 2016 roku z okazji 150-lecia śmierci Petera Josepha Lenné odbyła się wystawa *„Mistrzowskie jak rzadko które …". Ogrody Petera Josepha Lenné w Polsce,* stanowiącą podsumowanie polsko-niemieckiego projektu naukowego. W ramach badań opracowano kompleksowy przegląd założeń ogrodowych i parkowych, zweryfikowano, w jakim stopniu Lenné i jego współpracownicy byli zaangażowani w tworzenie ogrodów, a także ustalono, czy projekty zrealizowano zgodnie z pierwotnymi założeniami autorów. Do oceny projektów posłużyły zachowane plany i rysunki ogrodów ze zbiorów Stiftung Preußische Schlösser und Gärten (SPSG), a także dane uzyskane podczas kwerendy archiwalnej oraz badań terenowych wykonanych w latach 2014–2015.

Słowa kluczowe: Peter Joseph Lenné, zabytkowe ogrody, badania w Polsce

1. Introduction

Peter Joseph Lenné (1789–1866), as a garden designer, town planner, pomologist, teacher and long-term royal gardens director, significantly affected the field of garden design in the nineteenth century. He treated design as a type of mission from the very start, and his life's motto was "however, the most important matter that we rely on is influence and the power of example" [22, p. 11]. He was convinced that we could make the world better and establish positive models by creating beautiful surroundings. His name has also been associated with an artistic revolution – he supported the development of garden design as an artistic and academic discipline[1]. The *Association for the Development of Horticulture in the Prussian States* that he had helped to establish, and later the *Potsdam Horticultural Academy*, contributed to the reform of the previous system of educating horticulturalists and created the foundations of the development of garden design as an independent and interdisciplinary profession [3, p. 1].

The works of Lenné were broadly discussed in monographs by Gerhard Hinz [23, 24], as well as in the publication by Harri Günther and Sybille Harksen [18]. The German authors discussed projects that were completed across an area that is currently located within Poland's borders, however, their knowledge was based solely on historical materials, without a familiarity with the area itself, and ignored archival materials stored in Poland. The first comprehensive work discussing Lenné's design activity in Poland was written by Bożena Łukasik [34]. She expanded the German studies, preparing a report describing the state of preservation of each garden layout ascribed to Lenné and listed by Hinz [23, 24]. However, it should be noted that studies carried out at the local level [2–4, 29–31] have shown, that the number of projects ascribed to the Potsdam-based designer demands further verification.

2014 saw the initiation of joint Polish and German research that was meant to systematise and expand the previous state of knowledge concerning Lenné's works in Poland. The joint project was started on the initiative of the Technical University of Dresden and the Neubrandenburg University of Applied Sciences, in cooperation with the Wrocław University of Environmental and Life Sciences (2014–2015)[2]. The primary objective of the project was to perform a comprehensive review of Lenné's works in Poland. In addition, the degree to which Lenné and his associates had been involved in the creation of each garden layout was assessed, as well as whether the projects had been carried out in accordance with their authors' initial assumptions. Situational plans, sketches and drawings from the collection of the Stiftung Preußische Schlösser und Gärten (SPSG), as well as Polish archives, libraries and museums, in addition to data collected during site surveys performed in the years 2014–2015, were used as the basis for the study. The project's results were used to prepare a bi-lingual exhibition,

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[1] Since the beginning of the nineteenth century a discussion was taking place in Germany on a new organisation of the arts, as a part of which garden design was to become a separate artistic and academic discipline. Lenné contributed to the institutionalisation of garden design, creating new production and horticultural education structures [39, pp. 156–159].

[2] The project entitled *Dziedzictwo dyrektora pruskich ogrodów królewskich Petera Josepha Lenne (1789–1866) w Polsce: z okazji 150. rocznicy jego śmierci* was funded by the Polish and German Science Foundation in the years 2014–2015.

entitled *„Mistrzowskie jak rzadko które …". Ogrody Petera Josepha Lenné w Polsce*[3] and the publication entitled *Die Gärten Peter Joseph Lennés im heutigen Polen. Eine Spurensuche jenseits von Oder und Neiße* [27]. The exhibition was presented both in Poland and in Germany in 2016, as a part of celebrating the sesquicentennial anniversary of Lenné's death. This article is meant to familiarise Polish readers with Lenné's work, referring both to the results of the joint Polish and German research project and to earlier studies that had been conducted in Poland.

2. The major stages in Lenné's life

Lenné belonged to a generation of gardeners who obtained their education by travelling and practicing their profession at various court gardens. The fact that he had been a descendant of a long line of gardeners who had taken care of the court gardens in Bonn for over 100 years was not without influence here. Thanks to private and professional contacts, the young Lenné began studying in Brühl at the age of 16, under the eye of his uncle, Clemens Weyhe (1807–1871). A breakthrough in his career occurred during his practical training at the *Jardin des Plantes* in Paris (1811/1812), where he cooperated with André Thouin (1747–1824), the director of the botanical garden, and his brother, Gabriel Thouin (1754–1829). During this time, Lenné began studying at the *École Polytechnique*, which was founded in 1794, and thus, as one of the first "artist-gardeners", he devoted himself to an academic education. At the university, he became familiarised with the system of educating architects, as well as with knowledge of town planning, which he later used in his city planning career [39, pp. 156–159; 43, pp. 1–4].

In 1812 Lenné arrived in Munich, where he came into contact with Friedrich Ludwig Sckell (1750–1823), the designer of Munich's famous Englischer Garten. During the same year he was given a position at the royal gardens of Schönbrunn in Vienna. In 1814 he moved to Laxenburg, the summer residence of the Habsburgs, for which he drafted his first major garden landscaping design [23, pp. 8–9; 43, p. 6]. After a year, with the title of an imperial gardening engineer, he travelled to Koblenz, where in 1816 he received a summons to Potsdam. King Friedrich Wilhelm III was searching for a new royal gardener at the time. Thanks to the recommendations of court marshals: baron von Maltzahn and count von Hacke, as well as general chief forester von Hartig, the 27-year-old Lenné was employed as a gardening apprentice in Sanssouci [22, p. 8; 23, p. 9]. After a trial period, he became a member of the royal garden authority as a gardening engineer. In 1828, after Johann Gottlob Schulze retired, Lenné took over the post of the director of the royal gardens. From that moment on, he supervised not only the royal gardens of Potsdam and Berlin, but also those in Brühl, Düsseldorf and Koblenz. For the next several years, thanks to his extensive knowledge and artistic talent, he managed to rise to the post of the Prussian Gardens General Director in 1856 [43, p. 6; 22, p. 8].

[3] Exhibition entitled *„Mistrzowskie jak rzadko które …". Ogrody Petera Josepha Lenné w Polsce* organised by the Technical University of Dresden, the Wrocław University of Environmental and Life Sciences, the Berlin--Brandenburg Foundation for Prussian Palaces and Gardens and the German Culture Forum for Central and Eastern Europe.

2.1. Garden designer and town planner

As an employee of the garden directorate, Lenné could expect to receive commissions both from the aristocracy and the bourgeoisie. He received his first private commission as early as in 1816, from the Prussian chancellor Karl August, prince of Hardenberg, the owner of the Klein-Glienicke estate, the father in law of prince Hermann von Pückler-Muskau. He carried out his subsequent projects not only in the Potsdam–Berlin area, but also in Brandenburg, Mecklenburg-Vorpommern, Silesia, Pomerania and Austria. Lenné developed his town planning activity in parallel to his private commissions. In 1824 he drafted a plan for the *Klostersberge* in Magdeburg, which was the first public park in Germany to be built on the initiative of the city itself. We can learn from the surviving textual section of the design that Lenné wanted to direct the residents' attention to Magdeburg's history. To this end, he skilfully used the topography of the park and directed views towards the city's panorama, along with its distinct elements, such as the port or the cathedral [42, pp. 103–106]. The Klostersberge programme revealed Lenné's views on the role of city parks, which in his mind should have been not only a place for walks and to rest in, but also a place of education and building identity. From that moment on, Lenné, when creating public spaces, would always take social matters into consideration. He designed various sites, including parks and city squares, curative parks, hospital gardens, zoological gardens and cemeteries. From the 1840s onwards Lenné drafted and approved urban plans, e.g. for Berlin (1839–1855), Munich (1854), Wrocław (1855), Dresden (1859) and Vienna (1858). In Berlin he took part in designing the surroundings of the city's water canals and the delineation of railway lines (Potsdam–Magdeburg, Berlin–Hamburg).

Lenné honed his skills in beautifying the landscape at the estate in Radaczew, which belonged to Carl Gottlieb von Bethe (1778–1840), the director of the Association for the Development of Horticulture in the Prussian States, of which Lenné was also a member. It was Lenné whom Bethe commissioned to draft a plan of remodelling his 4500 morgen estate. The first plan, drafted in 1820, covered 750 morgen [15, p. 78], while the one that followed, named "Radaczewo estate planting plan", drafted in 1825, covered 3500 morgen (ca. 875 ha) [18, No. 465; 27, p. 166]. Bethe attached the second plan to his treatise *On planting in the pastures and fields*, published in the "Journal of the Association for the Development of Horticulture in the Prussian States" [15, pp. 80–88]. The detailed guidelines formulated by Bethe and Lenné would contribute to the improvement of aesthetic assets and the economic and infrastructural conditions at the estate. Radaczewo became a model example of combining agriculture and garden design. Lenné used these experiences when beautifying Potsdam Island, where, according to the will of King Friedrich Wilhelm IV, the Potsdam residences were to form a cohesive landscape resembling Arcadia [22, p. 11]. In 1968 Konrad Buchwald[4] described the project in Radaczewo as "a pioneering, artistic, planning, landscaping and ecological achievement" [16, p. 79].

[4] Director of the Institute of Landscape and Wildlife Presservation of the University of Hannover.

During his many years of professional work, Lenné developed his own principles of shaping landscape gardens. His work was initially under the strong influence of his father, and later under that of Friedrich Ludwig Sckell and William Kent. Lenné came into contact with the latter's work during a three-months-long trip to Great Britain in 1822 [22, p. 11]. The influence of the abovementioned designers can be seen in his earlier projects in Laxenburg, Neuer Garten and Sanssouci (from the period between 1815 and 1829), which are characterised by natural simplicity. From the 1830s and the 1840s onwards, the composition of his gardens started to feature more and more refined elements, such as flower beds and water pools. The combining of geometric gardens near houses with landscape forms in the more distant parts of layouts was called the "mixed style" [23, pp. 77–79]. From the 1850s onwards Lenné began to use regular, symmetrical layouts, subjected to an architectural landmark with distant visual linkages. He was inspired by Italian models, with which he came into contact during his trips to Italy (1844 and 1847), which were funded by king Friedrich Wilhelm IV [24, pp. 27–28]. The examples of his later geometric style include: the terraces of the Orangerie Palace in Potsdam [23, pp. 77–79]. The design solutions developed by Lenné were perfected by his student and co-worker, Gustav Meyer (1816–1877), who published the "Handbook of beautiful garden design" in 1860 [37]. The book became a sort of a "bible" of landscape garden design, and the Lenné Meyer School dominated German garden design until the end of the nineteenth century.

2.2. Teacher and organiser

Apart from his work as a designer, Lenné became involved in horticultural education reform and in the establishment of the basic structures of horticultural production. In 1822, along with ten other members, he established the Association for the Development of Horticulture in the Prussian States (*Verein zur Beförderung des Gartenbaues in den Königlich Preußischen Staaten*)[5], whose goal was the development of garden design and horticulture, as well as the beautification of the landscape as academic and artistic disciplines [39, p. 156]. With the Association's aid, Lenné managed to establish the Royal State Tree Nursery (*Landesbaumschule*) in 1823 along with the Horticultural Academy in Potsdam (*Gärtnerlehranstalt in Potsdam*), which was the first academic centre for horticulturalists in Germany[6]. Many city gardeners, garden designers and plant nursery owners from Wrocław, Gdańsk, Poznań and Szczecin, as well as a number of garden designers and gardeners from Warsaw and Krakow, received their education at this esteemed academy [5]. The university became a model for similar institutions that were established in Belgium, Russia and Silesia. In 1847, the *Königliche Landschaftliche Lehr-Anstalt* institution was established in Prószków, near Opole, and whose founder was Hannemann, a student of Lenné's [23, pp. 18–19]. The

[5] Since 1910 the Association has existed under the name of the German Horticultural Association (*Deutsche Gartenbau-Gesellschaft*).

[6] There was a three-tiered education. After completing the first, the graduate was given the title of *Gärtner* (gardener), after the second, that of *Kunstgärtner* (artist-gardener), and after the third, that of *Gartenkünstler* (artist-garden designer).

State Tree Nursery in Potsdam was also an important centre – it provided plant material for many court garden layouts and arboretums, including the arboretum in Niedźwiedź near Krakow, which belonged to Stanisław Wodzicki [8, p. 28].

3. Lenné's design work in Poland

While assessing Lenné's impact on garden design in Poland, we cannot ignore his own projects. As a part of the research project, a detailed analysis was performed, focusing on garden and park layouts (28 sites in 25 different localities) for which original plans and drawings confirming the participation of Lenné and his closest associates have survived. The highest number of sites documented in original plans has survived in the following voivodeships: the Western Pomeranian voivodeship (13), the Lower Silesian voivodeship (7) and the Lubusz voivodeship (4) (Fig. 1). Apart from a few exceptions, most of them were in a state of neglect or were almost completely dilapidated, while some no longer exist (the Eichborn Garden in Wrocław[7], the garden near the former hospital in Słońsk). Two plans could not be attributed to any locality. The first (Graf Hacke in Schlesien, 1819) [18, No. 502; 28, pp. 186–187], associated with Silesia, was drafted for count von Hacke in 1819 [28, p. 187]. The second, signed as *Grenze mit der Weissenburger Feldmark* (1840) [18, No. 478; 20, p. 188], was probably mistakenly linked by Günther and Harksen [18] with the village of Boże in Masuria. Of note is the fact that the composition of this layout resembles the plans of beautifying landed estates drafted by Hans Jancke (*Musterentwurf von Hans Jancke*, 1870) and Gustav Meyer (*Musterplan eines verschönerten Landsitzes*, 1860). Perhaps this plan was also meant to be merely a theoretical, model solution [20, pp. 189–191]. The remaining sites (marked in grey, Fig. 1, No. 5), are layouts ascribed to Lenné, but that have not been documented with original plans and for which no confirmation in source material has been found. In 2009, Bożena Łukasik [34, pp. 227–246] listed 25 such layouts. Lenné's participation in a number of those has been ruled out, i.e. Staniszów, Bukowiec and Karpnik [31, p. 208]. Iwona Bińkowska [2, p. 77] managed to find a report for the *Promenades and Parks Commission* from 1865 [32], which confirms Lenné's involvement in the design of Szczytnicki Park in Wrocław. Of note is the fact that the author of this article herself has found an original official letter by Lenné in the State Archive in Wrocław, which recommended his student, Julius Lösner (1818–1890) for the post of city gardener of Wrocław [3, pp. 132–147; 4, pp. 132–133].

Most of his completed designs were residential parks designed for the royal family, the aristocracy and various burghers. These were both designs of the beautification of the estate in Złotów and Radaczewo, as well as small sites, like the surroundings of Otto's Well in Pyrzyce. Lenné also took part in designing the city greenery of Szczecin, Świnoujście and Wrocaw. He strived to link gardens with their surroundings and to create a cohesive

[7] For reasons that remain unknown, the villa was dismantled in 1907 and the garden was assigned for the construction of tenement houses.

cultural landscape in each of these places. The most accurate description of the character of his designs was expressed by Heinrich von Salisch[8] in 1885, who described the park in Krasków: "The traveller who does not know the history of the landscape work will say: how beautiful, how wonderful, once again we can see here: that untouched wildlife is and forever will be the most beautiful" [41, p. 343]. Although Lenné's parks appeared to be the work of nature herself, they were actually created as a result of laborious and often very expensive projects. The scale of these projects is illustrated by selected cases from Silesia and Pomerania.

Fig. 1. Park and garden layouts by P.J. Lenné in Poland; Legend: 1 – major cities, 2 – the seat of the Prussian royal family and Lenné's place of work, 3 – layouts belonging to the royal family, 4 – layouts confirmed by plans, 5 – layouts attributed to Lenné; Condition (6–10): 6 – dilapidated, 7 – neglected/abandoned, 8 – well-maintained, 9 –renewed, 10 – commissioned to Lenné, probably not built; by J. Mazur and J. Jaworek-Jakubska, 2014

8 Heinrich von Salisch (1846–1920), German forester and politician, brother of the owner of Krasków, Georg Gustav Rudolf von Salisch und Stübendorff.

3.1. Major residential layouts

The royal gardens in Mysłakowice and Kamieniec Ząbkowicki are considered among the artist's most precious works. The names of these localities, along with Oliwa and Wrocław, have found themselves among his fifty most important projects – which were listed on the laurel wreath prepared on the occasion of the fiftieth anniversary of the start of Lenné's professional career in 1866 [24, pp. 32–33]. The greatest wealth of design documentation survived for Mysłakowice in Kotlina Jeleniogórska. Here, at the beginning of the nineteenth century, three residences: in Karpniki (1822), Mysłakowice (1831/32) and Wojanów (1829) became the property of the Prussian royal family. The newly-purchased estates were to form a compositionally cohesive whole, which is why Lenné sought to connect them together from the very start. The formation of the gardens began with delineating an access road to Bukowiec in 1833, along with an observation spot at Mount Mrowiec. Afterwards, an avenue was delineated to Karpniki, the so-called Royal Road, which was linked with an older avenue linking Bukowiec with Karpniki [45, pp. 81–90]. In 1836, Lenné drafted a plan for Mysłakowice, covering the area between the palace and a planned church. The work that followed was supervised by his associate, Gerhard Koeber (1809–1852), with the carrying out of the project initially given to a gardener named Teichler, who had worked for count Gneisenau. In the 1860s Bruno Teichler was given the position of general gardener and later that of court gardener in Mysłakowice [9, p. 58; 40, p. 166]. Lenné subjected the composition of the pleasure ground to the main visual axis aimed at Mount Śnieżka (Fig. 2). The frame for the view was created by a church designed by Karl Friedrich Schinkel (1781–1841)[9]. From the east, the palace grounds bordered on a farm complex, with a utility garden and horticultural production area, where exotic plants such as camellias, pineapples and roses were grown in greenhouses. From the south side, the pleasure ground connected with an extensive landscape park. Here, on the shores of picturesquely formed lakes, we could see changing views of the palace and the surrounding mountains, including Śnieżka, Mrowiec and Krzyżowa Góra. The skilfully staged plants ensured an optical integration with the surroundings. The planting plan drafted by Lenné featured 171 different taxa, including willows (31), elms (11) and poplars (6), as well as ornamental bushes like the amphora, the mock-orange and shrub and tree-like hortensias [24, pp. 393–395]. Due to climate conditions that were unfavourable to many of the plants, the plan was not fully implemented. In the 1840s the park and its surroundings became filled with Swiss-style houses and villas, inspired by a colony of religious refugees from Tyrol that had been established in Mysłakowice[10]. The royal garden formed in this manner became a part of an extensive park landscape, which was called the "Silesian Elysium" in the nineteenth century and was compared to the beautified Potsdam Island [17, pp. 56–57; 7, p. 60; 11, pp. 142–143].

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[9] A complex of Classicist Revival buildings (a palace and a Bachelor's House) as well as buildings with Italian-style forms (e.g. a church) were built in Mysłakowice in accordance with a design by Karl Friedrich Schinkel. After the death of Friedrich Wilhelm III, his son and heir Friedrich Wilhelm IV commissioned Friedrich August Stülerowi to remodel the residence in a Gothic Revival style (1800–1865).

[10] In 1837 king Friedrich Wilhelm III transferred a portion of his estate in Mysłakowice to protestant religious refugees from the Zillertal Valley in Tirol.

Fig. 2. Panorama of the Giant Mountains, watercolour, count von Groeben, ca. 1850
[SPSG, GK II (5) 1108, unknown photographer]

Kamieniec Ząbkowicki was inherited by duchess Marianna of the house of Oranien-Nassau in 1837[11]. An impressive residence was built on her initiative on the slopes of Castle Hill, designed by Karl Friedrich Schinkel, who had been involved in constructing the palace at Lindenstrasse in Berlin for duchess Marianna's husband – duke Albert Hohenzollern – since 1828 [17, p. 71]. The design and construction of the palace were complicated and Schinkel modified his proposals numerous times. Ultimately, after an on-site visit, he proposed the construction of a Gothic Revival residence. This version of the design became the starting point for later detailed plans, which were prepared by his associate Ferdinand Martius (1811–1889) [17, p. 78; 6, p. 358; 10, p. 76]. The surviving drawings located in the collection of the National Museum in Wrocław [21] show that the architect's intent had been to harmonise the palace with the local landscape. Locally available materials were used in its construction, and the composition of the south-western facade of the palace and the layout of the terraces was subjected by him to the main visual axis, aimed at the Nysa Kłodzka River Valley. Lenné, who visited Kamieniec in 1858, developed this proposal further [17, p. 116]. A plan of the upper terraces was drafted two years later [18, Nos. 496, 497], followed by a design of their extension, drafted by Martius and Lenné [17, pp. 115, 117]. According to his proposal, the garden descended towards the

[11] Wilhelmina Frederika Louise Charlotte Marianne, Prinzessin von Oranien-Nassau (1810–1883), daughter of Wilhelm I, king of the Netherlands (1772–1843) and Wilhelmina Frederika von Preussen (1774–1837), the wife of prince Albrecht von Preussen (1809–1872) in the years 1830–1849.

valley in the form of seven stone terraces, connected with each other through external stairs with a total of 174 steps. Its distant visual linkages in the style of Italian villa layouts, rich architectural details and flowerbeds with a rich collection of exotic plants are the characteristic of Lenné's late geometric style [26, p. 45]. The entirety was supplemented by an elaborate water layout with surprising solutions, for instance, the fountain on the lower terrace reached the height of the fountain at the upper terrace and ejected water up to a height of 33 m [36, p. 97; 12, p. 92]. A complicated and expensive installation supplying the terraces with water from a lake near the Budzówka River was built to feed the fountains. The water was pumped to a reservoir at the top of Castle Hill, from which it flowed downwards unassisted into the valley and supplied all of its fountains [38, p. 639; 25, pp. 41–49].

During the expansion of the residence, a maximum exposure of the main visual axis was sought, as well as the deliberate restriction of development in the areas between the former abbey and the Nysa Kłodzka River [14, p. 28]. The terraces were compositionally linked with an extensive landscape park, as well as forest parks (*Wildpark* and *Pilzenpark*), which became filled with numerous observation points and resting spots (Fig. 3). The design for Kamieniec Ząbkowicki was the last great joint work by Schinkel and Lenné. After the death of the Gardens Director, a garden with a pool and a Perseus' grotto were built in Kamieniec. Above the grotto there was an eleven-metres-tall column with a three-metres-tall statue of the Goddess of Victory. It was meant to commemorate the Prussian–French war of 1870–1871. The placement of the cornerstone for the column in 1872 is considered the official date of the completion of the over thirty-years-long construction of the palace and park complex, which cost 971,692 thaler to build (the equivalent of around 3 tons of gold) [35, p. 92].

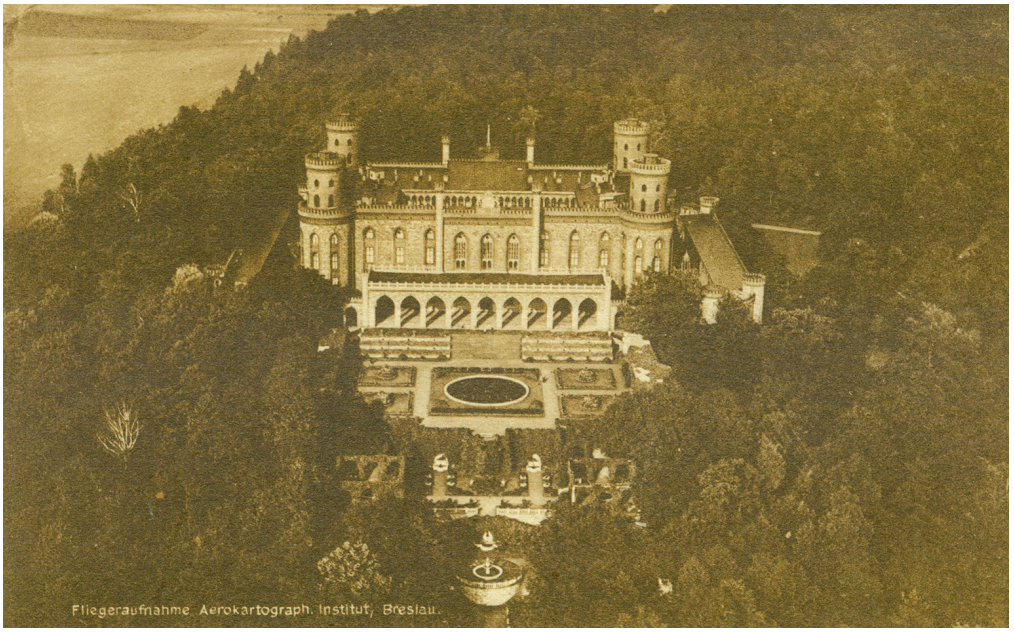

Fig. 3. Palace and garden terraces in Kamieniec Ząbkowicki, aerial photograph, beginning of the twentieth century, from the private collection of J. Dubiel

3.2. Urban designs

Since 1825 Lenné had been involved in the expansion of public areas in Szczecin and Świnoujście. These projects were supervised by the oberpräsident of the Pomeranian regency, Johann August Sack (1764–1831), with the aid of the Beautification Society. It was by his initiative that new areas of greenery were established in Szczecin, on the basis of its former fortifications. In 1825 the Gardens Director drafted a design of the first city park in front of the Lady's Gate (Frauentor) [18, No. 470], and four years later – a plan for the eastern part of the park in front of Leopold's Fort [19, p. 16]. In 1825 he also took part in beautifying the surroundings of the city. The *Weinberg bei Frauentor hill* (Szczecin-Golęcino), which had been named *Elisenhöhe,* in honour of Friedrich Wilhelm IV's wife, was remodelled in accordance with his guidelines. In the middle of the 1840s, Lenné designed a decoratively-shaped square in front of the city theatre, whose erection on the *Königsplatz* (currently named Plac Żołnierza Polskiego) was commissioned by Szczecin's merchants. In all probability, the scope of the work of the Berlin Gardens Director in Szczecin was much greater, as evidenced by his correspondence with oberpräsident Sack, who asked him to provide a plan for the arrangement of a municipal tree nursery [13, BPH, Rep. 192, Nl. Lenné, No. 3; 19, p. 18]. In nearby Świnoujście, Lenné, by request of oberpräsident Sack, prepared a design of the surroundings of a spa building (*Gesellschaftshaus*) in 1826. Two years later, a plan of the development of an area stretching towards the buildings of the captain of the port was drafted [19, pp. 22–25]. Lenné completed two more private commissions in Szczecin, associated with the beautification of the Zittelmann (1826) and Dohm (1853) family estates in Szczecin-Klęsków (*Höckendorf*), as well as a design for the Eckersberg estate for the Kugler family (1820) [19, pp. 19–22].

In 1853 the Prussian minister of trade, August von der Heydt, presented a draft of the planned regulation of Przedmieście Świdnickie, Mikołajskie and Oławskie to Lenné for approval. The garden director placed his remarks on the plan *Situationsplan der Nikolai-, Schweidnitzer und Ohlauer Vorstadt von Breslau,* of which a single copy had survived in Berlin prior to the Second World War. The changes included the extension and the beautification of squares and roads in the area of the present-day Main Train Station, the Świebodzki Train Station and the no longer existing Lower Silesian–March Train Station [24, pp. 377–380; 25, p. 50]. In 1855 Lenné also consulted the shaping of the Oder riverbank and the Town Moat. In order to improve sanitary conditions, he recommended that the geometrically-shaped moat canals be converted into a flowing waterway [1]. The remodelling of the southern suburbs of Wrocław coincided with work on remodelling Wrocław's system of greenery. In September 1853, Heinrich Robert Göppert (1800-1884)[12] presented a proposal of developing greenery on a city-wide scale [3, p. 89]. In 1863 the post of city gardener was given to Julius Lösner (1818–1890), who had been recommended by Lenné [3, pp. 43–44]. In 1865, work began on the construction of Szczytnicki Park under his supervision and according to Lenné's guidelines [2, p. 77; 32, p. 4]. The Gardens Director employed his signature solutions here –

[12] Göppert Heinrich Robert (1800–1884), director of the Botanical Garden of the University of Wrocław (1852–1884), from 1826 a member and from1846 the president of the Silesian Association of Homeland Culture and from 1849 a member oft he Promenade Deputation.

he highlighted the topography and the historical elements, as well as the distant views. Of note is the fact that the designer from Potsdam treated the park in Stare Szczytniki as an element of a greater complex of recreational, didactic and sports grounds from the very start[13]. This has been evidenced by his remarks on the design of the Zoological Garden by Julius Lösner. He recommended, among other things, the delineating of promenades and accessways connecting Stare Szczytniki with the city [44]. This vision was consistently developed by gardeners and architects in the nineteenth and at the start of the twentieth century.

4. Conclusions

The study included the verification of the previous state of knowledge concerning the design activity of Peter Josepha Lenné in Poland. The collected archival materials from German and Polish collections made it possible to distinguish 28 projects confirmed by original plans. Two plans could not be linked with any existing parks. In the case of 2 sites (Wojanów and Park Szczytnicki in Wrocław) documents have been found proving the involvement of the Potsdam-based designer in the construction of their gardens. In the case of the remaining 20 sites, no confirmation in source documents has been found. Valuable conclusions concerning the composition and the state of preservation of the garden layouts have been drawn from field studies. Previously unknown traces of past garden structures have been found. For instance, in Kotlina Jeleniogórska, on Eisenberg Hill in Wojanów, the foundations of a belvedere were found, as well as of a circle composed of linden trees; a stone with an inscription reading Waldemar's Tower has been discovered in nearby Karpniki, along with a mock-orange – the remains of the garden near the no longer existing Mariannen Cottage. These are elements of a past beautified landscape and that are not listed in any heritage sites registry or planning document. This means that even the most well-known places, like the Valley of Palaces and Gardens of Jelenia Góra require further in-depth field studies, particularly in the area of restored parks and gardens.

In conclusion, there are garden layouts that illustrate various phases of Peter Joseph Lenné's work (the mixed and the geometric style) in Poland, as well as the types of projects he worked on (palace gardens, urban villa gardens, public greenery, urban designs and landed estate beautification plans). The most recognisable of these are the gardens and parks near residential complexes. Lenné's design work in Szczecin and Wrocław can be considered interesting, although it is still poorly investigated. The Prussian Gardens Director closely cooperated with the authorities of both cities and exerted an immense influence on period city gardeners and town planners. The fact that in 1861 the Gardens General Director received an honourable doctorate from the Wrocław University for his remarkable contributions, with the decision to confer it being justified as follows: "…because he created a new art of garden design, enhanced not only through professional knowledge, but also through its long-term use, far from any imitation…", can be seen as proof of the significance of his achievements [22, p. 11].

[13] The park was near a pasture at Dąbie, where horse races were organised from 1833 on the initiative of the Silesian Horse-Racing Association. In 1863 work commenced on establishing a zoological garden to the south of the park.

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Urban sozology assumption in the planning of housing areas

Sozologia urbanistyczna w planowaniu obszarów mieszkaniowych

Abstract

Sozology is a newly discovered direction in urban planning stem from the growing threats to the natural environment. A contemporary man pursues close and positive relations with the environment and focuses on the premises of human ecology that directly impact the process of planning and composing urban spaces. The article presents the influence of climatic conditions on the shaping of housing areas. The problem was presented on the basis of an analysis of a specific example. The assessment included the shading of the buildings by neighbouring buildings, the shading of the common spaces and the issue of ventilation. These phenomena connected with the structure of the buildings, their scale and intensity have a significant impact on the conditions of the residence. Other factors also affect the housing environment. Their rational use with the help of teams of experts from complementary fields can contribute to raising the standards of the housing environment even at the planning stage, and later to optimising land use by the community of its inhabitants.

Keywords: ecology, sozology, urban planning, climatic conditions

Streszczenie

Sozologia urbanistyczna z uwagi na narastające zagrożenia środowiska przyrodniczego to na nowo odkrywany kierunek w planistyce. Współczesny człowiek, podążając za kształtowaniem bliskich i pozytywnych relacji ze środowiskiem, coraz większą uwagę skupia na przesłankach ekologicznych, mających bezpośredni wpływ na proces planowania i komponowania przestrzeni miejskich. Środowisko naturalne w różnym stopniu było i nadal jest przekształcane przez człowieka. Dziś zawiera ono jedynie naturalne elementy, a w całości należy je nazywać środowiskiem antropogenicznym bądź przyrodniczym. W artykule poddany został rozważaniom wpływ uwarunkowań klimatycznych na kształtowanie obszarów mieszkaniowych. Problem przedstawiono na podstawie analizy konkretnego przykładu. Przy jego ocenie wzięto pod uwagę zacienienie budynków przez sąsiadujące obiekty oraz zacienienie przestrzeni wspólnej towarzyszącej zabudowie, a także problem przewietrzania. Są to zjawiska, których wpływ na warunki zamieszkania uzależniony jest od skali oraz intensywności zabudowań. Czynników oddziałujących na środowisko mieszkaniowe jest o wiele więcej. Ich racjonalne wykorzystanie przy wsparciu zespołów ekspertów z komplementarnych dziedzin przyczynić się może do podniesienia standardów tego środowiska już na etapie planowania, a następnie do optymalizacji użytkowania terenu przez wspólnotę jego mieszkańców.

Słowa kluczowe: ekologia, sozologia, urbanistyka, uwarunkowania klimatyczne

1. Introduction

1.1. The essence of sozology

The development connected with modern times brings not only positive effects. The negative phenomena are primarily associated with the destruction of the environment. The irreversible changes in its structure make it necessary to take actions aimed at stopping the process of further degradation. It is an overarching goal of the sozology, often mistakenly called "ecology", mainly dealing with the relationship between living organisms and the environment. Sozology allows the development of specific methods to prevent or minimise the effects of adverse environmental changes. In urban planning, planning sozology is defined as planning of residential areas, taking care not only about the environment with its natural elements and living conditions but also about human health. By analyzing available research methods and tools, it is used for the protection of nature and contributes to the sustainability of its resources [1].

Sozology (Greek *sōzō* = protect, *lōgos* = science) as an interdisciplinary science, occurred in 1965 on the initiative of W. Goetl – an outstanding Polish geologist and an international precursor of sustainable development, recognised by the UN as a global priority in 2016.

It should be added that prof. W. Goetl initiated open seminars on nature conservation and securing the durability of its resources. He also created the Technician and Humanist Club[1]. The priority of his scientific activities that aimed to improve the quality of the natural environment was the need to undertake comprehensive research from the borderline of many fields of science, including architecture, urban planning, sozology and sozotechnics [3].

It is difficult to present a sufficient amount of literature on sozology in urban planning. In the current state of research, however, publications of such authors as W. Michajłow [1], W. Goetel [4], Z. Kłos [5], J. Dołęga [6], A. Więckowski, J. Kobylarczyk have become permanent. Mikhailov describes sozology as a science that can have positive effects in reduction of problems that arise in the human life environment; W. Goetl describes the problem of sozology in the context of the natural environment; Similarly, subsequent authors of the studies describe the impact of sozology on a specific area. Also, the co-author of this study describes sozology in one of her works as a science that can be used in urban design; she analyzes selected housing areas examining them in terms of compliance with the rules of sozology [7] and explains precisely how the issues related to ecology differ from the issues related to sozology. In this context, issues in the field of sustainable development and design are also important. They prioritize not only care for resources and the current state of the environment but also its future and the future of generations. The approach of W. Goetel has been continued by Prof. J.W. Dobrowolski, whose scientific activity [8–11] is based primarily on conducting interdisciplinary research based on the idea of sustainable development oriented towards the integration of eco-innovation. In his work, Prof. Dobrowolski uses laser biotechnology, of which he is a precursor [2].

[1] Information on this subject was presented by The Institute of Quality of the Jagiellonian Center of Innovation based on the interview with J.W. Dobrowolski [2].

In addition, Prof. Dobrowolski developed a model of training regarding interdisciplinary cooperation between scientific workers and representatives of Student Scientific Circles that aims to solve systematic problems of sustainable development. Together with his colleagues, Prof. Dobrowolski has perfected this model for 50 years, developing cooperation between the experts and a knowledge-based society from various regions of Poland and over a dozen countries from Brazil to China [12, 13].

The aim of the article is to present the application of sozology also in architecture and urban planning, contributing to the rational use of the existing natural conditions in the planning of housing areas. Care for the endangered state of the natural environment is an obligation and requires the promotion of pro-environmental activities consistent with the principles of sozology.

1.2. Architecture in harmony with the natural environment

The use of appropriate technologies and building materials ensuring low energy demand and minimising the negative impact on the natural environment is important in architecture. Created buildings undergo a broadly understood sozoeconomic assessment, including economic and environmental benefits in the process of investment planning, the operation of the building, its demolition and the entire process of production and processing of building materials, as well as waste treatment of the materials [14] which are not always subjected to self-decomposition. The environmental benefits that can be obtained boil down to the rational management of the natural resources, the adaptation to local, but also to changing climate conditions, the use of renewable energy sources and the use of building materials with low energy consumption (so-called embodied energy). It is directly related to the exploitation of raw materials and their renewal. Today, the need to produce ecological and low energy materials (such as smart and composite materials) is triggered due to the exhaustibility of raw materials applicable in the construction industry. Nanotechnology and dynamic development of nanomaterials [15] may bring promising results in the near future.

1.3. Sozology in spatial planning

The article proves that sozology also includes urban conditions. It allows conducting rational land management with respect for nature and its resources. This approach also embraces the problem of increasing compactness of the buildings within urban interiors. Too high intensity displaces green areas, which not only negatively affects the microclimate, but also the well-being of people and living standards. In order to raise them, it is important to adapt the building structures to the existing climatic conditions whose scope of influence depends, among other things, on the location and size of the area under consideration, as well as the number of its users. When planning residential areas, the selection of the right values that are related to the distance between the facilities, service zones and industry is not without significance. It is vital to decide on the scale of development and the size of the biologically active area.

When undertaking the efforts to improve the quality of the housing environment one must be aware of conflicts occurring at the level of the importance of the needs, preferences and priority choices, as well as the activities in the environment [16, pp. 10–14]. They increasingly trigger the sense of improvement of the living conditions, which is becoming and will be the overarching goal of urban sozology in the future. This problem has also become an important subject of the study. It should be noted that due to the dynamic development, it is difficult to unequivocally assess the interventions that will be needed in the future as well as the possibilities of their implementation. However, the need to look into the future with concern for the natural environment and its deteriorating conditions is clear and obvious.

2. Climatic factors including ventilation and sun exposure in the design of the residential areas

2.1. General remarks

The basic problem that appears when analyzing sozology and its application in urban design, is the lack of respect for existing natural conditions, including climate in design practice. Therefore, spatial planning that would take into account climatic factors considered on a macro scale seems vital. They allow characterizing in general terms the conditions prevailing in a given region. It is much more difficult to adjust to climatic factors, which vary in the time understood as the time of the day and the changing seasons. The climate is also changing due to environmental pollution and phenomena such as the urban heat island [17]. This phenomenon is related to the local air circulation and arises as a result of impeded warm exchange, so-called "used" air in built-up areas and cold air coming from open areas, i.e. free of building.

The negative effect of the formation of heat islands, apart from air pollution, is the overheating of urban spaces. Therefore an important solution of the problem is an appropriate choice of materials, both vertical divisions and horizontal divisions, surfaces of the floor, whose task is to keep the balance between the absorbed solar energy and the reflected radiation. The city geometry itself, shaped by the street routes, can limit the excessive air circulation, and the growing hazards associated with its pollution. One of the most important reasons is also the increasingly limited size of the natural surfaces, which maintain the same temperature as the air as in the extra-urban areas. Some surfaces, such as the walls, can be much warmer. Hence, the solution to the problem should be connected with the keeping of the right proportions between built-up and building-free areas. The scale – height – of buildings and the way roofs are shaped are also important. It should be noted that the surfaces of the roofs or vertical surfaces maintain higher temperature as they not only absorb the sun's rays but also effectively limit the wind speed by creating the so-called canyon effect. Inside it, there is a dynamic increase in air temperature with a limited flow [18, 19].

The construction process responsible for the emission of greenhouse gases and triggers the need for using fossil fuels energy has a very large impact on climate change. Research conducted by the American Institute of Architects has shown that buildings consume 48% of

energy, and also cause greenhouse gas emissions – commercial architecture 17%, residential architecture – 21%, transport – 27%, industry – 35% annually.

These studies do not take into account all stages of the life of objects, that is the values associated with the production of building materials, the process of building objects and the final phase of their demolition and the utilisation of their components. Nevertheless, the results clearly indicate the necessity to undertake actions allowing to avoid irreversible climate changes and determining the effects of the interaction between the natural and built environment. The use of positive effects of these impacts may contribute to raising the quality standards of the living environment – shaping the appropriate spatial conditions accompanying architectural objects, taking into account climatic factors affecting the planning process of buildings of appropriate scale and form. These conditions can be considered in relation to various scales, including – the macro scale referring to the country or the smaller region, the mesoscale – the city, the local scale – the district, housing estate, micro-neighbourhood [20].

2.2. The analysis of the problem on microscale – the neighbourhood

On the scale of the neighbourhood, factors such as the location of buildings shaping building quarters with accompanying spaces of social and public importance, selection of building materials and equipment, which depending on the climate require cooling or reheating are important. In this context, the ability to determine the intensity of solar radiation becomes crucial. Calculated on the basis of Davis's formula, it indicates more than three times the total radiation during the summer in Poland than in the winter in its southern part. The daily sum of the radiation energy in the south of Poland on the June solstice is almost seven times higher than during the December solstice [21]. The insolation is limited in the periods of cloudiness that prevent the free flow of solar radiation, which reaches the Earth in a dispersed form.

The problem associated with excessive heating of built-up spaces can be eliminated by using appropriate surfaces. The degree of the reflection of solar radiation is determined by the albedo. Generally, its value depends, among other things, on the colour of the surface, its roughness and humidity. The darker, rougher and wetter the surface, the smaller the albedo. It can be concluded that the size of the albedo is influenced by the type of land development – the intensity of the buildings, the scale of vegetation, its variability, and terrain configuration. All these elements contribute to the degree of reflection of solar radiation. The albedo value in the built-up areas is 10÷27% (less by 10÷20% than in the undeveloped areas).

In the discussed aspect, one should also indicate the benefits that are associated with the design of water reservoirs. The horizontal water surface is characterized by a variable albedo value, depending on the solar incidence angle. During winter (when the sun is relatively low over the horizon), it is a highly reflective surface, while in the summer, when the sun rays strike at a higher angle, it becomes a light absorber. This behaviour meets the variable seasonal demand for sunlight and solar heat – it allows, among others, to reduce the amplitude of the external air temperature, and as a result, to improve the quality of the microclimate in the city [22].

As it was previously explained, the height of the buildings and their content is also important. The friendly scale of the objects with limited intensity can facilitate the penetration of the sunlight, illuminating the interiors. In this respect, the size of parameters determining the proportions between the height of buildings and the distance between them H/S is significant – when the objects are of the same height and $(H/S)_p = (h_1+h_2)/2(s_1+s_2)$ when they have different heights or vertical offsets. While: h – height of objects, s – distances of vertical planes covering the walls of buildings from the P point.

Similarly, the difference in the height of objects adjacent to each other (higher building shades the lower object) or the distance between the building and the greenery as well as the height of the greenery itself is of significance for the degree of shading. The shading may also be caused by the loggias, balconies or eaves. When the h_a angular height of the sun (Fig. 1) is greater, the shading from the neighbouring building is smaller but greater from the balconies and eaves. The h_a angular height of the sun depends on the geographical latitude of the point and the time of day. The biggest values are obtained at noon, while during the sunrise and sunset they are equal to zero. The duration of sunlight on the façade during the day also depends on the location of the building relative to the sides of the world [23].

The impact of the climatic factors on the area of residence is largely determined by the building development – its height, the degree of diversification, their layout – loose housing, compact housing, quadrilateral housing, open or closed systems [24] (Fig. 1–7). These systems facilitate or hinder ventilation of the residential areas.

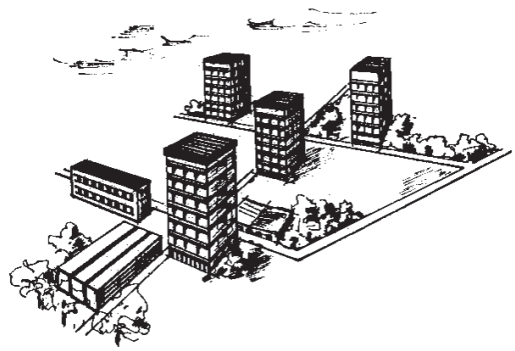

Fig. 1. Loose, high, open housing. It allows free airflow and even actuates it [24, p. 26]

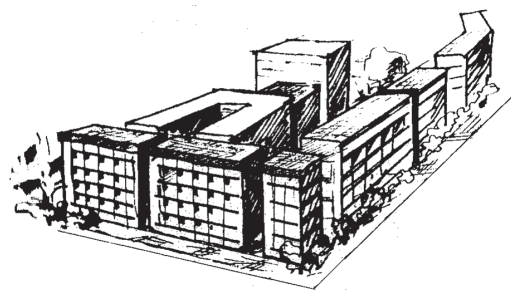

Fig. 2. Medium-high, compact housing, closed in some places which hinder ventilation. Narrow breaks between the buildings actuate the wind leading to "drafts" [24, p. 27]

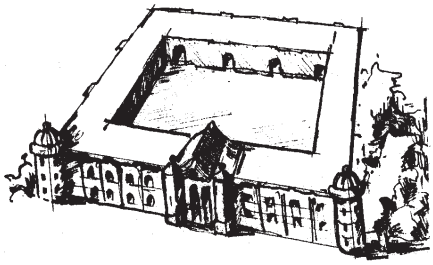

Fig. 3. Medium-high buildings with a closed inner yard that causes air stagnation [24, p. 27]

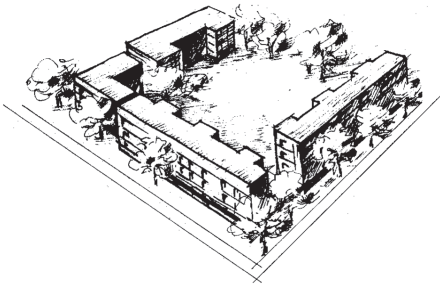

Fig. 4. Mid-high housing with a semi-closed system. The airflow can be hindered by the growth of the greenery [24, p. 27]

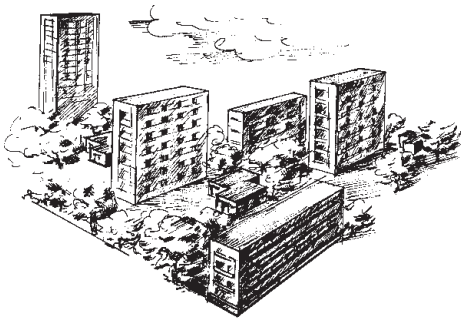

Fig. 5. Mixed housing with a different number of storeys. The most favourable climatic conditions occur with this type of building in green spaces [24, p. 28]

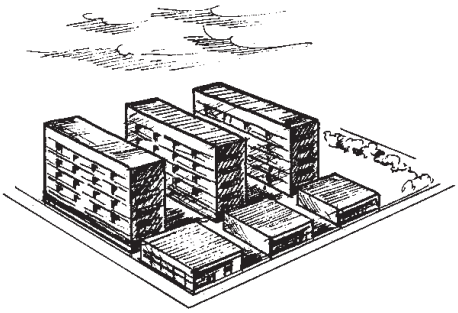

Fig. 6. Diverse, mixed housing development with a loose, open layout and a small amount of greenery. There will be excessive wind speeds when the wind blows along the buildings. In the area with higher and longer buildings, wind speeds will be even higher [24, p. 28]

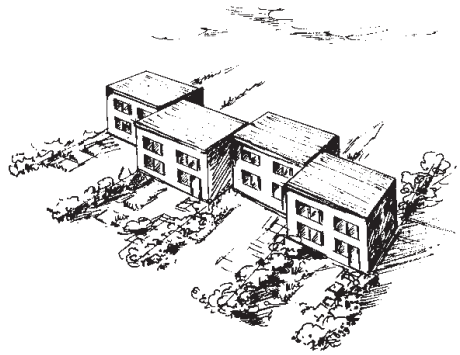

Fig. 7. The type of a low, compact, open housing with a small amount of greenery. This type of building interferes with the prevailing airing conditions to the slightest degree [24, p. 29]

The geometry of the building and its intensity, taking into account the distance between the buildings, regulates the shading and insolation of the area. Moreover, it also affects the strength and direction of the wind (Fig. 8).

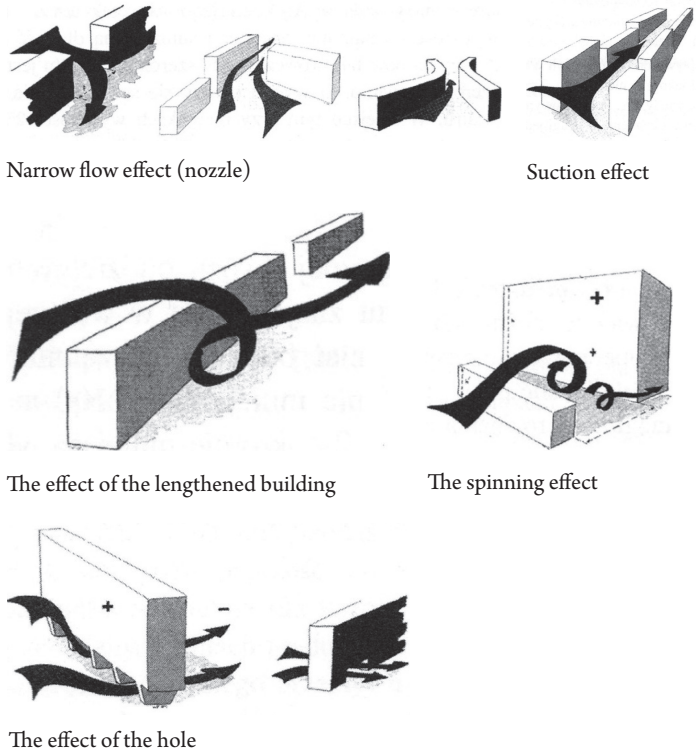

Fig. 8. Wind flow with different building geometry [25], according to A. Flaga [26]

The ventilation intensity is higher when the area is more open. It decreases with increasing building intensity and its height.

3. The case study

3.1. General remarks

The purpose of the undertaken analysis was to indicate the extent the area of residence chosen for the research, that is the estate of Dywizjonów 303 in Cracow implements the assumptions of urban sozology. The adopted research method is based on field studies – a site inspection, which allowed the analysis of functional and spatial conditions of selected areas, and thus the relationship between the natural environment of these locations and the constructed area. Given the fact that the analysis concerned the existing area, it should be perceived as a diagnosis of existing conditions. The elements and phenomena subjected to evaluation concerned: the impact of climatic factors – insolation, ventilation – on built-up areas, traffic noise and the assessment of the intensity of car communication inside the areas selected for testing and their influence on the degree of air pollution.

Sunlight patterns were created in Sketchup computer program. They show not only a spatial picture of the shading of the area during the analysis, but also present the intensity of shading and lighting over the next 10 hours.

The threat of noise in selected settlements has been presented on the basis of the location plan generated by means of a publicly available portal: http://observatorium.um.krakow.pl/ [27]. The colour differentiation signifies the different frequency of road noise expressed in db and thus indicates the areas most at risk of excessive noise.

3.2. The results of the analysis

The subject of the study – the estate of Dywizjonów 303 (Fig. 9), in Cracow – has been inhabited for years, therefore the analysis included the assessment (which was already emphasised) of the existing conditions, not planned. They are shaped by the building structure, and the area free from it, intended for interiors with a social character. The greenery accompanies the neighbourhood and public spaces, taking the form of squares and a park located on the north side. The balance of the greenery expressed by the ratio of built-up areas to the green spaces is very favourable. It has a beneficial effect on the microclimate as a barrier to excessive ventilation of the area and protects it against the road noise and pollution caused the transport. Therefore it contributes to the development of health-promoting conditions.

The structure of the building creates a free, open layout with objects of mixed scale from 4 to 11 storeys. This system determines the free air circulation. Due to the scale of the highest point-spaced objects, the insolation is limited (Fig. 10).

The diagrams show that most sunlit areas are those where the greatest distance between the objects is preserved. In these areas, shading lasts only an hour. Adjacent to them is the area, which shading does not exceed two or three hours.

The shading of the terrain is additionally introduced by the high greenery, the location of objects forming strings and elements co-creating their shape – balconies, roofed entrances to staircases.

Fig. 9. Dywizjon 303 housing estate, source: http://obserwatorium.um.krakow.pl/obserwatorium/ (access: 1.08.2018)

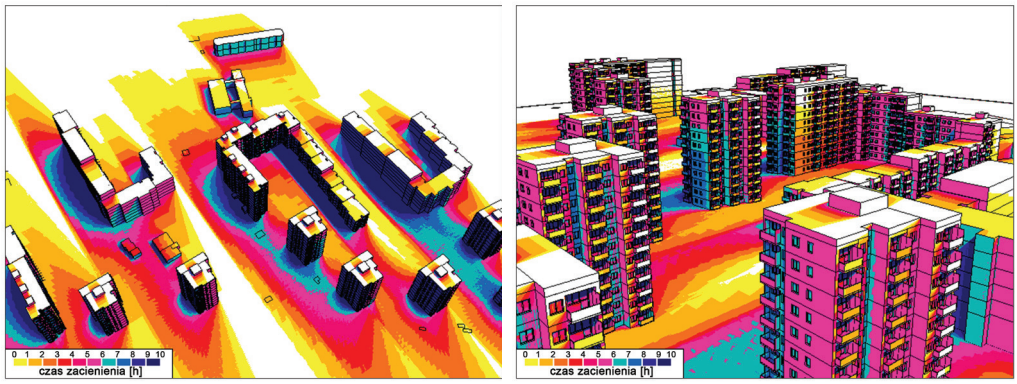

Fig. 10. Diagram of insolation of the Dywizjon 303 estate in Kraków, own study

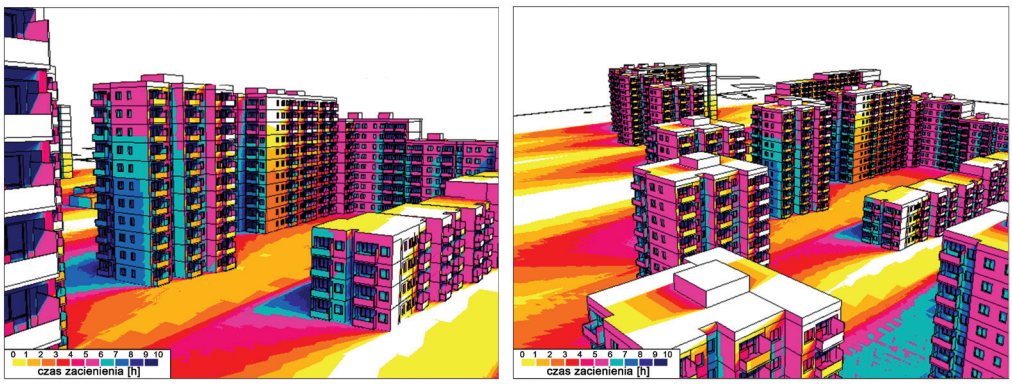

Fig. 11. Shading of the elevation

The façade surfaces from the side of the neighbouring objects are the most exposed to the limited availability of sunlight. The time of shading lasts 6–7 hours. The remaining fragments of the objects – their façades are mostly shaded for 5–6 hours.

The blocks themselves are characterised by a monotony of solutions devoid of individual features, which is typical for multi-family large-panel housing estates from the turn of the 70's and 80's of the 20th century. However, the estate can be assessed positively due to spatial and environmental conditions. The team has large reserves of free areas, which contributes to the formation of pro-health conditions, including maintaining the biodiversity of the space. Also, the harmonious inclusion of housing in the natural environment, and thus adaptation to the existing terrain is important in relation to sozology.

The biggest inconvenience of the housing estate is connected with the intensity of transport traffic (Fig. 12). It forced the application of acoustic insulation such as screens constituting a barrier for noise and vibrations as well as earth embankments. The chaotically arranged communication space inside the housing estate introduces conflicts in its spatial and functional layout. Noise pollution of 65÷70 decibels occurs in the space adjacent to the roads. However, inside the estate, this nuisance does not exist. The highest noise value amounts to 50÷55 decibels.

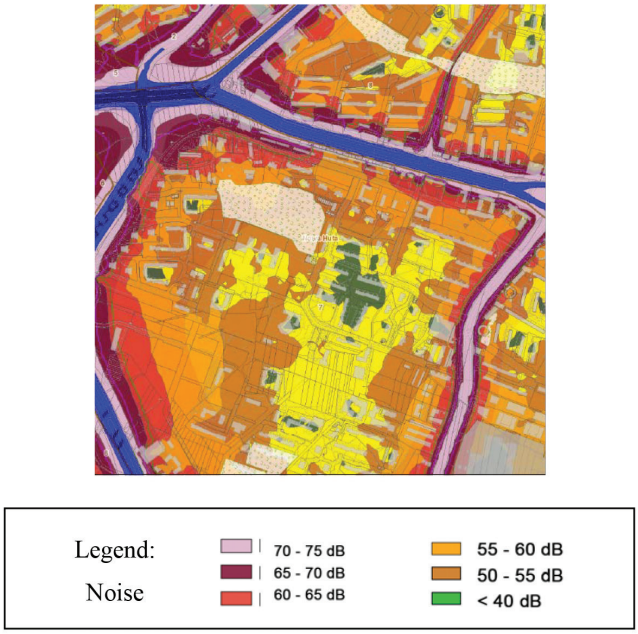

Fig. 12. Noise pollution in the Dywizjon 303 housing estate in Krakow [27]

The analysis offered an insight to the issue of urban sozology dealing with the relationship between the built and the natural environment in order to rationally plan housing areas with the emphasis on the role and importance of the areas constituting the resources of the natural environment. The analysis covered the problem of sun exposure and shading, ventilation and noise pollution. The analysis shows that there are close relationships between the natural environment and architecture, which can be shaped by adjusting to the existing climatic, location, and terrain conditions. The rational use of

these dependencies may contribute to shaping appropriate housing conditions with pro--health features, indicating the need to care for the state of the natural environment (which is consistent with the planning sozology).

4. Final conclusions and remarks

The results of the analysis proved an important role of urban sozology in spatial planning, It includes the relationship between the built and the natural environment in order to rationally plan housing areas with the emphasis on the role and importance of the areas constituting the resources of the natural environment. The analysis covered the problem of sun exposure and shading, ventilation and noise pollution. The results show that there are close relationships between the natural environment and architecture, which can be shaped by adjusting to the existing climatic, location, and terrain conditions. The rational use of these dependencies may contribute to shaping appropriate housing conditions with pro-health features, indicating the need to care for the state of the natural environment (which is consistent with the planning sozology).

In recent years, more and more attention has been directed toward the natural environment. Hence, an urgent need to rediscover the principles of sozology, including urban sozology that allows rational planning of housing areas. The development of design assumptions is characterised by dynamic advances in technology and construction as well as in materials. It enables the pursuit of low-energy architecture, the increased use of renewable energy sources and the creation of friendly living conditions also in the field of urban solutions, as demonstrated by the housing estate selected for the research. The estate of Dywizjonu 303 is an example of implementation from the 70's and 80's. Despite the fact that the areas from that period are characterized by the low standards regarding finishing, architectural detail technological or even spatial solutions. These estates may be perceived positively due to their spatial conditions. They provide proximity to extensive green areas, free building systems, often with a friendly scale. The housing teams in question were the places where neighbours formed close relationships, and the social spaces lived their lives.

Although we return to the idea of the past period, it should be remembered that the lifestyle and the needs of contemporary people have changed. New trends in architecture and spatial planning, taking into account the priorities of planning sozology, try to deal with these issues. They should be regarded as recommendations for housing planning. They include pro-environmental activities, expressed in maintaining appropriate proportions between built-up and building-free areas; creating the possibility of access to open green areas and other assumptions that take into account natural elements. It should be noted that both water assumptions and greenery, apart from aesthetic and functional values, are important in maintaining an appropriate microclimate – air humidity and temperature, but most importantly, they contribute to reduction of air pollution. The walls of greenery used on the roads not only isolate against noise but also absorb pollution from traffic. When designing a residential area, it is necessary to take into account the scale of the building and its impact on the ventilation of the area and the microclimate of the

interior of the buildings, especially on their top floors. The use of appropriate materials on the floor with appropriate roughness and colours enabling reflection or accumulation of radiation heat is also significant. It can, therefore, be assumed that new trends in architectural design that turn towards low-energy architecture using climatic factors and alternative energy sources such as solar radiation or wind energy.

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The issue of integration of elevated transport routes in the areas of historic polish cities. Example of the modernization of a cross-city railway line in the Śródmieście district of Kraków

Problem integracji nadziemnych tras komunikacyjnych w obszarach zabytkowych polskich miast. Przykład modernizacji średnicowej linii kolejowej w obszarze krakowskiego Śródmieścia

Abstract

The aim of the article includes presentation and interdisciplinary analysis of design solutions proposed in the works awarded in the international urban architecture competition entitled "New life between flyovers" and concerning the area around the cross-city railway line, currently under modernization, running through the Śródmieście district in Kraków, from the area of Miodowa Street to the PKP Kraków Główny station. In the applications, possible scenarios of flyovers space development and the possibilities of integrating the transport route into the historic district have been assessed, taking into account historical urban relations and contemporary technical conditions. The analyses were aimed at optimising future investments so that they can become a starting point for public consultations, drafting a land development plan and determination of the development strategy for the studied area. The applied method may be helpful in determining the directions of a spatial policy aimed at the protection of cultural landscape endangered by overground transport routes.

Keywords: Kraków, integration of transport routes, public space, railway flyover, railway viaduct, modernization of infrastructure, modern architecture, adaptation

Streszczenie

Celem artykułu jest przedstawienie i interdyscyplinarna analiza rozwiązań projektowych zaproponowanych w pracach nagrodzonych w międzynarodowym konkursie urbanistyczno-architektonicznym „Nowe życie pomiędzy estakadami", dotyczącym obszaru wokół modernizowanej obecnie średnicowej linii kolejowej przebiegającej przez krakowskie Śródmieście od rejonu ul. Miodowej do stacji PKP Kraków Główny. We wnioskach oceniono możliwe scenariusze zagospodarowywania przestrzeni pomostowych i możliwości integracji tras komunikacyjnych z zabytkową dzielnicą z uwzględnieniem historycznych relacji urbanistycznych i współczesnych uwarunkowań technicznych. Analizy te ukierunkowano na zoptymalizowanie programu przyszłych inwestycji, tak aby mogły stanowić zaczyn do konsultacji społecznych, opracowania MZPZ i wskazania strategii rozwoju badanego obszaru. Zastosowana metoda może być pomocna przy wytyczaniu kierunków polityki przestrzennej, służących ochronie krajobrazu kulturowego zagrożonego przez pojawianie się naziemnych tras komunikacyjnych.

Słowa kluczowe: Kraków, integracja tras komunikacyjnych, przestrzeń publiczna, estakada kolejowa, wiadukt kolejowy, modernizacja infrastruktury, współczesna architektura, adaptacja

1. Introduction

The issue of elevated transport routes in historical areas in Polish cities gains on importance especially in the face of the necessity of modernizing and restructuring the existing railway infrastructure [1]. It is accompanied by a technical discussion on the operation efficiency of specific systems and their influence on the development of agglomerations and life comfort of their inhabitants. Discussions also concern specialized issues connected with the influence of city flyovers, viaducts, and bridges on the formation of historical-cultural landscape. As a result of growing transport needs, both in the local and super-local context, railway lines are already being modernized in Kraków [2], Warszawa [3], and Gorzów Wielkopolski, where in 2019 regeneration of a 2-km stretch of a city flyover was completed [4]. Wrocław[1] is at the stage of feasibility analysis. The most efficient solution to the problem of elevated routes disturbing the urbanized structures includes demolishing them and replacing with tunnels what has been done for example in Rotterdam [6], Stuttgart [7] and Łódź [8]. This allows for essential improvement in the fluency of railway and city traffic, reduction of noise levels and gaining attractive investment areas. However, such solutions are extremely complex to implement and costly. Therefore, a need emerges to search for methods of reconstructing and adapting space over and under bridge structures to accommodate services and green areas there and to integrate them into the historical city tissue.

In this article, we analyse possible solution scenarios for areas in the direct vicinity of elevated transport routes at the example of concepts awarded in the international urban planning and architecture competition "New life between flyovers". This competition closed in October 2018 and pertained to the cross-city railway line crossing the Śródmieście district in Kraków that has been in the process of modernization for a couple of years [9]. In 2019, commissioned by the Kraków City Office, we run analyses aimed at an assessment of potential variants for development of bridge areas proposed in the competition, taking into account historical urban development relations and technical conditions. We used comparative materials from experiences in the implementation of similar investments all over the world [10]. The conclusions drawn serve as a basis for social consultations, development of a city land development plan and future investment in PKP areas. They should also be helpful in determining further directions in space policy and development strategies for the Śródmieście district in Kraków.

2. The origin and terms of the competition

International, open, two-stage studio competition in urban design and architecture, organized by the Kraków City Office and Kraków SARP branch in May 2018, pertains to areas in the Kraków city centre related to railway embankments and flyovers from

[1] In June 2019, PKP PLK presented an enquiry for development of Preliminary Feasibility Study for the Wrocław Railway Junction that would apply to all the railway lines in the city of Wrocław and in the surrounding 19 communes [5].

PKP Kraków Główny Railway Station to the Vistula River (between Kopernika St. and Podgórska St.) in the Śródmieście district. The surface area subject to competition was ca. 199,300 m^2, with the free space under new flyovers estimated at ca. 15,000 m^2. The competition area is currently subject to dynamic changes related to PKP PLK investment started in 2012 and entitled *Works on the E30 railway line from Kraków Główny Towarowy to Rudzice, with added agglomeration railway tracks*, that includes modernization works covering many industries at a great degree of complexity. The goal of this investment, co-financed by the European Union under CEF instrument "Connecting Europe" (investment value exceeding one billion zloty) was to adapt the parameters of the city line to new standards and international AGC requirements (on major international railways lines) and AGTC (on major international combined transport lines) for transport corridors i.e. for circulation of passenger rail with classic cars, with max. speed of 160 km/h and cargo cars with a speed of 120 km/h [11].

Competition documentation was very vast and included, among others, video and photo documentation of the area, basic and cadastral maps, binding and currently proceeded city plans, as well layouts and investment schemes of PKP PLK. Historical development depicting the creation and development of cross-city railway line [12] constituted an important element of competition materials (Figs. 1 and 2).

Fig. 1. Fragment of "Kraków City Cadastral Map" of 1848 with the future railway line stretch marked [12, p. 14]

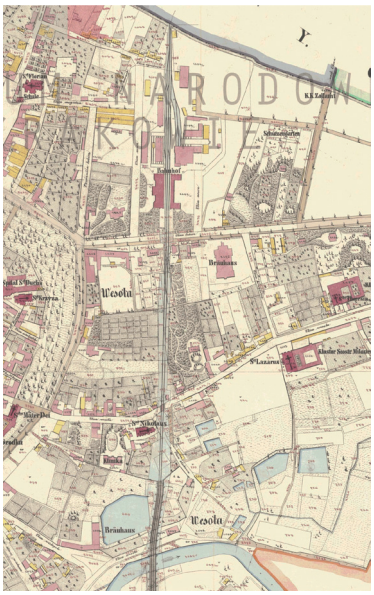


Fig. 2. Fragment of the "Kraków City Cadastral Map" from 2nd half of the 19th century depicting the course of the southern stretch of the railway line [12, p. 15]

Fig. 3. Fragment of a contemporary Kraków City map depicting the course of the central cross-city railway line under modernization since 2012 (basic map of the area subject to the development, M2 appendix to competition rules [9])

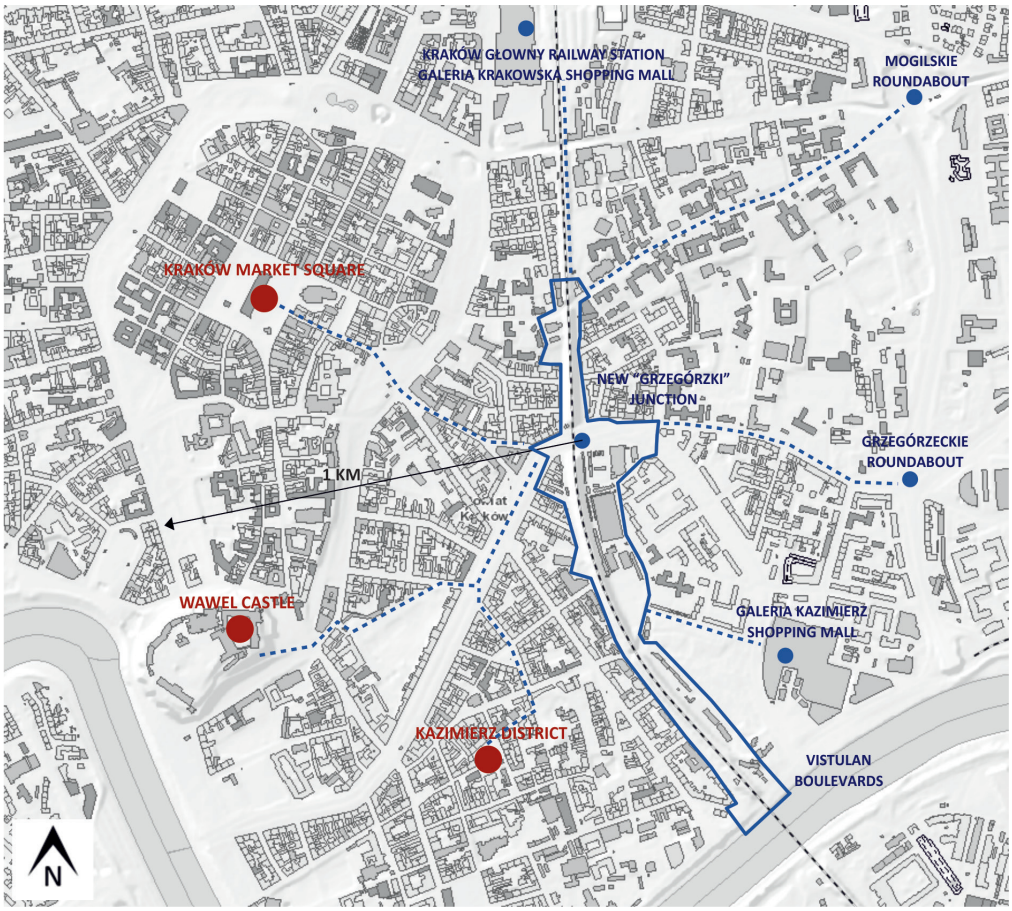


Fig. 4. Location of the modernized cross-city line, from Kraków Główny Railway Station to the other bank of the Vistula river and major transport connections for this area, and the scope of competition development (by E. Komarzyńska-Świeściak)

The point of departure for competitions concepts included "fait accompli" by PKP PLK that, without consulting it with city authorities, decided to replace the existing embankments with flyovers with a purely structural form, with the areas under them intended for car parks [13]. In the area subject to competition, between the Kraków Główny railway station and the Vistula river, the scope of PKP PLK works included among others construction of a new railway station (Kraków Grzegórzki), 850 m of the railway line on a 4-track flyover from Kopernika St. to Miodowa St. (replacing the former embankment) (Figs. 3, 4 and 5), as well as adding two tracks (from the eastern side) to the historical railway viaduct over Grzegórzecka St. (Dietla St.) (Fig. 6)[2]. This investment of PKP PLK significantly changed urban, transport and social relations for the whole Kraków agglomeration. A special challenge includes the integration

[2] Since then, new viaducts and flyovers under the first, out of four, tacks have been created. Further, demolition of the 19th century embankment and construction of viaducts and flyovers for the remaining tracks is planned [2].

of the newly-created facilities with the historic environment, both from the point of view of architectural composition and their functional role. The analysed stretch of currently modernized railway is located in an area subject to art restorer's protection and entered on the list of historical urban layouts and having the status of Historical Monument. Moreover, two facilities (viaducts) along this railway line are subject to art restorer's protection as these are entered on the list of historical facilities. The development in the vicinity of the embankment is also protected with individual decisions on entry to the list of historical facilities or commune record of historical buildings [9]. In such a situation, the main task before competition participants was to propose a method of developing and using the space under bridge structures (in the place of former embankments) and designing a fully integrated transport junction (railway – new Kraków Grzegórzki SKA[3] station, tram, bus, bike) that

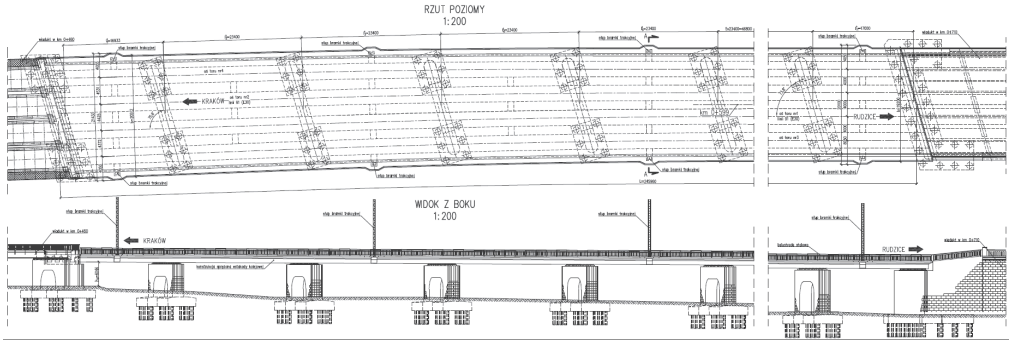


Fig. 5. Scope of modernization of the railway line between Kraków Główny Railway Station and the Vistula River: site plan – stage III [13]

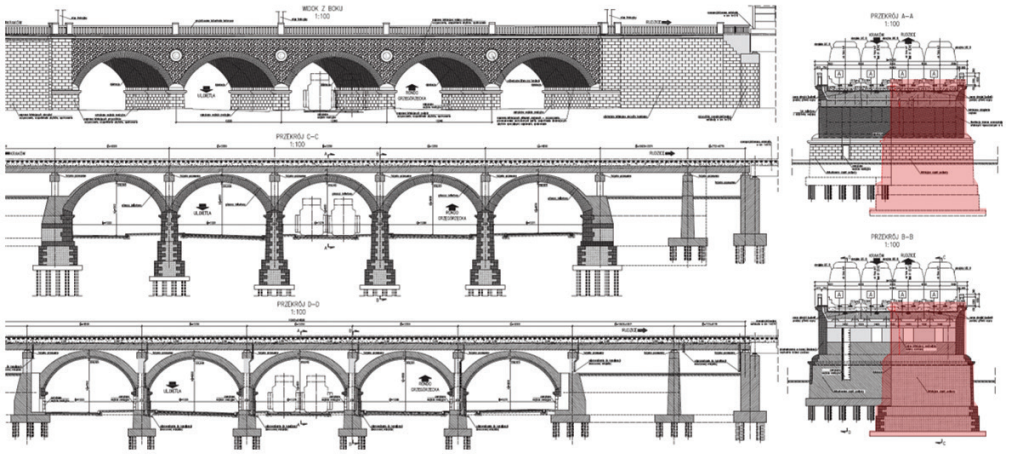


Fig. 6. Scope of modernization of the railway line between Kraków Główny Railway Station and the Vistula River: expansion by two tracks (from the eastern side) of the historical railway viaduct over Grzegórzecka St. (Dietla St.) [13]

[3] SKA – high-speed urban railway in the Krakow Agglomeration.

would take over a large share of passengers using the Kraków Główny railway station [9, p. 14][4]. The area subject to competition included not only the space created under the built flyovers and expanded viaducts, but also areas adjoining the reconstructed railway line and pertained to the creation of frontages of surrounding streets and interrelations in space that has previously been separated by the railway embankment.

The subject to the first stage of the competition included urban development plans with a proposal for functional and space programme for the "recovered" space thanks to a reconstruction consisting in demolishing embankments and replacing them with "transparent" flyovers. This pertained to new urban and transport relations and also opportunities for using the adjacent areas and new opportunities in shaping city centre that will emerge once the embankment barrier disappears. The subject of the second stage of the competitions included an architectural concept for a fragment of the reconstructed railway line located between Kopernika St. and Grzegórzecka St. and including three spans together with their direct vicinity. It was required to present it both in the form of drawings in 1:500, 1:200 scale, and in the form of a model in 1:50 scale (Figs. 7, 8).

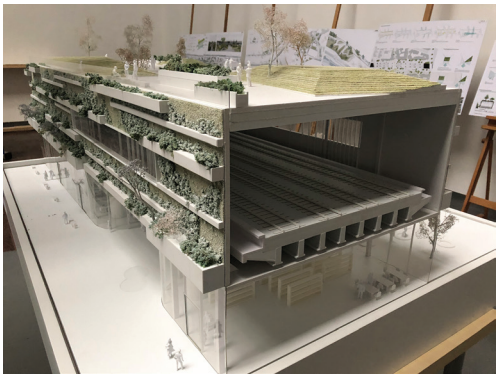


Fig. 7. Three-layer functional hybrid: model in a 1:50 scape (2nd stage of the competition), 1st prize (Ton Venhoeven c.s. Architekten B.V., the Netherlands) (by E. Komarzyńska-Świeściak)

Fig. 8. Roofed pedestrian and bike passage with extensive green areas: model in a scale 1:50 (2nd stage of the competition), 2nd prize NM architekci Z. Szpocińska and T. Marciniewicz; K. Kamieniobrodzki, J. Grochulski, G. Rejniak, Warszawa) (by E. Komarzyńska-Świeściak)

In competition conditions, it was also stressed that proposals concerning functions under the flyovers should take into account the fact that railway traffic generates vibrations and noise. Its elimination should be included in the proposed design solutions. The main goal of the competition was to obtain variant concepts and ideas for the development of the whole historical Kraków city center that would be useful in setting directions for urban development strategies and policies, for dialogue, and social consultations. As it was stressed in competition

[4] The Grzegórzki junction will provide attractive possibilities of changing between various public transport means, but will also become a starting point for walking for the inhabitants of this area and travellers heading to the Old Town and Kazimierz districts. Passenger traffic in this station would be only slightly smaller than in Kraków Główny railway station. Major traffic congestion is expected in the morning. Ca. 2400–3000 will get off trains per hour, with ca. 1100–1300 getting on. Nearly all of them will use the passage to Grzegórzecka St. [9, p. 14].

rules: "the ordering party expects modern land development, urban layout, architectural, technological and ecological solutions of top quality, developed with special attention paid to the spacial context: urban layout, historical, transport and social; it expects proposal of a vision of a city-friendly for its inhabitants" [9, p. 12].

3. State of the art

The analyses presented in this article constitute a continuation of many years of our research in regeneration of historical public utility facilities, including railway stations and junctions [14, 15], as well as conditions and form of functional and spatial transformations for the areas under bridge facilities implemented in European cities at the turn of the 21st century [16]. Example reconstructions of railway flyovers collected and analysed during this research provided a valuable reference point for assessing the feasibility of the solutions proposed in the competition, estimating their costs and impact on the urban environment. The bibliographic analysis points to insufficient research comprehensively dealing with the integration of elevated transport routes in historical city areas. The issues concerning developing space under bridge facilities, if aborded at all in Polish scientific discourse, mostly pertains to historical issues [17–19] or are reduced to small architecture with green areas in the vicinity of transport routes [20, 21]. World literature is also scarce in overview works on investments of this type. What is mostly encountered are case studies of specific implementations [22, 23], and essays on such issues [24].

4. Research methodology

The topics discussed by the authors when analysing results of the "New life between flyovers" competition border several scientific disciplines i.e. architecture and urban development, construction, and transport, as well as broadly understood environment shaping. The analyses covered solutions in urban design and city engineering, architecture connected with construction, vibro-acoustics, protection of historical facilities and cultural landscape. Sociological data obtained from social consultations was also used. The main focus was to generate conclusions relating to use plans and creation of space around the flyovers. Such conclusions will serve as a basis for further social consultations and provide some guidelines for future provisions of urban land development plans.

Post-competition analyses included the following elements:

- The character of competition works;
- Characteristics of the area subject to the development (division into zones);
- Solution scenarios and their assessment in the context of the researched areas (questionnaires, cross-industry discussions, assessment of the solutions based on reference implementation, cost estimation);
- Recommended solutions and potential directions for actions;

- Summary and conclusions;
- Problems and contemporary trends in the development of transport areas (annex).

For the purpose of precise assessment of design solutions in the competition, it was necessary to analyse the current condition of the area subject to the competition. Local inspection together with analysis of historical [9] and urban planning [25–33] documents allowed for dividing the area into four functional zones characterized by their vicinity and cross-section of the route (Fig. 9):

- **ZONE A**: the area along the flyover, between Podgórska St. and Miodowa St.;
- **ZONE B:** the area under Miodowa St. – "Grzegórzki" junction flyover;
- **ZONE C:** integrated "Grzegórzki" junction (Fig. 10);
- **ZONE D:** the area under the flyover and the adjacent green area between "Grzegórzki" junction and Kopernika St. (Fig. 10).

The main assumption for post-competition analysis was to search for scenarios without replicating the work of competition jury who already performed an in-depth assessment of

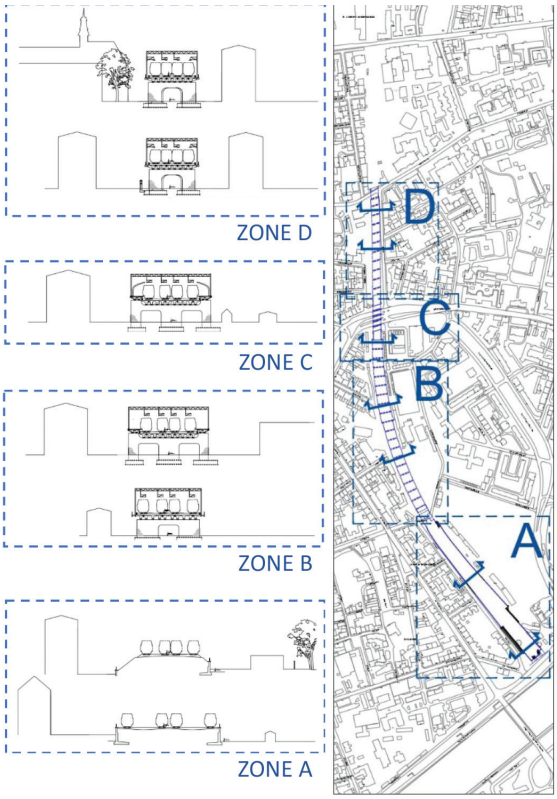


Fig. 9. Division of the area along the new cross-city line and under it into four stretches (functional zones) [10]

Fig. 10. Selected fragments of the area, two overview photos: zone C – historic viaduct at "Grzegórzki" junction and new-built flyover situated along existing market Unitarg, lower photo: zone D – view of the flyover along Blich St. (by E. Komarzyńska-Świeściak)

each work. Thus, the analysis was limited to short characterization of the works and pointing to their distinctive features. Then, we proceeded to indicating and characterizing the scenarios for programme and design solutions included in these works. Finally, we compared specific work zones with optimal solution scenarios for them (cf. chapter 6). Synthesis of the obtained results allowed for formulating conclusions for further perspectives and setting directions for spatial policy as well as development strategies for the analysed area.

5. Assumptions and characteristics of the awarded competition entries

Results of the first stage of the "New life between flyovers" competitions were announced in August 2018. Four works were qualified for the second stage. In October 2018 Competition Jury, composed of arch. Tomasz Bobrowski, arch. Jacek Ewý, arch. Marlena Happach, Piotr Lewicki, arch. Stanisław Deńko, Krzysztof Drebot and Leszek Jasiński, decided to grant three awards and one distinction (Fig. 11). Characteristics of the awarded works provided us with a set of starting scenarios for consideration for specific locations between the Vistula River and the Kraków Główny Railway Station.

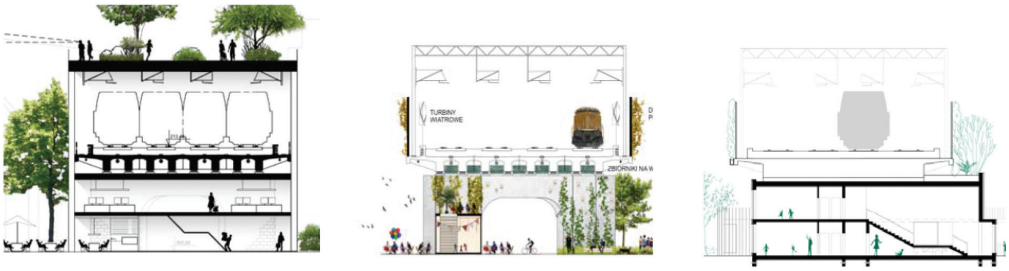


Fig. 11. Selected cross-sections of the railway flyover from Podgórska St. to Dietla St., fragments of competitions works qualified for the 2nd stage of the competition. From the left: 1st award (Ton Venhoeven c.s. Architekten B.V., the Netherlands) [34], 2nd award (NM architekci Z. Szpocińska and T. Marciniewicz; K. Kamieniobrodzki, J. Grochulski, G. Rejniak, Warszawa) [35], 3rd award (Miastopracownia Dominika Wilczyńska, Kraków) [36]

1st award: *Tri-layer functional hybrid*[5] is a project authored by architects E. Anthonie, J. Venhoeven, J.-W. van Oorschot, P.M. Gierek, M.A. Reinares San Martin, G. Baliński, A. Ganczarek from Ton Venhoeven c.s. Architekten B.V. from the Netherlands. This project plans recuperation of 150% of the area lost as a result of constructing the railway line (50% at ground level and 100% and tunnel roof level). The idea is to create a linear park over the flyover – the New Planty (Fig. 12) that together with Aleje Trzech Wieszczów and the Vistulan Boulevards (in the future also Kalwaryjska St.) would create an attractive route with unique historical, vantage and functional values encircling the Kraków city centre (Fig. 12). Transformation of the new cross-city route into elevated green areas can be compared with the creation of a green "Boulevard Hausmann" Dietla St. in Vistula oxbow.

[5] Name adapted by the authors of this paper.

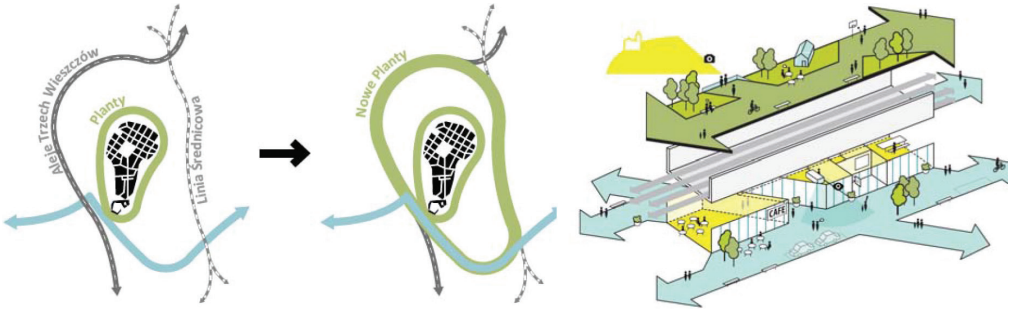


Fig. 12. On the left: Scheme illustrating the urban planning idea behind the project i.e. creation of the New Planty over the flyover and closing the green ring with a unique historical, vantage point and functional values. On the right: scheme illustrating the tri-layer functional hybrid. 1st award (Ton Venhoeven c.s. Architekten B.V., Amsterdam) [34]

When analysing this solution in architectural scale, it must be noted that the proposed transformation of the cross-city route into a tri-layer functional hybrid (Figs. 12–14) creates attractive functional spaces at three levels:

- Under the flyover: a sequence of service points, shops, sport and recreation spots with city-forming functions and functions intended for inhabitants stimulating positive changes in the surrounding public space and partially financing the upkeep of the public park in the top layer.
- At the railway line level, there is an infrastructural tunnel intended to completely eliminate the nuisance related to the railway and increase in railway traffic.
- Over the railway, there is a public park intended to conned the Kraków Główny railway station with Market Hall and Vistulan Boulevards and to provide vantage points over the city, as well as to introduce some green areas to the densely developed central area.

Fig. 13. Visualization of the city park over the railway line with city panorama – 1st award (Ton Venhoeven c.s. Architekten B.V., Amsterdam), source: https://dialogspoleczny.krakow.pl/wp-content/uploads/2018/10/1_Konk_Estakady_nagr_1.pdf

The park development design is based on vantage axes determining pedestrian routes and guaranteeing some intimacy feel to the inhabitant of the surrounding areas: pedestrian route at the level of residential building windows are drawn to the inside of the park or separated

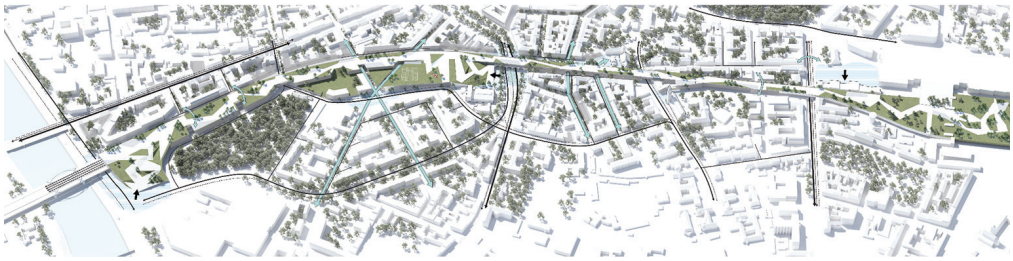


Fig. 14. Visualization of the designed development of the area around the modernized cross-city line – bird's eye view. 1st award (Ton Venhoeven c.s. Architekten B.V., Amsterdam), source: https://dialogspoleczny.krakow.pl/wp-content/uploads/2018/10/1_Konk_Estakady_nagr_1.pdf

from its edge with pot with plants. Compared to other works, this concept provides for maximum reduction of the negative impact of the railway traffic on the city. It actually consists in running the railway line in an overground tunnel (Fig. 15). According to the authors, such a tunnel should effectively reduce noise levels, air ionization, facilitate maintenance of the track and technical systems [34]. It provides for individually designed steel-structure walls with mixed filling: full (concrete prefabricated elements: boards for climbing plants and pot for plants and trees) or semi-transparent where travellers could enjoy the interesting view from the train board. Such a solution would, of course, be costly, but for example a similar Wientalterasse Park was implemented in Vienna (over a stretch of ca. 80 m), and another one, much longer of 800 m, was created on the roof of railway route running in a "tunnel" in the Sants district in Barcelona (Fig. 22). Architects assume that the height of the whole structure, together with the park, would not exceed cornices of the surrounding tenement houses and proportions in street parallel to the flyover would be similar to the surrounding, historical ones (Figs. 15, 16). Compared to other awarded works, this concept provides for

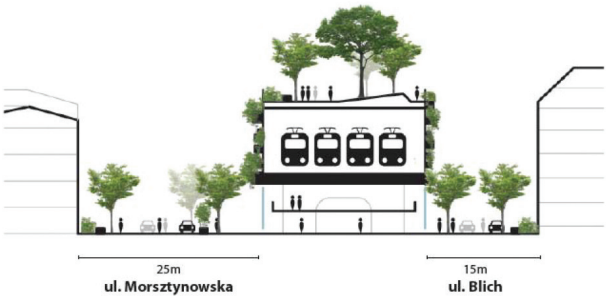


Fig. 15. Development and construction plan for the area under the new railway flyover of the modernized cross-city route; cross-section – a fragment of the competition work, 1st award (Ton Venhoeven c.s. Architekten B.V., the Netherlands) [34]

Fig. 16. Visualization of the new development and structures under the new railway flyover of the modernized cross-city route – a fragment of the competition work, 1st award (Ton Venhoeven c.s. Architekten B.V., the Netherlands) [34]

most extensive development and commercialization of the area under the flyovers consisting of multi-functional sales and service points activating the inhabitants (the area of Blich St.) with transparent shop windows and entries of parallel streets. Such development would cover 24 out of 30 free flyover spans.

Assumptions behind the concept winning 2nd prize, authored by a design team from Warszawa (NM architekci Z. Szpocińska and T. Marciniewicz, and K. Kamieniobrodzki, J. Grochulski, as well as G. Rejniak) were similar to those of the Dutch team. This proposal included the creation of an overground pedestrian and bike route under the cross-city route that would connect Planty Dietlowskie with Planty, along Daszyńskiego St., creating the common Planty Starorzecza that could provide an alternative to the pedestrian-bike path along the Boulevards (cf. Figs. 12, 17). Work of the Warsaw team proposes city-forming functions located exclusively under the flyover and intended for both inhabitants and visitors, with a representative, roofed pedestrian-bike passage, from Miodowa St. to Kopernika St. The passage could become a new communication route creating attractive public space. This project assumes three types of pedestrian traffic under the flyover [35]:

- Transit pedestrian – from point A to point B – finished with concrete slabs.
- Walking pedestrian – with direct access to green areas – finished in wood (Fig. 18, 19).
- Didactic footbridge – suspended under the flyover, running between vertical gardens designed on flyover supports.

Fig. 17. Layout illustrating the main idea behind this project i.e. creation of a new, overground walking and bike loop under the flyover of the new cross-city route – a fragment of the competition work, 2nd award (NM architekci Z. Szpocińska and T. Marciniewicz; K. Kamieniobrodzki, J. Grochulski, G. Rejniak, Warszawa) [35]

Fig. 18. Visualization of the structures under the flyover and green acoustic screens above – near Morsztynowska St. 2nd award (NM architekci Z. Szpocińska and T. Marciniewicz; K. Kamieniobrodzki, J. Grochulski, G. Rejniak, Warszawa) [35]

The design that won 3rd award, entitled *MARKET & RIDE concept – in search of open space*[6], authored by Miastopracowna Dominika Wilczyńska from Kraków (team consisting of D. Wilczyńska, B. Nawrocka, A. Gryc, E. Szymczyk, D. Włodarczyk, J. Nawrocki), is a proposal that combines the super-local perspective with local one [36]. The structural intensity, in this case, is intermediate between the versions granted the first two awards (cf. Fig. 20).

[6] Name adapted by the authors of the project [36].

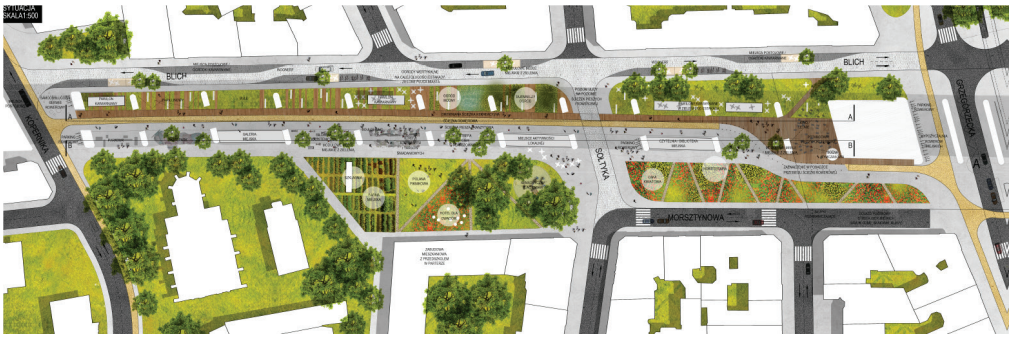


Fig. 19. Project for the development of the area between Grzegórzecka St. and Kopernika St. (scope required for stage II of the competition). 2nd award (NM architekci Z. Szpocińska and T. Marciniewicz; K. Kamieniobrodzki, J. Grochulski, G. Rejniak, Warszawa) [35]

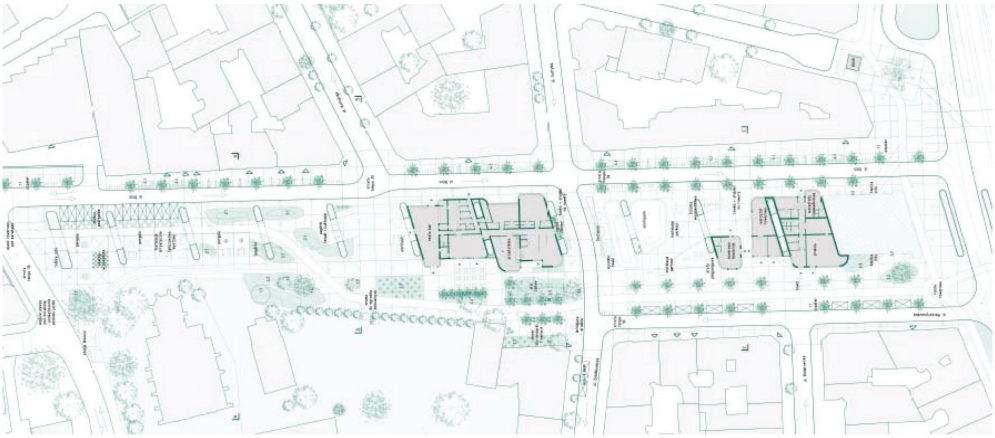


Fig. 20. Project for the development of the area between Grzegórzecka St. and Kopernika St. (stage II of the competition). 3rd award (Miastopracownia Dominika Wilczyńska, Kraków) [36]

This project balances structural elements and open public grounds in the area under the flyover, at the same time giving individual stretches some local character (in response to fears of the inhabitants of excessive commercialization of this area, formulated at the social consultation stage [37]). The main concept is based on two pillars.

- MARKET, represented by a two-level market, new local centre, woonerves and squares with sport and recreation functions,
- RIDE which in this case is a combination of transit function and transfer place within the Grzegórzki junction, and intensification of public city transport, pedestrian and bike traffic with a simultaneous reduction in car traffic levels.

The concept, studio competition "New life between the flyovers" allowed the architects, inhabitants, and decision-makers to visualize a whole variety of ideas, including innovative and original solutions. Results of this competition are not equivalent to the city implementing a given project, as it was not the goal of this competition [38]. As the jury verdict justification reads: "All the submitted competition project constitute very valuable materials allowing

for a comprehensive look at the development of Kraków city centre and they include many valuable proposals for solving these issues. Therefore, the knowledge gained as a result of the competition should be used for further works on setting the directions for development strategies, and then for planning and designing" [39, p. 1].

6. Proposed typology of design solutions

As already mentioned above, because of the need to obtain objective assessments of usability of specific solutions, in the analysis of competition results, we renounced comprehensive analysis and assessment of the awarded works. Instead, we proposed indicating and characterizing the programme and design solutions proposed there as scenarios adequate for individual areas (Fig. 21).

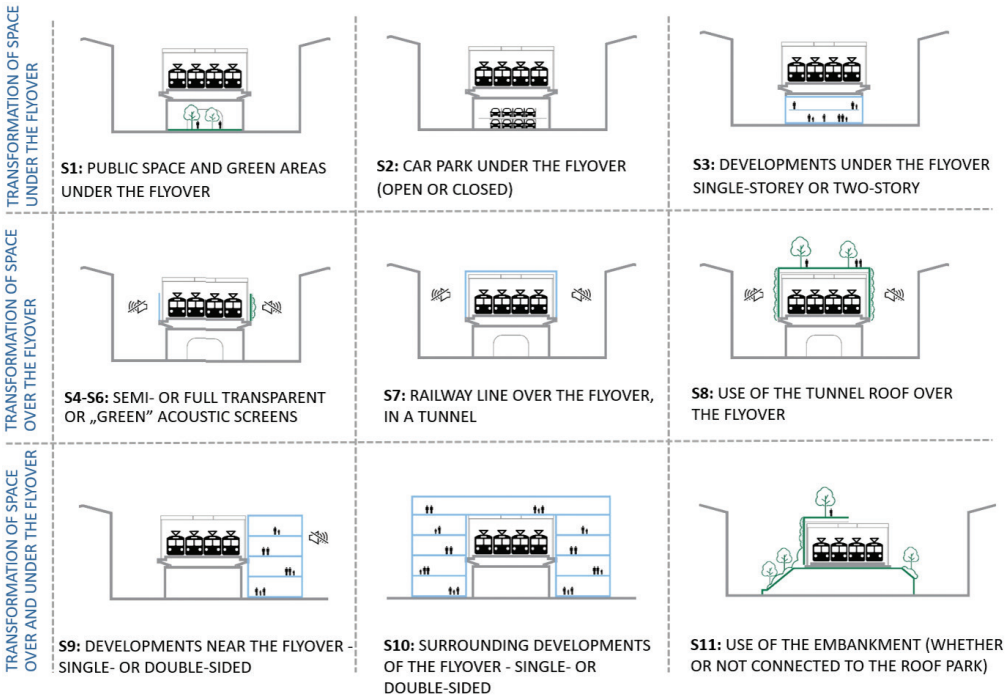
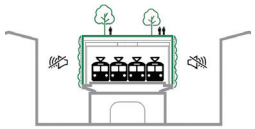


Fig. 21. Comparison of scenarios encountered in competitions works isolated in the post-competition analysis [10]

These solutions have been classified according to:

- Transformation of space under the flyover
  - Scenario 1: public space and green areas under the flyover,
  - Scenario 2: open car park (single-story) or two-story (open or closed) under the flyover,
  - Scenario 3: developments under the flyover – single-storey (free standing) or two--story (freestanding or covering the whole space) shopping facilities;

Table 1. Fragment of a table with characteristics of scenarios encountered in competition works isolated in the post-competition analysis [10]. Scenario 8 i.e. use of the tunnel roof over the flyover. Scope of description: pictogram, description of the solution (basic data, complexity level, estimated costs), reference implementations, indication of competition works which proposed a given scenario, advantages and disadvantages of the variant in the context of the analysed area [10]

No	Scenarios encountered in competitions works isolated in the post-competition analysis	Description of the solution / basic data / Complexity level	Reference implementations	Indication of competition works which proposed a give variant
8	 Transformation of space over the flyover, scenario 8: use of the tunnel roof over the flyover	Functional and spatial variants Linear parks connected with transport routes are mainly organised on downtown, off-road or railway flyovers, such as the High Line in New York, Viaduct des Arts in Paris or Seoullo 7017 promenade in Seoul. Linear parks are also being created over active railway flyovers, such as Rambla de Sants in Barcelona. Such a solution – a park located on the roof of the "tunnel" enclosing the existing embankments and flyover - was proposed in the winning competition work. The park stretches over a distance of two kilometers above the entire railway route from Vistulan Boulevards to Kraków Główny Railway Station. The pedestrian passageway-garden implemented on the roof of the "tunnel" is attractive and varied. It connects with the adjacent areas by means of stairs and lifts, and large slipways (roof decks). In many places it is an excellent viewing platform. The scale of the project is unprecedented, which would make such a structure extremely attractive, but would also entail huge technical problems and costs. In sections where the flyover runs close to buildings (from Podgórska St. to Grzegórzki junction and north of Kopernika St.) such a 15-metre high structure would obscure the view from windows. Therefore, it seems that the implementation of such a development would be justified only on a part of the route.	▸ Olympic Sculpture Park in Seattle – linear park over train tracks and an arterial road – Weiss Manfredi; ▸ Vienna Valley Terrace – public space bridging over the entrenched U4 subway line – Architekten Tillner Willinger; ▸ Miyashita Park above a parking lot in Tokio – Atelier Bow-Wow; ▸ High Line – linear park on a closed railway flyover – Field Operations and architects Diller Scofidio + Renfro (New York); ▸ Rambla de Sants in Barcelona – city park covering the railway line – Sergi Godia, Ana Molino, arquitectos Esteyco Ingenieria; ▸ Seoullo 7017 in Seoul – park on a closed road flyover – MVRDV; ▸ Promenade plantée in Paris – linear park on a closed railway flyover – Jacques Vergely and architect Philippe Mathieux; ▸ Madrid Rio in Madrid – linear park over burried city's Ring Road – West8; ▸ all kinds of wildlife bridges over highways (estimated cost: ca. 19mln PLN/100 running m).	Project with 1st award (a linear public park designed to connect the main railway station with Unitarg Fair Hall and Vistulan Boulevards, as well as to highlight the city's scenic values and introduce greenery into the densely built-up area of the city centre). Project with 2nd award (no tunnel with a park). Project with 3rd award (no tunnel with a park).
	ASSESSMENT OF FEASIBILITY: The implementation of a linear park on the roof of the "tunnel" enclosing the railway flyover can be rational within the Grzegórzki station (ZONE C) and on the section between the station and St. Nicholas church (ZONE D). In the remaining sections, due to the size of such a structure and small distances from tenement houses, the view from all windows would be obscured, which undermines the purpose of this solution. ESTIMATED COSTS: The cost of constructing a linear park on the roof of the tunnel enclosing the railway flyover would be extremely high. Additional increase of costs would be necessary to ensure safe access (lifts, escalators) and evacuation of users and appropriate systems enabling vegetation of greenery. The whole "tunnel" with a line park would cost about 1 million PLN per 1 running meter of the structure. TECHNICAL SOLUTIONS: The construction of a "heavy" linear park slab would have to be supported by the construction of a "tunnel", which can only have supports beyond the outline of the flyover. Due to its large width (from 20 to 30m) and loads of about 10 kN/m2, such a structure would have to have large cross-sections (in the winning work it was shown symbolically without any indication of dimensions). ADVANTAGES: A unique architectural structure would provide a new accent in the cultural landscape of Krakow. The greenery of the park would compensate for the cutting down of several hundred trees removed during the construction of the flyover. Excellent views of the panorama of Krakow from the level of the park would be possible. DISADVANTAGES Cultural landscape change in a historic district. Huge costs of construction and maintenance of the object.			

- Transformation of space over the flyover
  - Scenario 4: semi-transparent acoustic screens,
  - Scenario 5: fully transparent acoustic screens,
  - Scenario 6: "green" acoustic screens,
  - Scenario 7: railway line over the flyover, in a tunnel,
  - Scenario 8: use of the tunnel roof over the flyover;
- Transformation of space over and under the flyover
  - Scenario 9: developments near the flyover – single- or double-sided,
  - Scenario 10: surrounding developments of the flyover – single- or double-sided,
  - Scenario 11: use of the embankment (whether or not connected to the roof park).

Additional scenarios (e.g. scenario 10 with surrounding developments around the flyover) were added to the scenarios proposed in the awarded works to create a broader spectrum of transformation possibilities for the cross-city line (Fig. 21). Each of these scenarios was described in detail and symbolically represented in the table whose selected fragments can be seen in the table (Tab. 1). This breakdown informs which of the awarded works proposed a given transformation and references implementations were also provided (cf. Figs. 22–25) where such a solution was realized (some of these investments were also discussed in a vast appendix to the analyses).

The analyses included assessment of implementation feasibility for a given transformation form in the area of the new cross-city route with an indication of optimal location for a given structure. Costs and technical complexity level for implementation of each of the scenarios were also estimated. Advantages and disadvantages of specific solutions in the context of applying them in a selected fragment of the area under analysis were also indicated. Such conclusions from the analysis allow for indicating recommended solutions and determining potential directions for actions in the area of the new cross-city route.

Fig. 22. Implementation of scenario S8: the JARDINES ELEVADOS DE SANTS project – surrounding structures and covering the railway line (a stretch of ca. 800 m, surface area of 48,400 m^2) with a city park in Rambla de Sants district in Barcelona, designed by Sergi Godia, A. Molino, arquitectos Esteyco Ingenieria (https://www.plataformaarquitectura.cl/cl/801124/jardines-elevados-de-sants-en-barcelona-sergi-godia-plus-ana-molino-architects)

Fig. 23. Implementation of scenarios S9 and S10: design of an office and service building over a decommissioned flyover in Vienna (13,700 m^2, length ca. 180 m), designed by Tillner und Willinger ZT GmbH, 2008 (https://www.b2match.eu/system/building2017/files/01_TILLNER_ONLINEVERSION.pdf?1495443960)

Fig. 24. Implementation of scenario S1: the VIA VERDE project – vertical gardens covering pillars of the flyover for Mexico City ring road (the gardens are intended to cover eventually 1000 pillars), designed by VerdMX (https://www.thecivilengineer.org/news-center/latest-news/item/1157-vertical-gardens-in-mexico-city-to-combat-pollution)

Fig. 25. Implementation of scenario S3: market hall Im Viadukt under Wipkinger Viadukt and Lettenviadukt in Zurych (9008 m^2, stretch length ca. 600 m), designed by EM2N, 2010 (https://www.im-viadukt.ch/en/home/?lang=set)

7. Conclusions

The awarded competition works can above all show the Kraków inhabitants, that in spite of the destructive influence of the elevated, expanded and modernized railway line, the recovered spaced under and over the flyovers can also play a constructive role. These areas may be included in the network of public space and the feeling of a transport route as a physical and mental barrier in the city may be minimized. A significant number of works took up the challenge to search for a new formula for the space around the new cross-city route, mostly interpreted as multifunctional public space integrated into the surrounding space and adapted to its context and the needs of local communities. This linear, adapting functional structure may be a warranty of high-quality combination of urban design solutions after the demolition of the railway embankment.

With respect to the search for new forms of transforming elevated transport routes, the selected works (1st and 2nd award) went beyond the competition assumptions and related the concept to the whole city, future changes in this area and possibilities of dividing the investment in railway areas into stages. This allowed for opening the discussion on the future of these areas. The above-mentioned competition works present two drastically different strategies for adaptation of transport routes to new functions. The work awarded 1st prize presents a broader, urban perspective as it proposes a new structure adapting the elevated route in harmony with the city. The concept of "Tri-layer functional hybrid" is a zero compromise proposal influencing urban structures in a given area with momentum. Such a revolutionary change was duly compared by the authors to drying the Vistula basin in the place of the present Dietla St. What is interesting, as the report on social consultations in the form of questionnaires [40] reads, this work also met with the greatest approval of

Kraków inhabitants[7]. In opposition to it, the work awarded 2nd prize proposes interesting gardens and service points under the flyovers only, maximally limits interventions in the bridge structures of SKA route, thus not requiring great investment expenditures and deep changes in the structure of both the flyovers and city infrastructure. This shows, that the concepts acquired as a result of the competition may provide partial, but not total guidelines for future works intended for implementation of both fragments and finally the whole investment, and for planning to divide it into stages.

This selection of awarded and distinguished works constitutes a voice in a discussion, so much needed in Poland, on the model of solutions interfering with historical spacial structures of the city, both at urban planning and architectural level, with foreign, linear shapes of elevated transport routes. Especially the winning project illustrates the opportunity lost a couple of years ago for PKP designing a multifunctional, hybrid facility integrating the flyovers with local architecture and landscape in cooperation with the city. As part of conclusions from analyses draw by us, we proposed a selection of previously described scenarios (cf. chapter 6) for the assumed functional zones in the railway line area, from the Vistulan Boulevards to Kopernika St. (cf. chapter 4) – Tab. 2.

Table 2. Breakdown of the designated functional zones in the development area with scenarios proposed for them

Zone in the development area	Proposed scenarios
ZONE A The area along the flyover between Podgórska St. and Miodowa St.	**S1** – public space and green areas under the flyover; **S4/S4+S5+S6** – semi-transparent or mixed acoustic screens (from the west, the stretch from Przemyska St. to Miodowa St.) – coupled with other safeguards; **S11** – development of the embankment (attractive green solutions);
ZONE B The area under the flyover Miodowa St. – "Grzegórzki" junction	**S2** – single-story open or two-story car park ; **S3** – single-story shopping facilities (free standing); **S4/S4+S5+S6** – semi-transparent or mixed acoustic screens (from the west, the stretch from Miodowa St. to Joselewicza St.) – couples with other safeguards; **S10** – developments at the flyover, single-sided (adjoining the Cracovia skating ring);
ZONE C Integrated "Grzegórzki" junction	**S3** – two-story (open or closed) car park under the flyover; two-story (free-standing of covering the whole space) shopping facilities; **S4** – semi-transparent acoustic screens coupled with other safeguards; **S7±S8** – railway line over the flyover, in a "tunnel", optionally with development of a park on the "tunnel" roof; **S10** – single-sided development at the flyover (at the south-eastern side of the Grzegórzki station);

[7] At the consultation stage, Kraków inhabitants and all the stakeholders were asked to assess the awarded and distinguished works and point to which out of the four concepts should be implemented and which elements from the remaining ones could be additionally included. In a closed question asking for selection of a single concept most closely corresponding to their expectations concerning development of the areas under the flyover, the vast majority of respondents pointed to the project authored by Ton Venhoecen c.d. Architekten B.V. (73% of respondents) [40].

ZONE D The area under the flyover and the adjacent green area between "Grzegórzki" junction and Kopernika St.	**S1** – public space and green areas under the flyover (for fragments); **S3** – two-storey (free-standing of covering the whole space) shopping facilities; **S7±S8** – railway line over the flyover, in a "tunnel", optionally with development of a park on the "tunnel" roof;

Taking into account conclusions from the analyses, we formulated the following postulates and directions for further actions:

- To give the city appropriate time horizon for actions preceding the actual implementation in the SKA route area, it is recommended that the Kraków City Commune immediately applies to the Ministry for a permit to open the closed railway areas.
- To increase efficiency of use the areas under the SKA route, improve it functional, spatial, visual and aesthetic values as well as to determine their relations with the surrounding public space, we propose introduction in the target urban development plan for this area a rule for assigning individual intended use to the elevated transport route and the areas under it, and also making a division into temporary and target developments in this area (provisions providing for operation of the area in the transition phase i.e. until the area gets developed in a way provided for in the law; reference example: project of the land development plan for the areas surrounding the ks. J. Poniatowski viaduct in Warsaw [41]). Moreover, it is recommended to define the parameters of the developments located under the flyovers (i.e. maximum surface area, height, and building alignment) together with guidelines concerning the shape of frontage on the side of public space (e.g. provisions requiring the use of high-quality finishing and equipment materials).
- To optimize the selection of functional programmes for this area, we postulate including in the designing process the so-called non-statutory urban planning tools (i.e. public discussions, participation workshops) and competences of local communities[8].
- To boost the interest of private investors in the grounds under the SKA route, we propose developing a catalogue of model protection solutions together with administrative and organizational strategies for a given type of environmental transient conditions. Such a catalogue should be linked to databases and the maps of city real state of Kraków.
- Before starting development of a city urban development plan and later, before starting the investment project, in-depth analysis if the area under the SKA route is needed. It should be based on the results of interdisciplinary research spanning urban engineering, architecture, urban planning, construction, environment protection, vibro-acoustics, and sociology (social consultations).

[8] Another round of social consultations related to the project consisting in participation workshops entitled "Development of areas under the railway flyover under construction between Miodowa St. and Kopernika St." took place in September and October 2019.

8. Summary

The development process for the area of the new agglomeration route in Kraków constitutes a great organizational and design challenge. These actions may be difficult because of the complexity of issues (status of closed areas, limitations in City's disposing of the areas managed by PKP, difficulties in obtaining financing for investment of this type, inhabitants' being unconvinced of the potential of these areas) and the number of questions requiring analysis (unfavourable environmental conditions, possible collisions with the operation of the railway route, social needs). However, with appropriate planning, cooperation, and coordination, it may contribute to the creation of a new, unique public space, enriching the functional and spatial structure of the city and general improvement in the perception of this area. To conclude, we would like to stress the great value of the initiative consisting in organization of such a competition by the Kraków branch of SARP as it opened very important discussion on transport-related space and expressed appreciation of reliable and complete input materials for the competition, which translated into clear and detailed solutions presented in the competition works. Knowledge gained as a result of the competition and conclusions from the analysis should be taken into account in developing legal regulations determining the rules for urban design policy in this respect. These rules should be determined together with actions in the formal and legal sphere, especially with respect to changes in the status of existing "closed" PKP areas and City's disposal of the area under and in the direct vicinity of the SKA route.

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The architectural transformation of the von Wentzky family's Baroque palace at Rychnów near Namysłów

Przekształcenia architektoniczne barokowego pałacu rodziny von Wentzky w Rychnowie koło Namysłowa

Abstract

The paper presents the results of research work that has been performed on the von Wentzky family's palace at Rychnów. Firstly, the architecture of the palace is discussed and written sources concerning the village and the von Wentzky family are reviewed. Based on the architectural studies and the analysis of the details, the most important phases of the place's transformation were defined. The recognition of the wall construction chronology contributed to the identification of two construction and transformation stages. The original Baroque palace, with its modest architecture was erected on a classic three crosswise-section plan by Ernst Fryderyk von Wenzky in 1781. The building had survived without major changes up until the beginning of the twentieth century, when it was transformed in the years 1906–1907. An extension was added to the west elevation as were a loggia and a porch on the avant-corpses. The research work enabled the author to identify the reach of the palace's Baroque foundations, and it formed the grounds for generating recommendations to conservators concerning repairs and restoration work.

Keywords: Śląsk, architecture, palace, Baroque, Rychnów

Streszczenie

W pracy przedstawiono wyniki badań dotyczących pałacu rodziny von Wentzky w Rychnowie. Na początku omówiono architekturę pałacu i dokonano przeglądu źródeł pisanych dotyczących wsi i rodziny von Wentzky. Na podstawie badań architektonicznych i analizy detali określono najważniejsze etapy transformacji miejsca. Dojście do chronologii konstrukcji ścian przyczyniło się do identyfikacji dwóch etapów budowy i transformacji. Oryginalny barokowy pałac o skromnej architekturze został wzniesiony przez Ernsta Fryderyka von Wenzky'ego w 1781 roku. Budynek powstał na klasycznym planie o trzech przekrojach. Przetrwał bez większych zmian aż do początku XX wieku, kiedy to został przekształcony w latach 1906–1907. Do elewacji budowli od strony zachodniej dodano przedłużenie oraz loggie i werandę na rozalicie. Prace badawcze umożliwiły autorowi określenie zasięgu barokowych murów pałacu i stały się podstawą sformułowania wytycznych konserwatorskich do prac remontowych i restauracyjnych.

Słowa kluczowe: Śląsk, architektura, pałac, barok, Rychnów

1. Introduction

The palace is situated in the middle of the village of Rychnów near Namysłów. It is built to the north-east of St. John the Baptist's Gothic parish church and encompassed by an ancient--forest park to the south and a forest clearing to the north. To the west of the palace, there is the two-storey caretaker's building, which may have been built at the end of the eighteenth century as a classicistic structure that is decorated with a column portico. This paper aims to describe the original form of the palace and present the chronology of its transformations, which nota bene had only been previously described on a superficial basis. An attempt is also been made to present the palace's Baroque architecture and modifications that were introduced during the works at the beginning of the 20th century.

The palace was built on an elongated rectangle plan along the east-west axis and its façade faces south. This is a two-storey building covered with a mansard roof, the crosswise ridge of which accentuates avant-corpses with gable ends situated along the south and north elevation planes. A cuboidal extension with an interior staircase is attached to the western end of the palace; it is covered with a gable roof. The nine-bay, symmetrical, two-storey façade is accentuated with a shallow, three-storey, three-bay avant-corps that is finished with a two--storey gable end and volute curves. The elevation's architectural composition consists of pilasters that support the classic cornice beneath the eaves and are seated on a rusticated base course which has a protruding ledge along its upper edge. Between the pilasters, rectangular, smoothly trimmed window openings are positioned at regular intervals' if that is what you mean on the ground and first floors. Rectangular plates are arranged in the area between the storeys. In the base course of the building, the openings are decorated with segmental arches.

The elevation corners are embraced with a pair of pilasters. The avant-corps is preceded with a single-storey extension where there are an entrance, semi-circular windows and a balcony on the first floor. The second-floor openings are decorated with segmental head in the middle window bay and with two triangular head in the side window bays. The third--floor windows are decorated with aprons under the sills and plates in the window heads. The crowning takes the form of a gable end with volute framing and an elliptical oculus.

The north elevation faces, form the garden, is compose in a comparable manner. The avant--corps is emphasised with an arcaded loggia that is standing in front of it and has a balcony on the first floor. It is crowned with a low triangular tympanum with an oculus; a high roof can be seen from behind the tympanum. The east elevation consists of five window bays. The spaces between the equally spaced pilasters are filled with blind windows that are lined on two storeys. The ground-floor windows are arranged in three bays (I, II and IV – counted from the south) and the first-floor windows are arranged in two bays (II and IV). There are plates in the area between the storeys, as is the case with the façade, and there is a small dormer in the lower roof slope.

The west elevation is shaped slightly differently. The two side window bays are formed in a similar manner to the east elevation, although the middle part of the former palace is obscured by a two-storey extension. The extension's north and south *n* elevations have a single window bay and a pair of pilasters. The two-bay west elevation has pilasters in the corners and

a pair of pilasters to accentuate the middle bay. The openings are framed with smooth window trims and rectangular plates are arranged under the first-floor window sills. The west elevation is crowned with a gable end, which is embraced with volute curves with a triangular head on a pair of pilasters in Tuscan order. Between them, there are two, smoothly trimmed windows, one rectangular and one elliptical (Figs. 1–3).

The palace plan consists of three crosswise sections and two and three longitudinal sections (there are two longitudinal sections in first and second from East and there are three longitudinal sections in third). On the ground floor, there is a hall-way with two annexes that flank the stairs on the elevation plane in the middle crosswise section. Behind it, there is a hall with stairs leading up to the first floor and two windows and an exit to the garden--facing loggia. The two rooms are linked with the side crosswise section interiors via three doorways that are made in the crosswise section walls – there are two openings to the east and one to the west. The east crosswise section that spreads across two longitudinal sections consists of a large hall, which is in the front longitudinal section, and of two smaller rooms in the back longitudinal section. The smallest room is situated in the north-east corner and is covered with a barrel vault with lunettes; the other rooms are covered with ceilings. Daylight enters the large hall through five windows, of which three are in the south and two are in the east. The room in the back longitudinal section has two north-facing windows and one east--facing window. To the west of the hallway, the area is arranged in three longitudinal sections;

Fig. 1. Rychnów (dep. Namysłów), palace, view from the south-east, present state (photo by A. Legendziewicz)

Fig. 2. Rychnów (dep. Namysłów), palace, southern facade, projection of the main entrance, present state (photo by A. Legendziewicz)

Fig. 3. Rychnów (dep. Namysłów), palace, view from the north-east, present state (photo by A. Legendziewicz)

the entrance leads to a corridor in the middle section. At the end of the section, there is an extension with a staircase and two small rooms. The room layouts in the front and back sections are similar to each other. They consist of two rooms. In the south, they are accessible from the corridor and the staircase via one of the added rooms (Figs. 4–9).

The layout of the first-floor rooms is very similar to that described above, although it is slightly distorted as some of the doorways[1] are bricked in. Two flights of stairs lead to the entrance hall, which is situated in the middle crosswise section in the back longitudinal section. Daylight enters the entrance hall from the north through two windows and two terrace doors. Two doorways were built to access rooms in the side crosswise sections – one doorway is in the east and runs to the back longitudinal section, and the other is in the west and runs to the middle longitudinal-section corridor that is connected with the extension's staircase. In the east, the hall layout follows the ground floor pattern. In the front longitudinal section, there is a large room which is connected with the room that is above the entrance hall via a passage, and there are two smaller rooms that face the garden. The west crosswise--section rooms are arranged in a comparable way to the above. The front and back longitudinal sections consist of two rooms that are accessible from the corridor and are lit through three north-facing windows and three south-facing windows (Figs. 4, 5).

The general layout of the interior is also followed in the cellars. Beneath the entrance hall, there is a large cellar that is covered with a barrel vault with three pairs of lunettes along the north-south axis. In the south, there is an entrance to the cellar together with stairs that are situated between the pillars of the ground-floor vestibule walls. To the east, there are three vaulted chambers situated in two longitudinal sections along the east-west

[1] In the nineteen-sixties, the palace was adopted to flats and a kindergarten. Before the research work was performed, almost all secondary partitions installed at that time had been removed.

Fig. 4. Rychnów (dep. Namysłów), palace, ground floor, hall with stairs to the upper floor in the back in the middle crosswise sections, present state (photo by A. Legendziewicz)

Fig. 5. Rychnów (dep. Namysłów), palace, ground floor, hall in front of the eastern crosswise sections, present state (photo by A. Legendziewicz)

Fig. 6. Rychnów (dep. Namysłów), palace, basement, chamber in the middle crosswise sections, present state (photo by A. Legendziewicz)

Fig. 7. Rychnów (dep. Namysłów), palace, basement, back chamber in the west crosswise sections, present state (photo by A. Legendziewicz)

Fig. 8. Rychnów (dep. Namysłów), palace, basement, front chamber in the eastern crosswise sections, present state (photo by A. Legendziewicz)

Fig. 9. Rychnów (dep. Namysłów), palace, basement, back chamber in the eastern crosswise sections, present state (photo by A. Legendziewicz)

axis; the one in the front has three lunettes and the two in the north have one crosswise lunette each. There is a total of five windows in the lunettes of the chambers and two additional windows in the east wall. Whereas in the west crosswise section across the three longitudinal sections, there is a central corridor. At the front, there are two chambers, each covered with a barrel vault that is built along the east-west axis and lunettes with axes that determine the locations of the south-facing windows. The larger of the chambers has two lunettes and the smaller chamber has one lunette. The back longitudinal section follows a similar pattern as above; it differs only with the vault of the larger of the chambers where the vault is built along the north-south axis. At the end of the corridor, there are small rooms and stairs running up to the ground floor (Figs. 6–9).

2. Analysis of Sources, Archive Iconography and Bibliography

Rychnów (Reichen in German, Rachenaw in Latin) appeared for the first time in written sources in the agreement concluded between Duke Henry IV Probus and Fryderyk on 30 November 1273 on the transition of the village to German law [10, No. 214]. The village is also quoted in *Księga uposażeń biskupstwa wrocławskiego* [4, No. 240].

Written sources document changes in the ownership of the Rychnów estate, which in 1273, was owned by a duke [10, No. 214]. In the second half of the fourteenth century, it was in private hands. A deed of sale issued in 1359 has the names Heidan of Falkenberg (the seller) and Peter Kraynpusch (the purchaser) [9, No. 505]. In 1400, the village belonged to Michel and Peter Crenpuch [1, Rep. b, 541 b], and five years later, it belonged to Konrad of Falkenberg [2, Rep. 132 a, 46]. The following owners can be identified in a sale agreement of 1424 concluded between Dorothea, the wife of Mikołaj of Gemel, and Peter and Jorge Cromposch [1, Rep 1 b, 541 c, d].

At the beginning of the eighteenth century, Rychnów belonged to the family von Wentzky und Petersheyde [11, Table 123, p. 27]. In 1781, it was owned by Ernst Fryderyk [5, p. 178, Illustration 302], and after his death on 22 July 1791, the estate was inherited by his son Hans Fryderyk. Hans Fryderyk's widow sold the Rychnów estate to Bonaventura Freiherrn von Ohlen und Adlerskron in May 1851 [11, p. 27]. The latter's son Franz altered the palace in the years 1906–1907 according to a design produced by architect Fritz Larteyn [5, p. 178]. On 14 October 1909, the residence was purchased by Johannes Edgar Graf Henckel von Donnersmarck, a royal chamberlain and the Squire of Gręboszów [11, p. 27].

The written sources are supplemented by a few archive photographs of palace views. The oldest views show the palace from the north (i.e. from the garden) before it was subjected to the 1906–1907 alterations [12] (Figs. 10, 11). The residence layout, together with the land--steward see note at the start of the introduction building and the farm buildings, is documented on the maps of the Namysłów area dating back to from the close of the eighteenth century to the beginning of the twentieth century [3, Tables 14, 17 and 18].

The literature provides an overview of the palace architecture and its transformations. The history of the palace, mostly in the context of its owners, was briefly discussed for the

Fig. 10. Rychnów (dep. Namysłów), the palace in the view from the north, a postcard from the beginning of the 20th century www.polska.org.pl (access: 15.12.2018)

Fig. 11. Rychnów (dep. Namysłów), palace in view from the south-east, view from the first half of the 20th century www.polska.org.pl (access: 15.12.2018)

first time by Robert Weber [11, Table 123, p. 27]. In his catalogue of Namysłów district's' buildings of historical value in the German language, Kurt Dergen included a general and brief description of the palace mass and transformations [5, p. 178, Illustration 302]. Kurt Dergen found that the residence was erected in 1781 by Ernst Fryderyk von Wentzky and that this fact was confirmed by a marble plate that showed the initials of Ernst Fryderyk von Wentzky and his wife Juliane Sophie von Wentzky und Prittwitz and included the date of construction. The plate had been hung over the entrance; it no longer survives. He linked the 1906–1907 alterations with the activity of Fritz Larteyn, an architect of Namysłów. In his opinion, the triangular gable end of the north avant-corps, the forged balustrade of the garden terrace and the front balcony were new elements of the elevations. Inside, the new elements included first-floor rooms with plated ceilings, a vestibule with a brass-fitted door and stairs in the main hall. However, the authors of a post-war publication about Namysłów district and the city's buildings of historical value stated that the scope of transformations to the residence had been much broader [6, p. 53]. In their opinion, the layout of the rooms on each of the floors was completely changed; neo-Baroque gable ends of avant-corpses were introduced and extensions were added at the front and in the west. The palace was presented equally briefly by Józef Pilch [8, p. 174]. Józef Pilch stated that the Baroque and classic mass of the palace was partly altered and a portico, terrace and the west extension were probably added. In his opinion, the interior was thoroughly transformed.

3. Research Methodology

The authors of the publications that have been issued thus far have not made any attempt to determine the extent or form of the original palace layout that was implemented in 1781 by Ernst Fryderyk von Wentzky. The findings they presented were general outlines of the neo-stylish transformations that were introduced in 1907. Therefore, the recognition of the residence's Baroque form and the precise description of the neo-stylish transformations

required architectural research to be conducted. Such an opportunity was presented to the author of this paper as a result of planned construction works [7]. The identification of specific phases in the construction of the building was based on thorough analyses of building technology, building materials, the composition and texture of mortars, the forms of architectural details and crucial elements, as well as source records and archival iconography. The results enabled the author to challenge the theses that had been presented thus far and also to form the grounds for a detailed discussion of building history and transformations.

4. The results of the architectural research

The original Baroque palace was funded by Ernest Fryderyk von Wentzky in 1781. It was erected on a 31.5 x 15.1 m elongated rectangle plan along the east-west axis and its façade faces south. The building has two storeys, a base course, three-bay three-storey avant-corpses and entrances in the longer elevation walls. The mansard roof was probably covered with ceramic roof tiles; it consists of a multi-pitched roof and a crosswise ridge to emphasise the avant-corpses. There was a landscape park around the residence. There was an entrance gate in the south-west (Figs. 12–14).

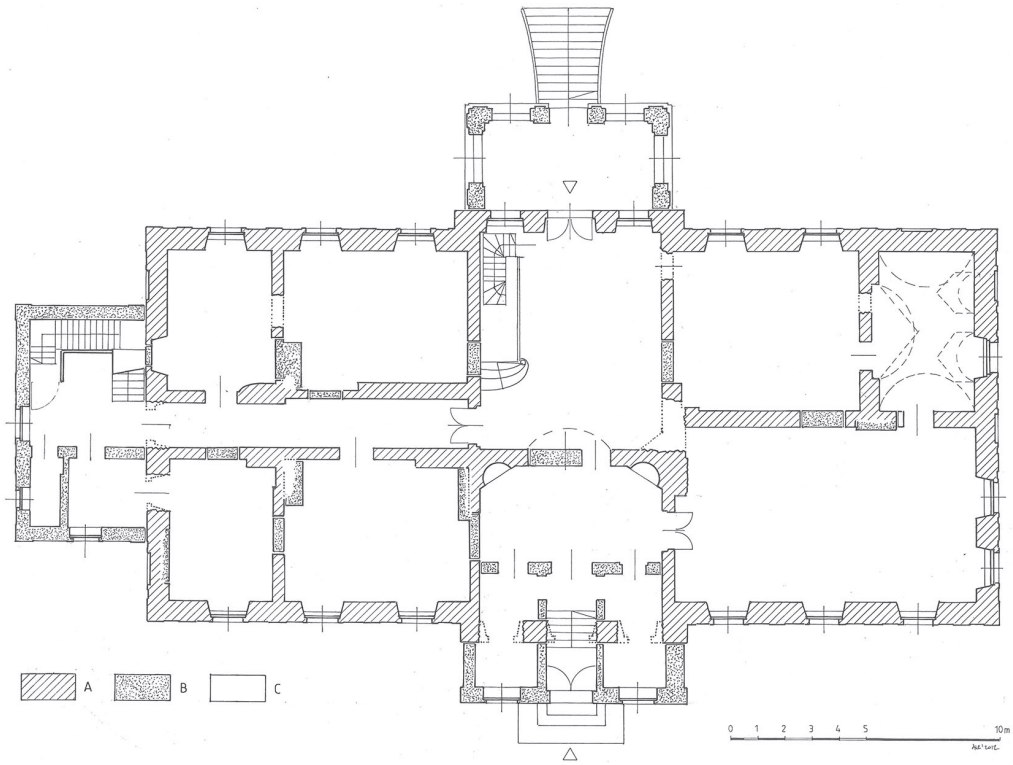

Fig. 12. Rychnów (dep. Namysłów), palace, ground floor plan with chronological wall stratification. A – walls from 1781; B – walls from 1906–1907; C – contemporary and unrecognized walls (edited by A. Legendziewicz)

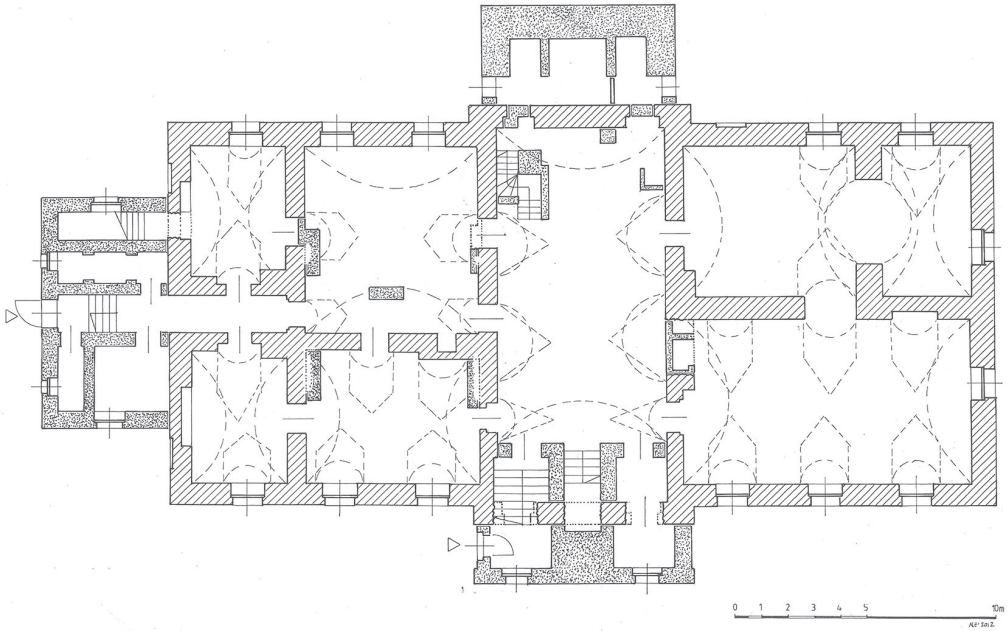

Fig. 13. Rychnów (pdep Namysłów), palace, first floor plan with chronological wall stratification. Signs as on the ground floor drawing, compiled by A. Legendziewicz

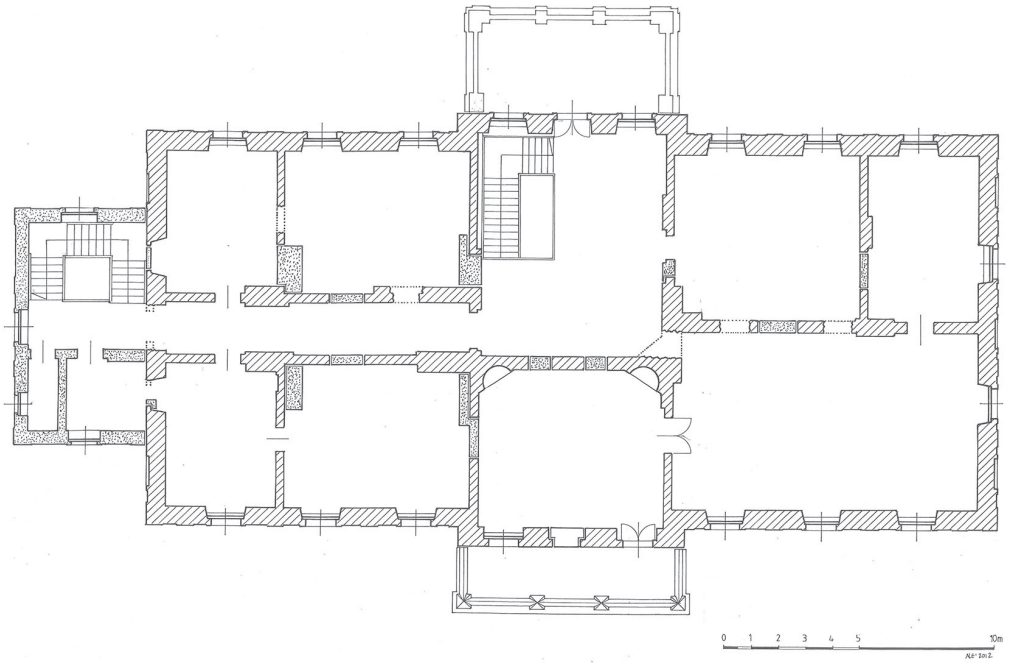

Fig. 14. Rychnów (dep. Namysłów), palace, projection of basements with chronological wall stratification. Signs as on the ground floor drawing, (edited by A. Legendziewicz)

The palace's longer elevations (the front and garden walls) included nine bays and three--bay avant-corpses to emphasise the entrances. The equally spaced rectangular window openings were smoothly framed. Beneath the first-floor windows, there were rectangular plates with cut out corners. The elevation layout was highlighted with smooth pilasters between the window bays. A pair of pilasters was used to decorate the corners. The ground--and first-floor elevations were built on a rusticated base course with a protruding ledge along the base's upper edge and had segmental arched windows.

Protruding about 70 cm in front of the elevation face, the avant-corpses were arranged in a similar manner to those described above. On the ground floor, in the middle window bay, there was an entrance preceded by stairs. The entrance opening was covered with a basket arch and surrounded by a profiled frame. The first-floor windows were decorated with panels. On the panels there were head; the middle head was segmental in shape, whereas the two side ones were triangular. The second-floor windows had aprons beneath the sills and plates without corners above the openings. The avant-corpses were probably topped with triangular tympanums; there was a smoothly framed oculus in each of them. The shape of the north tympanum has survived (Figs. 1, 2).

The side elevations were arranged in a similar manner to that described above. They are regularly shaped with five window bays, of which three have openings. Counting from the south, the east elevation had windows in the first, second and fourth bays; the west elevation had windows in the second, third and fourth bays[2]. There were plates in the strip between the storeys. The regularity was emphasised with pilasters (Fig. 1, 3).

The elevation colour scheme was designed according to the Carl Schmidt canon that was followed in the second half of the eighteenth century. Smooth architectural details such as pilasters, window frames, plates, panels, aprons, head and cornices were pained Roman white (the colour of natural lime (Keim code: 9870) and were placed on a gently textured light-grey (9590 acc. to Keim code 9590) background.

The palace is based on a classic plan consisting of three crosswise sections and many longitudinal sections. On the ground floor, the middle crosswise section contained a hallway, which was lit through two south-facing windows. At the north-wall corners there were two obliquely situated, semi-circular niches. A wide passage was arranged in the entrance hall where there were stairs leading up to the first floor and an exit to the garden. A fireplace may have been built in the south-east corner of the hall. The two rooms were connected through two doorways with the east wing and through three doorways in the west wing (Fig. 12).

The east crosswise section filled the entire wing and probably contained fine rooms. The largest of the rooms, maybe a ballroom, was located in the front longitudinal section. It was lit through five windows, three of them were south facing and two of the them were east facing. A decorative fireplace with an ornately' shaped hearth was built by the intersectional wall. In the back longitudinal section, there was another large room – probably a library. It was lit through two north-facing windows and was connected with the ball room through a wide door.

[2] It cannot be excluded that in the middle bay of the west elevation, there was a service staircase for access to the cellar where there was a kitchen.

A small rectangular room was built in the north-east corner of the wing – maybe a secret study. It was covered with a barrel vault with lunettes and was lit through an east-facing window. It was connected with the other rooms of the wing through two doors, from the west and south.

The west wing was arranged in three longitudinal sections. A corridor filled the middle section. There might have been a service staircase in the west end of the wing; it ran up to the first floor and down to the cellars. The front section had two enfiladed rooms whose doorways were in the middle of the walls. The larger room was situated near the entrance hall and was lit through two south-facing windows, and the smaller room was lit through one south--facing and one west-facing window. Both rooms had fireplaces in their north-east corners and were connected with the corridor via doorways. The back longitudinal section, where there may have been a dining room, was arranged in a comparable manner'? to the front section, although the doorways enfiladed along the south wall. Fireplaces were also built along this wall; the fireplace built near the entrance from the hall had a decorated hearth (Fig. 12).

A similar room layout to that described above was also introduced to the first floor, where there were the owners' rooms. The centrally situated hall filled the middle section and consisted of two rooms. The north room was lit through three garden-facing windows and contained fine stairs. The south room was connected with the north room via a doorway decorated with two semi-circular niches. The light also entered through three windows. In the east crosswise section, there were two symmetrical, two-room suits situated in the front and back longitudinal sections. Both of them had four windows: three windows faced either south or north and one window faced east. The suits were connected via a doorway that was built in the intersection wall. The room layout in the west crosswise section was the same as the ground floor arrangement. The front and back longitudinal sections contained two-room suits, and in the middle section, there was a not very narrow' corridor that led to the service stairs. The rooms were slightly smaller than in the east wing; they were lit through three south and north-facing windows and one west-facing window in each of the rooms. It is worth noting that each of the suits was accessible through one doorway from the hall and two doorways from the corridor (Fig. 13).

Cellars were used for service and storage purposes. These were covered with basket-shaped barrel vaults with crosswise lunettes. Two of the rooms in the chamber situated under the entrance hall and in the adjacent chamber in the north-west were built along the north--south axis; the other chamber rooms were built along the east-west axis. The cellar floors were constructed from 26 x 26 x 7 cm ceramic tiles.

The largest of the chambers had a span of almost 6.7 m; it was situated under the entrance hall and was used as a storage area. Three chambers in the east crosswise section might have been used for a similar purpose. A kitchen was probably located in the west wing along the north wall; this is indicated by the location of chimneys. Meals might have been prepared in the rooms that were situated along the west wall, where the service stairs came down to the corridor (Fig. 14).

The analysis of sources and bibliography items indicates that the palace was altered at the beginning of the 20th century, in the years 1906–1907 [11, p. 27; 5, p. 178]. The scope of work affected building mass and architecture to a relatively small extent. The elevation's Baroque arrangement and details remained unchanged. The avant-corpses were extended by adding a vestibule with a balcony on the first floor and an arcaded loggia from the north. The south

gable end was altered; it was raised and the shape of the crowning was changed to semi-circular shape and finished with volute curves. The most significant change to the mass consisted of the addition of an extension to the west elevation, which included an interior staircase, probably in place of service stairs. The extension was covered with a gable roof and topped with a gable end with a triangular head that was based on pilasters and finished with volute curves. The colour code of the elevation was also partly changed. The background was painted ochre (Keim code: 9051') and the details remained Roman white (Keim code: 9870').

There are more changes inside the palace. The vestibule was partitioned off in the entrance hall on the ground floor; it included stairs, and annexes were arranged on its sides. The doorway to the rooms situated in the front section of the west crosswise section was bricked and the doorway to the hall was reduced in size. The stairs up to the first floor were relocated to the west wall and the doorways to the rooms in the back areas of the west and east crosswise sections were bricked in. New stairs down to the cellars were built under the lower flight. In the east crosswise section, the ballroom was divided into two smaller rooms and the doorway between the ballroom and the library was bricked in. In the west crosswise section, the large rooms were separated from corner annexes, which were converted into separate rooms. Some of the doorways from the corridor and both of the enfilades were bricked in. One of the windows in the south-east corner room was converted into a doorway to connect the room with a new room that was located in the added extension with an interior staircase. As the new rooms were partitioned off, additional chimneys ducts were erected; the ducts were either attached to the intersectional walls (an enfilade in the back area of the west crosswise section) (Figs. 1 and 3).

A similar arrangement plan to that described above was applied to the first floor, where corner annexes were partitioned off in the west crosswise sections to form separate rooms; the south room was connected with the annexe of the newly constructed extension. The partitioning of separate rooms involved the bricking in of enfiladed doorways. The hall was enhanced with exits to two balconies, one in the south and one in the north. The balconies were built on the extensions added to the avant-corpses.

The most significant change to the cellar passages was the relocation of the entrance from the west elevation to the south avant-corpse basement. This involved the conversion of the southern part of the chamber situated under the entrance hall, where a porch and two small annexes were built. Service stairs were built in the north-west corner; these led to the area under the fine stairs. In addition, lower sections of chimney ducts were built in the west crosswise section by the intersectional walls as additional chimneys were needed. No such changes were made in the east wing. Only the lower parts of the ducts in the intersectional wall of the front longitudinal section were altered.

Adaptation work in the palace was probably performed after the war. The palace rooms were converted into seven flats for workers of a farming cooperative. The fine rooms on the ground floor were probably used as offices. The large rooms situated in the west crosswise section on both storeys were divided into smaller rooms as were the rooms situated in the east crosswise section of the front longitudinal section. A corridor and two small rooms were added in the back section. Two utility rooms were partitioned off in the north part of the hall by the east wall, near the stairs. The doorway to the niche room was bricked in and the room

was divided into two smaller rooms and the middle window of the south avant-corpse was bricked in as a result of this change. The new partitions in the cellars in the west wing and under the entrance hole were installed for the purpose of partitioning off cubbyholes for residents. The cellars in the east crosswise section remained undivided and were probably used as storage areas. The elevation was painted pale pink (Keim code: 9169) and no architectural details were emphasised.

5. Summary

Two construction and transformation stages have been identified in the structure of the von Wentzky family's palace at Rychnów in the light of the conducted architectural research. The original Baroque palace, with its modest architecture, was built on a classic three crosswise--section plan in about 1781 owing to the efforts made by Ernst Fryderyk von Wenzky. The layout had survived without major changes up until the beginning of the twentieth century, when in the years 1906–1907 it was subjected to repair and alteration. The work resulted in the construction of an extension by the west elevation and of a loggia. Minor transformations to the interiors were mostly applied to the west wing rooms.

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The problems of small towns in Ukraine and Poland

Problemy małych miast na Ukrainie i w Polsce

Abstract

The development of particular towns is a factor that determines the economical, social and spatial development of the country. Therefore we turn our attention to it with a critical eye. On 20th October 2015 the government in Poland accepted a bill connected with the Country Town Policy 2023, that is addressed to towns. Its main point is to strengthen towns in their sustainable development, betterment of standards of living and workplace creation. The socio-economical transformation that occurred in Poland in 1989 has caused a lot of changes in the country. In Ukraine it happened in 1991 and it appears that due to various reasons, its transformation seems to be a much longer process and the process has not finished yet. This article focuses on the development of small towns in Ukraine and Poland, which, in currently difficult times, find themselves in a hard and unstable socio-economic situation. This article analyzes the economic, demographic and spatial aspects of small towns in Ukraine and Poland.

Keywords: urban-type settlement (UTS), small urban settlement, creative economy, decentralization, united territorial communities

Streszczenie

Rozwój jednostek miejskich jest czynnikiem, który determinuje rozwój gospodarczy, społeczny i przestrzenny każdego kraju. Dlatego rozwojowi miast poświęca się wiele uwagi. 20 października 2015 r. w Polsce przyjęto uchwałę Rady Ministrów dotyczącą Krajowej Polityki Miejskiej 2023, która adresowana jest do miast. Głównym jej celem jest wzmocnienie miast do zrównoważonego rozwoju, poprawy jakości życia oraz tworzenia miejsc pracy. Transformacja społeczno-gospodarcza, która miała miejsce w Polsce w roku 1989, spowodowała wiele zmian w kraju. Na Ukrainie zmiana nastąpiła w roku 1991, ale, jak się wydaje, z różnych przyczyn przejście Ukrainy na ustrój demokratyczny jest procesem o wiele dłuższym. Proces ten jeszcze się nie zakończył. Artykuł koncentruje się na zagadnieniach rozwoju małych miast na terenie Ukrainy i Polski, które w obecnych czasach znajdują się w trudnej, niestabilnej sytuacji społeczno-ekonomicznej. Poddano analizie aspekty demograficzne, gospodarcze i przestrzenne małych miast na terenie Ukrainy oraz Polski.

Słowa kluczowe: osada miejska (UTS), małe miasto, gospodarka kreatywna, decentralizacja, zjednoczone wspólnoty terytorialne

1. Small towns in Ukraine

Formulation of the problem. The relevance of the research topic is due to a need for the sustainable development of small towns in the difficult conditions of socio-political instability, aggravation of social problems and the strengthening of economic factors for a successful solution. Small towns, along with urban-type settlements, make up the vast majority of urban settlements in Ukraine (93.5%), with 32.9% of the urban population.

Analysis of recent research and publications. The works of V.O. Timokhin [12] and A.V. Goblyk [3] are devoted to the problems of cities' and towns' territorial organization, to the discovery of self-organization as an opportunity for their harmonious development. The processes of revitalization and revalorization of cities/towns as manifestations of self-organization were researched in the works of N.A. Leshchenko [7], M. Orlenko, Yu. Ivashko [10]; demographic aspects of sustainable urban development – in the works of A.Yu. Dmytrenko [5], I.I. Ustinova [14]. The methodological principles of small towns' socio-economic development have been studied by A.V. Hurenko [4], N.V. Zhukov [6]; the urban development practices of small towns have been generalized by V.M. Liakh [8]; the prospects for the development of Ukrainian cities in a post-industrial society were investigated by I.V. Starodub [11], land problems in small towns – by O.V. Malynovska [9] and others. Strategies for increasing the competitiveness of small towns based on branding were investigated by L.V. Borodych, V.V. Shulyk [1], P. Courtney [2], I. Frankel [15] and others.

The main material. According to the normative documents [16], small towns in Ukraine are urban dwellings with a population of less than 50 thousand people. Today, they account for 373 towns, which is 80.9% of the total number of cities and towns. The average population in a small town is 17124 people (Table 1). In addition, urban-type settlements (UTS) which number 833, are also included in the category of urban settlements in Ukraine, (885 people). The average UTS population is much smaller – 4287 people. Unlike large cities, small towns have narrow-profile areas of development. Many small towns and urban-type settlements are the administrative centers of the districts, and according to the new arrangements, some of them are the centres of the united territorial communities. The lives of over twenty two million people are connected with small urban settlements in Ukraine. Such settlements play an important role in the formation of the settlement network.

Many of the small industrial urban settlements are located near mining enterprises. In the north-eastern part of the Donetsk region and in the south-eastern part of the Luhansk region, such small towns and urban-type settlements are the basis of the settlement network. They are also situated in the Dnipropetrovsk and Zaporizhzhia regions. The second common type of small industrial urban settlement are the settlements at agricultural processing enterprises (often a sugar factory).

Small urban settlements involved in transport are often located near major railway nodes (Debaltsevo, Romodan, Zdolbuniv).

It is possible to identify the following main types of small urban settlements according to their functional specialization: industrial, transport, resort and recreational, satellite

settlements (near large cities) and settlements without a specific specialization, which are the service centres for neighboring villages.

Most small urban settlements specializing in resorts and recreation are located in Crimea (Alupka, Saky, Haspra) and in the Carpathians (Morshyn, Vorokhta) near the corresponding natural (sea, mountains) or medical resources (sources of mineral water, healing mud, etc.).

Satellite settlements (Irpin, Vyshneve) are located near the most significant cities (Kiev, Kharkiv, Odessa, Dnipro) and serve as a kind of "sleeping area". The vast majority of their inhabitants work in the city centre.

The most widespread type of small urban settlement, which is characteristic of all regions of Ukraine (except Donbass), are settlements without a specific specialization, which are the service centres of the surrounding villages (Orzhytsia, Khorol, Zhashkiv).

The tendency of recent years, conditioned by the need to respond to the military aggression of Russia, is the revival of another functional specialization of small urban settlements – defensive. The increase in the size of the Armed Forces and the creation of new military units has led to a rather significant construction of housing for servicemen and their families as well as the development of social infrastructure.

Table 1. The small towns and urban type settlements of Ukraine region in 2018 [17, 18]

No.	Regions of Ukraine	Small towns			Urban type settlements (UTS)		Small towns and UTS	
		Number	Share of total cities /towns, %	Average population	Number	Average population	Share of the total urban population, %	Share of the total population, %
1	2	3	4	5	6	7	8	9
1	Autonomous Republic of Crimea (with Sevastopol)*	12	66.7	20081	56	4781	32.2	21.8
2	Vinnytsia region	17	94.4	17 635	29	4643	53.9	27.6
3	Volyn region	8	72.7	12 754	22	4676	37.7	19.7
4	Dnipropetrovsk region	14	70.0	24 582	46	4534	20.4	17.1
5	Donetsk region	39	75.0	18 910	128	3141	29.9	27.1
6	Zhytomyr region	8	66.7	14 808	43	3378	36.3	21.4
7	Transcarpathian region	9	81.8	16 053	18	6535	56.3	20.8
8	Zaporizhzhia region	10	71.4	18 411	22	4960	22.0	17.0
9	Ivano-Frankivsk region	12	80.0	11 411	24	4437	40.2	17.7
10	Kyiv region (with Kyiv)	22	81.5	20 971	30	6658	16.4	14.1
11	Kirovohrad region	10	83.3	16 610	27	4738	48.8	30.7
12	Luhansk region	28	75.7	17 783	108	3111	44.2	38.5

Tab. 1 (cont.)

1	2	3	4	5	6	7	8	9
13	Lviv region	39	88.6	11 507	34	3986	37.9	23.1
14	Mykolaiv region	7	77.8	20 234	17	5071	29.2	20.0
15	Odessa region	16	84.2	18 463	33	4754	28.4	19.0
16	Poltava region	13	81.3	17 019	20	4765	36.0	22.4
17	Rivne region	10	90.9	22 157	16	5168	55.2	26.2
18	Sumy region	12	80.0	20 822	20	3842	43.3	29.9
19	Ternopil region	17	94.4	10 760	17	4185	53.7	24.1
20	Kharkiv region	15	88.2	21 459	61	5766	30.9	25.0
21	Kherson region	8	88.9	22 807	31	5404	54.6	33.4
22	Kmelnytskyi region	11	84.6	24 354	24	3602	49.0	27.8
23	Cherkasy region	13	81.3	15 493	14	4185	37.7	21.3
24	Chernivtsi region	10	90.9	7658	8	6023	32.0	13.8
25	Chernihiv region	13	81.3	10 907	29	3655	37.4	24.3
Ukraine*		373	80.9	17 124	883	4287	32.9	22.7

* data on the Autonomous Republic of Crimea and Sevastopol are given as of 01.01.2014 [18]

Small urban settlements have a number of advantages over other urban settlements:

- the inhabitants of these settlements enjoy close proximity to nature;
- the favorable environmental conditions of most of them;
- the rhythm of life is less tense than in large cities;
- a shorter commute to work;
- the convenient location of social infrastructure objects (within pedestrian accessibility).

However, the demographic and functional characteristics of towns are determined by certain negative features that affect the process of their development. These include:

- attitudes towards small towns as peripheries by central and regional authorities;
- probability of high unemployment;
- low wages:
- excessive demographic sensitivity of the town system;
- increased influence of the inhabitants of the surrounding countryside, who use the infrastructure and production potential of the town, which affects its arrangement and its financial and economic situation.

In Ukraine, state support for small towns is very limited. In 2015, the Resolution of the Cabinet of Ministers of Ukraine on the State Target Program for Supporting the Socio--Economic Development of Small Towns for 2011–2015 expired. During the first stage of its implementation (2011–2015) it had been envisaged to develop and adopt normative legal acts on the socio-economic development of small towns and improve territorial administration. In practice, the only step taken was in 2012, when a decision was made on certain issues regarding the monitoring of the socio-economic development of small towns, but this was not enacted.

Researchers in the field of economics, investigating the transformation of rural settlements in the post-industrial era, have come to the conclusion that there are deep interconnections between small towns and rural settlements, and therefore there is an urgent problem in developing new approaches to support the socio-economic development of small towns, which also takes into account the enhancement of the "town – village" interconnection [13]. The analysis of the European regional policy revealed the introduction of comprehensive support for small towns as a necessary condition for the preservation of rural settlements. The small towns of European countries act as "hubs" and "drivers", which extend to the economic development of rural settlements [2].

One of the modern approaches to planning a small town development strategy, proposed by a number of studies [1, 2, 15], is based on the understanding of cultural and natural resources as a combination of economic assets and cultural capital of the town that can make a direct and indirect contribution to the economy. The boom of "creative" or thematic cities in Europe and the United States in the 1990s is an example of how the socio-economic problems of urban regeneration can be addressed through cultural strategies.

The main aspect that connects the culture and economy of the town, is their local identity in the age of globalization. Cultural policy and promotion of the city's brand and its image in this case, is not a political aspect. It is a means to defend individuality and local specificity against the backdrop of the dominant globalization processes in urbanization.

According to the UNCTAD study [13], cultural heritage (traditional culture, crafts, festivals, monuments of architecture, history, culture and archeology, etc.) is one of the basic groups of creative economical development. Development and export in the field of cultural content have the following advantages for the national economical development:

- creation of towns with high added value at the expense of the use of cultural resources;
- creation of new jobs in the service sector;
- creation of conditions for increasing awareness of the town or its brand of territory;
- development of specialized tourism (tourism events, extreme tourism, etc.).

As can be seen in Table 1, the small urban settlements of the Poltava region are quite typical for Ukraine; as places, by their role in the settlement system and also by population. Therefore, by their example, it is advisable to consider certain characteristic town planning features of this type of settlement.

The peculiarities of the socio-economic situation at the end of the 20th century and the beginning of the 21st century (first of all, the lack of funds) led to the fact that the town planning documentation in most of the small urban settlements was not updated in time. Their urban development was guided by master plans developed in Soviet times, which did not correspond to modern realities. A mass update of town planning documentation for small towns and urban-type settlements began in the early 2010s and has continued until today. By 2021 it is planned to fully provide all settlements (including rural settlements) with town planning documentation developed using geographic information systems (GIS).

Specialists of the Poltava National Technical Yuri Kondratyuk University also took part in the elaboration of master plans for small urban settlements (in particular, Bilyki and Orzhytsia of the Poltava region). This made it possible to identify town planning problems, which are also characteristic of other small urban settlements.

The basis of the small urban settlements' economies are manufacturing enterprises. However, their placement often does not meet the current sanitary standards. Not only residential development, but also the public centre area (Fig. 1) falls within the sanitary--protective zone of the enterprise. In the urban-type settlement of Bilyky, the main problem was the placement of a pig farm, where, in separate periods, up to 120,000 pigs were kept in close proximity to the public centre. In the development of the master plan, the capacity limitations of the enterprise were set – not more than 2500 pigs. Now the company no longer conducts business. However the closure of such enterprises is far from always the basis of significant socio-economic problems for small urban settlements. Indeed, due to the use of advanced technologies, these enterprises do not require a large number of employees and often have a legal address outside of their actual location, where they pay taxes.

Another problem is the central location of the cemeteries in the settlement, which developed historically (Figs. 1, 2). As a rule, the development of new master plans for settlements is expected to close such cemeteries. In their sanitary zones, there are restrictions on the new construction of residential buildings, educational institutions, health care, etc. for twenty to twenty five years following the most recent burial. A new cemetery is expected to be built on the periphery of the settlement.

It should be noted that the problems with the observance of sanitary protection zones from industrial and communal areas are not typical for all small urban settlements. First and foremost, they are relevant for urban-type settlements (UTS) and those towns that have recently moved from the category of UTS to the category of town. In small towns with a larger population, these problems were generally solved in the Soviet period.

As a rule, when developing a new master plan for small urban settlements, its territory expands, mainly due to agricultural land or forest funds. This is due to the efforts of the territorial community to control more land resources. When developing the master plan of the urban-type settlement of Orzhytsia (Orzhytsia district, Poltava region) the area was increased from 589.26 hectares to 1060.05 hectares. From this area, 87 hectares are occupied by forests, 10.2 hectares by rivers and other natural reservoirs and 355.05 hectares by agricultural lands. The same trend is observed in cities/towns in general. Thus, according to [19, p. 124], built-up areas (residential, public, industrial, communal, etc.) in Ukrainian cities/towns occupy only 35.3% of their total area, while agricultural lands occupy 33.1%, forests and other forest-cover areas – 20.6%, land of water resources – 4.2%, land of other purposes – 6.8%.

The public centres of most small urban settlements (with the exception of several regions in Western Ukraine) were formed in the Soviet period and have all the necessary sets of administrative buildings and facilities for service and trade (Fig. 3). As a rule, new master plans provide for the addition of existing service facilities, trade arrangements (especially so-called small architectural forms – kiosks, trade pavilions, etc.), as well as streamlining the street and road networks and improvement of the territory.

The improvement of the central parts of Ukraine's small urban settlements has recently been influenced by two reforms: decommunisation, wherein monuments to Lenin and other communist figures were dismantled, as well as fiscal decentralization, which resulted in much larger local budgets.

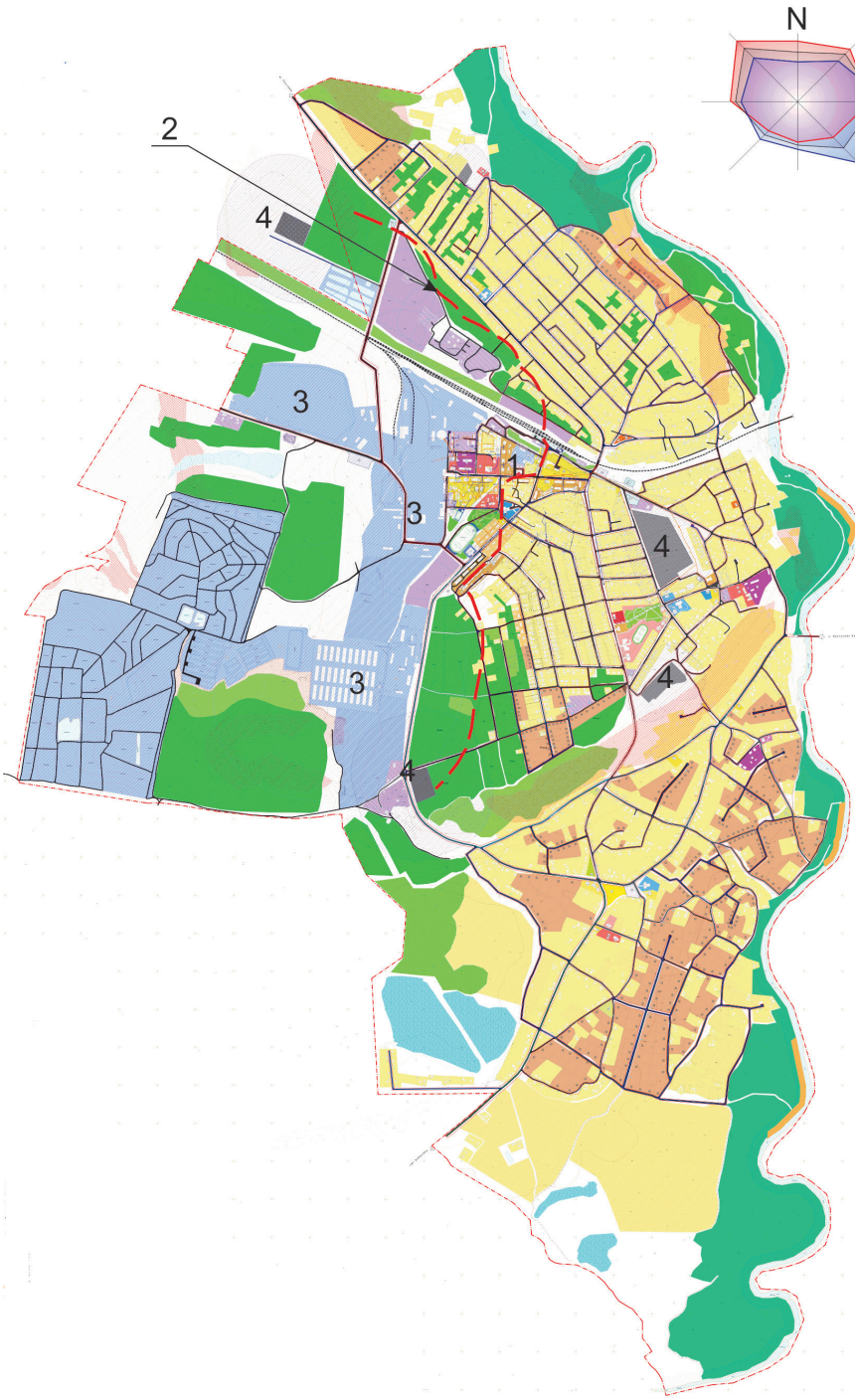

Fig. 1. The master plan scheme of the urban type settlement Bilyky, Kobeliaky district, Poltava region, Ukraine (PoltNTU, Chief Architect of the project A. Dmytrenko, 2016): 1 – public centre; 2 – boundary of the sanitary protective zone; 3 – production areas; 4 – cemeteries (existing and projected)

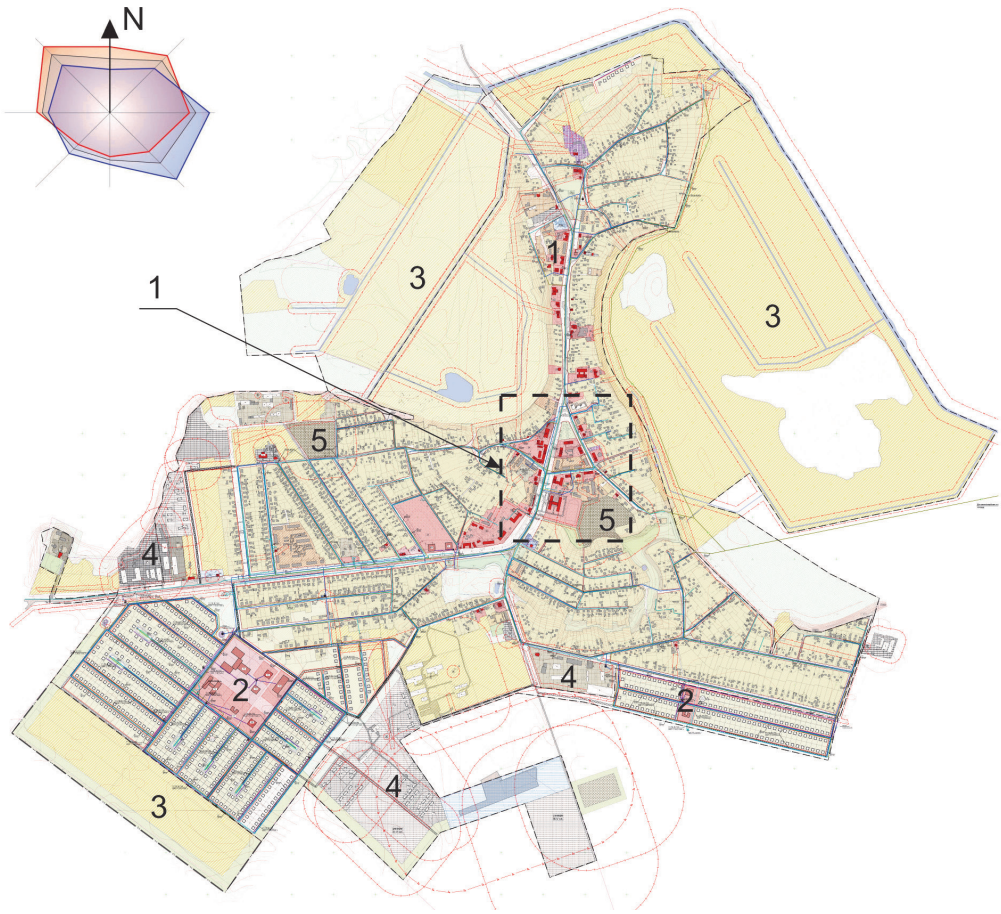

Fig. 2. Master plan scheme of the urban-type settlement Orzhytsia, Orzhytsia district, Poltava region, Ukraine (PoltNTU, Chief Architect of the project A. Dmytrenko, 2017): 1 – public centre of the settlement; 2 – public sub-centres; 3 – agricultural lands; 4 – production areas; 5 – cemeteries (currently in use)

After Ukraine gained independence in 1991, monuments to Lenin were dismantled only in its western regions. In the rest of the territory, the monument to Lenin (or other figures of the communist regime) was the central element of the public centre ensemble in all district administrative centers until 2014–2015 as well as the vast majority of urban settlements in general. The wave of "Lenin falling", which swept the country in 2014–2015, posed a problem, if not for reconstruction, then at least for the improvement of the central areas of the cities/towns (including small ones).

At the same time, the decentralization reform that started in Ukraine in 2014, already led to a significant increase in local budgets in 2016. For local authorities, the improvement of the central part of the settlement (along with road repairs) has become one of the most effective ways to demonstrate to voters their desire and ability to take care of community interests. Therefore, since 2016, with massive reconstruction and major repairs of communal educational, cultural, and health care facilities in many small urban settlements,

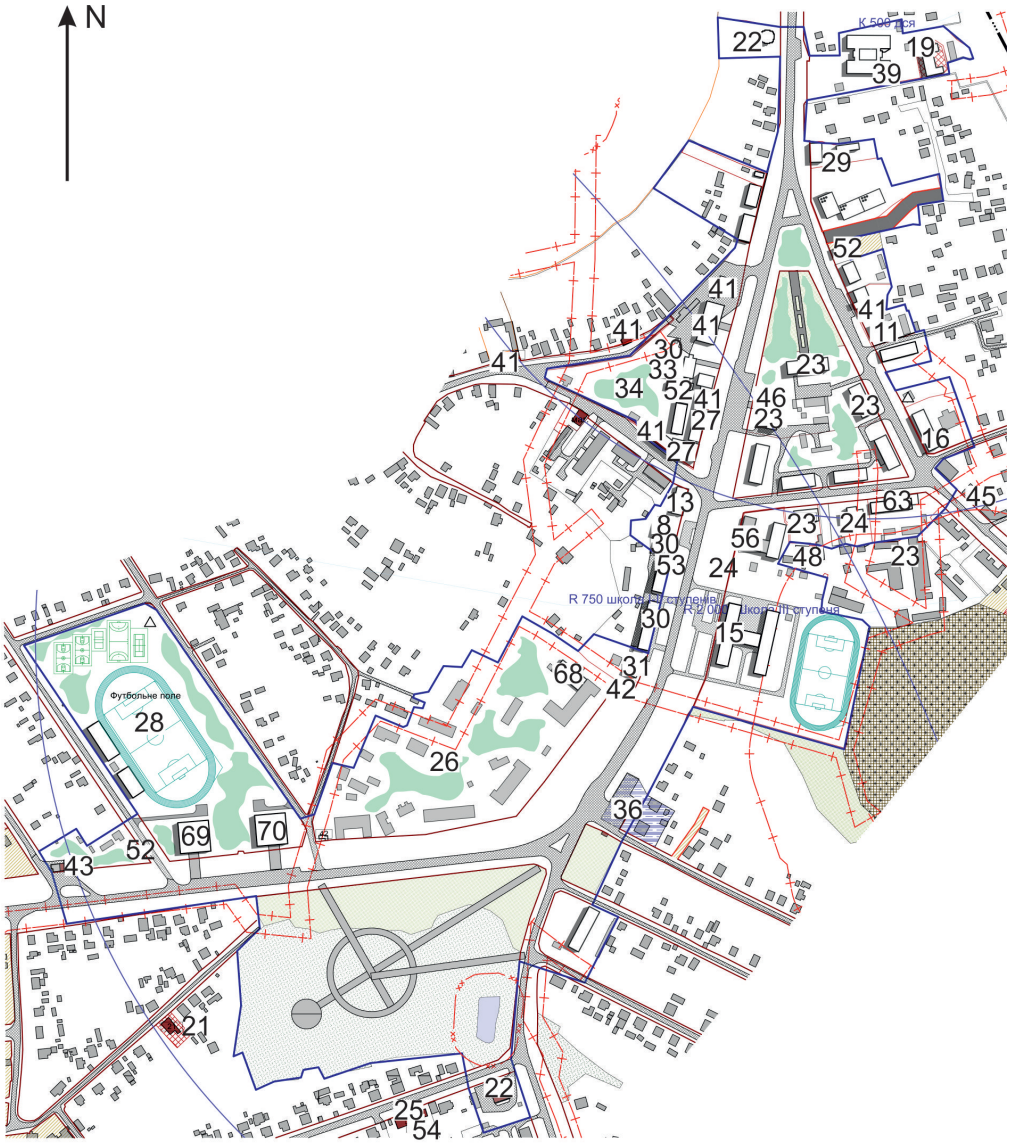

Fig. 3. Scheme of the Orzhytsia settlement public center (PoltNTU, Chief Architect of the project A. Dmytrenko, 2017): 8 – Executive Committee of the Orzhytsia settlement Council; 11 – public prosecutor's office; 12 – court; 13 – district department of the Pension Fund of Ukraine; 15 – school; 16 – editorial office of the district newspaper 'Orzhytski Visti'; 19 – library, historical Museum; 21 – prayer house; 22 – orthodox church; 23 – Orzhytsia distict Council; 24 – fire department; 25 – veterinary hospital; 26 – central district hospital; 27 – pharmacy; 28 – stadium; 29 – branch of the State Treasury Service; 30 – bank branch; 31 – insurance company office; 33 – district Consumer Union office; 34 – market; 36 – bus station; 39 –kindergarten; 41 – shop; 42 – shopping pavilion; 46 – game library; 48 – municipal utility company office; 52 – office building; 63 – district Police Department; 68 – polyclinic (project); 69 – sports hall (project); 70 – indoor swimming pool

major repairs or reconstruction of the central part have already been fulfilled or at least planned. In this case, as a rule, there is no other construction placed on the site of the demolished monument. Instead, the replacement of paving, landscaping, street benches and lanterns was carried out.

Conclusion. Today, most small towns in Ukraine are characterized by low levels of socio-economic development and business activity, but they have significant touristic and recreational, cultural-historical and natural potential. Promotion of tourism development in small cities should be considered as a tool for raising the level of employment of the population, reducing labor migration, strengthening business activity, improving the financial performance of enterprises and forming a positive tourist image.

A quantitative ratio analysis of small towns in the urban settlement system of Ukraine was carried out; their place, role, advantages and unfavorable features were determined in comparison with large cities. Modern approaches to town strategy planning are presented. By the example of small urban settlements Bilyky and Orzhytsia, typical town planning problems were identified from this category of Ukraine's cities.

2. Small towns in Poland

For a Town Policy to be effective it is necessary to have knowledge of town development processes in order to monitor it. Having the right town policy is a very complicated process; we need to know a lot about towns, their development and functionality.

The subject of small towns in Poland has been studied for a long time and it has been dealt with by the greatest Urban planners, architects and authorities. The issues of continuously occurring change and transformation, were investigated by Adamczewska-Wejchert [20], Baginski [21], Bartowicz [22], Zaniewska [33] and Gzell [23, 24].

From the general number of 184 average-sized towns, up to 51.6% were located in five provinces: śląskie (21), wielkopolskie (18), dolnośląskie (17) and łódzkie (15). In the most urban province, śląskie, almost every third town was located (30.8 %). Small towns are presented in a much larger number in the structure of Polish settlement units [30]. According to him, a town status and so-called "town privileges" is given to 893 settlement units. Small towns, i.e. of around twenty thousand residents, make up the largest group at 673 units. The number of medium-sized towns, (twenty to eighty thousand residents) is 180, whilst the number of cities, (more than eighty thousand residents), is only forty [37, p. 32; 11].

Small towns are shrinking. The shrinking of town populations is one of the most important social, economic and spatial phenomena occurring nowadays.

The greatest influence on the process of shrinking towns in Poland are determinants which are inseparably connected with economic transformation, the restructuring of industry, as well as related demographic aspects. The problem of shrinking towns [38] is visible in urban centers where population loss, falling employment rates and negative natural growth are being observed (the balance of migration and transformation of the urban economy structure are not insignificant).

The socio-economic transformation that occurred in Poland in 1989, caused a return to the market economy. One of the main factors influencing urban development was the fact that the control over town spaces was given to local authorities. They represented the interest of local communities in a new political situation.

The socio-economic transformation restored the importance of right to property and freedom of choice. That led, in a great part, to the development of private enterprise in Poland, resulting in an increase of the number of small and medium-sized companies.

The political and economic occurrences observed after the transformation, contributed to the existence of "new" phenomena: increased land-use, dynamic change of urban landscape and architecture as well as an increase in the number of functions within urban areas.

To develop dynamically; municipalities, cities, counties, or voivodeships need an influx of development factors: financial capital, technology, work force and information [27, 28]. Gaining them through marketing became the aim [39]. In his book 'Territorial Marketing', Markowski states that the essence of territorial marketing lies in motive recognition, creating the migration of individuals, owners, managers of firms and supervisory authorities and creating an interesting offer for them, based on the assets of a particular town [27, p. 53].

To fulfill this aim, groups of strategists take actions. They prepare, realize and coordinate marketing activities in a particular town in order to "increase the attractiveness of settlement units".

The tools and means of planners' activities are about recognizing the benefits which can be offered to particular groups of interest: investors, entrepreneurs, tourists and new residents. In practice, the steps will favour new investments, new funds, new workplaces, a new work force, etc. [8].

In order to realise these aims, Markowski believes it is necessary for us to familiarize ourselves with the new needs and desires of all social groups, most of all residents of towns, to adjust the organization and conditions of service held by public institutions [27, p. 61].

Gradually, towns will start competing with each other and the differentiation of their economic development will become more visible. The competitiveness of cities depended, in a great way, on their inherited resources, different potential and local authorities' policy.

First and foremost, the large metropolises of Poland; Warsaw, Krakow, Poznan, Wroclaw and Trójmiasto, became the most competitivedue to their potential to attract new investment and people.

Regions play a great role in town development. Through their ambience, they can have a favourable influence on a particular enterprise [31]. However, the key feature that influences the localization of an enterprise is "availability of communication infrastructure", which is intrinsically linked with the availability of recipients and suppliers, or skilled personnel. The investment localization is often linked with the entrepreneurs' place of residence (The town of Nowy Sącz may serve as an example) [40]. The Von Boventner School of Localization, that expands the theories of Christaller and Losch, underlines the role of places with high centralization.

Another localization feature connected with investments is the presence of firms of the same field in the same area. (The town of Oswiecim may be an example.) The town of

Fig. 4. Oswiecim – map, [online] https://www.google.com/maps/place/O%C5%9Bwi%C4%99cim/@50.0514635,19.1990327,14z/data=!4m5!3m4!1s0x471694e04f384c31:0x1e1c6b2131976ebd!8m2!3d50.0343982!4d19.2097782 (access: 11.07.2019)

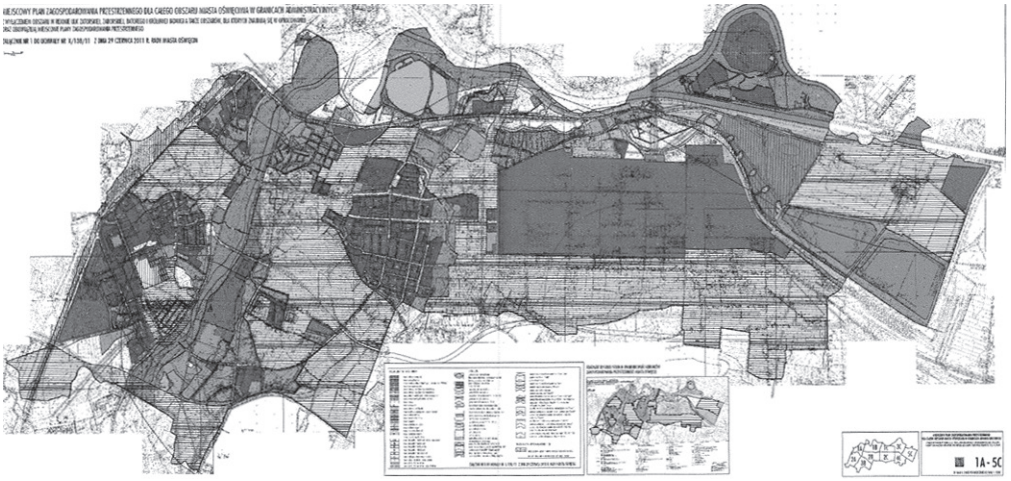

Fig. 5. Development Strategy, Town of Oswiecim, local zoning plan, appendix no 1 Strategia Rozwoju Miasta Oświęcim, Plan miejscowy zał. Nr 1, [online] http://web.um.oswiecim.pl/strategia-uwagi/strategia_rozwoju_miasta_oswiecim_na_lata_2014-2020.pdf (access: 16.07.2016)

Oswiecim is an industrial town, attractive for the development of investment activities due to its location close to the important economic regions of: Górnośląski Okręg Przemysłowy, the Krakow agglomeration and the town of Bielsko-Biala. Economic activity varies; the dominant business is the chemical industry, the mechanical sector, electro-engineering and the production of construction materials. For years, the chemical industry attracted both people and entrepreneurs. We can easily say that the number of residents of Oswiecim has always been strictly connected with it. The census held in Oswiecim in 1946 declared 6708 residents. The largest number of residents occurred in 1992, which boasted a population of 44,874. By

2002 the number had decreased to 41,785 and at the end of 2016 it numbered about thirty seven thousand residents [41].

Through it's different processes, the socio-economic transformation of 1989 in Poland affected the chemical industry, particularly the Chemical Factory in Oswiecim, later known as Chemical Company Dwory. A lot of vacant areas and empty production halls appeared, which caused the shrinking of workplaces and an increase in unemployment. As an answer to this problem, the city reacted by creating the City Zone of Economic Activity and Oswiecim's Enterprise Incubator, that were to help create new workplaces and develop local enterprise. As part of Krakow Technology Park, the Special Economic Zone helped gain new investors. Through all the activities directed towards entrepreneurs and investors, the interest in the town has grown. This is visible today, i.e. in the area of the Town Zone of Economic Activity (MSAG), that occupies the land of the former Chemical Factory (Synthos company) [41].

A good investment atmosphere is always visible in the growth of town income, and consequently influences the quality of public services as well as the economic growth of the town and the region.

The low birth rate is worrying. Towns of this size in Poland are becoming abandoned by young people who cannot see any prospective for their personal development. People of a certain age tend to stay there due to economic and health reasons, but most of all due to a feeling of being rooted in the place, "feeling at home, being amongst ones' own people". They do not want to change their place of living. Since 2001: a negative population growth has been observed in the town of Oswiecim (except for the year 2007), with a negative migration balance in the years of 2001–2012. The number of residents in neighbouring towns has been increasing [34].

"The dominant group of age composition in Oswiecim is formed by people within working age, but the relative share of the post-working age population has been growing. The non-working age population per hundred people has been increasing successively over last three years relative to the working age population: from 60.7% in 2009, 61% in 2010, 62.1% in 2011 to 63.3% in 2012. In particular there is a clear and steady increase in the number of post-working age residents, which should be seen as an unfavourable demographic trend" [34, p. 49].

Stopping the outflow of residents from a town can be achieved through creating workplaces, and attractive conditions for living and rest. Investing in social infrastructure, culture, sport and entertainment, may be key for achieving the goal of making towns more attractive [10].

Towns should become places where we want to live and return to. The overriding objective of town management is to strive for a high quality of life [6] for the residents, an increase in prosperity expressed the large spectrum of their diverse needs. Sustainable urban development, sustainable urban design, urban construction and sustainable urban transport will be reflected in its social dimension [26].

3. Summary

The town development policy, both in Poland and Ukraine, should be based on the paradigm of sustainable development. The process of town shrinking visible in Poland and Ukraine can be seen as negative. The problem should be recognized as dependent on a variety of conditions that lead to multi-aspect consequences. The most crucial determinants are connected with economical transformation and industry structures. Towns are characterized by similar processes, both in Poland and Ukraine, such as: negative birth rate, a decrease in the number of workplaces, aging of societies and the worsening quality of the town environment.

The process of shrinking cities, which is visible in many Polish cities, can undoubtedly be considered as negative. One of the most important challenges for urban planning in 21st-century Poland is to counteract this phenomenon. In a small number of urban centers, the authorities have already taken some steps to reduce the negative effects of the process. The crucial objective is demographic growth in towns, which can be achieved through a variety of tasks at different levels [30].

Recommendations:

- Town involvement in interdisciplinary projects, innovation, systems of incentives, relief related to Special Economic Zones, aims to increase employment by achieving demographic growth in cities;
- Activities held at all levels by the authorities and management strategies with regard to achieving long-term effects particularly focused on the demographic changes of towns;
- Adaptation of towns to new needs, innovation and space development;
- Taking care of the quality of urban spaces and their use through cultural and recreational activities [32];
- Education.

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Multi-family residential development in the landscape of the small city

Zabudowa wielorodzinna w krajobrazie małego miasta

Abstract

The small city is a relatively well examined and widely described subject in literature. Usually, the urban structure of the small city is considered in relation to its original and historical spatial layout with juxtaposition of all subsequent developments in relation to the historical core of given settlement. The article attempts to identify various systems of urban structures in which one of the elements is a group or a single multi-family residential building, examine internal and external scenic relations and determine their impact on the landscape of the small city.

Keywords: city, small city, multi-family development, urban landscape

Streszczenie

Małe miasta jako problem urbanistyczny to zagadnienie stosunkowo dobrze rozpoznane i szeroko opisane w literaturze przedmiotu. Zwykle strukturę urbanistyczną miasteczek rozpatruje się w odniesieniu do genezy i budowy historycznego (pierwszego) układu przestrzennego, wszelkie późniejsze interwencje oceniając w odniesieniu do historycznego trzonu badanej jednostki osadniczej. W artykule podjęto próbę identyfikacji różnych układów struktur miejskich, w których jednym z elementów jest zespół lub pojedynczy obiekt zabudowy mieszkaniowej wielorodzinnej, a następnie zbadano relacje widokowe wewnętrzne i zewnętrzne oraz określono ich wpływ na krajobraz małego miasta.

Słowa kluczowe: małe miasto, miasteczko, zabudowa wielorodzinna, krajobraz miejski

1. Introduction

The small city is a relatively well examined and widely described subject in literature. The widespread existence of small cities as units in the settlement structure in Poland, causes persistent interest in them as research subjects in geographical [2, 7, 5], urban or landscape studies [15, 1, 6, 10]. It is worth noting that existing literature often focuses on the historical aspect of the existence of small settlements, and considers issues of development and functional/spatial transformation of small cities from the point of view of the fine development with a distinct market square [15, 1, 8].

It seems that the above-mentioned features are most often present in the smallest units, called little towns by Wejchert. Considering the size of these settlements, the background and foreground of harmonic view panoramas are clearly visible and they become the scenery for historical central zones, roofs and towers of town halls or churches. The little town is a small community which functions on the basis of a long-existing sense of identity based on memory, identification and consciousness. The values as well as cultural, social and economic characteristics of such a community are different from those of a big city.

It is worth noting that small settlements are no longer charming old towns and their functional structure has changed. Apart from single-family housing and small industrial units, these structures now consist of multi-family buildings (detached or formed in groups) and large commercial/service buildings, warehouses, storage facilities, industrial and production facilities. These transformations, particularly the implementation of multi-family development, are often described as dysfunctions eradicating small city landscapes. Unified apartment blocks constructed in the second half of the 20th century, which were often built in comb layouts, are now presented as destructive elements to the images and identities of places [3, 13] and also as a detriment to the skylines. At the same time, existing groups of multi--family buildings have in fact become integral elements of urban structures. The acceptance of 'large cubature' development is easier when one realises how small city units transformed in recent years. Only the units omitted by transformations have kept their historical structure and silhouette. Changes of architectural characteristics primarily took place during the socialism period, when new forms of residential development appeared even in small villages (multi-family buildings) and advanced during the political transformation period, when such development continued within zones under the influence of large cities.

2. Characteristics of small city landscape

One of the best-known definitions of the small city is given by S. Gzell, who wrote that it is a settlement unit with the following features: small spatial dimensions, a defined and clearly marked area and a close connection to the landscape. As indispensable elements of small cities, the historical aspect and the tradition of the spatial layout are presented, along with the historical formation of the role of the capital of a certain area, the interior aspect of the layout and the scale of the city, which determines the short-distance visibility [6]. This definition

coexists in full accordance with the concept of urban landscape as a meta-concept, which is superior to the constructed environment and is a conglomeration of cultural elements and natural variables in time [4]. This idea was extended by J. Nyka, who interpreted urban space as a specific landscape associated with the narrative of the road. The prospect of receiving urban structure in motion instigated the perception of the city in a formally undetermined and topographic manner, where the dynamics of the natural environmental interactions and the social interactions became important elements of reception [9].

The contemporary small city is not merely an idealistic vision of a historical skyline surrounded by nature. It seems that transformations which take place over time have caused the need of redefining the small city landscape paradigm. This can be seen on the example of some Polish cities transformed during the modernism period (mainly socialist modernism), with their spaces finally devastated in the transformation period (1989 onwards), where the lack of coordinated spatial planning and the continuity of planning decisions, legalisation of illegal constructions and, above all, the priority of spatial management over spatial planning caused irreversible changes to the shape of small cities.

Apart from the geographical and morphological interpretations that refer to hard data such as the number of inhabitants, the administrative status or various quantitative indicators, one can attempt to outline the framework describing small cities from the point of view of identification and perception (with elements of valorisation) of the urban landscape of this settlement unit.

Based on Gzell's definition, the contemporary small city has a limited area and height and is not necessarily clearly defined in space (e.g. Boguchwała, Podkarpackie Province). Another principle is the fact that the city usually functions in connection with the natural landscape (sometimes in a limited way, e.g. small cities of the Upper Silesian Industrial District (GOP) which are elements of an industrial conurbation). This example indicates that the small city landscape does not require references made to surrounding agricultural areas. The necessity of the existence of the impact of the city-forming factor on the plasticity of the city, the fragmentation of plots resulting from inheritance, the quarter development as well as the presence of buildings and complexes of a semi-rural nature have devalued over time. Today, buildings that are an integral part of small cities do not differ from those of large cities, or even metropolitan centres, and include: multi-family residential buildings, large shopping centres and industrial plants architecturally created according to the corporate archetype. Other contested features are "[...] tradition and history of the spatial arrangement; the interiority of the system: streets shaped as an interior with annexes derived from the irregularity of the plan, the integrity of interior enclosures [...]" [6]. There are small cities without any historical core (e.g. Nowa Dęba, Nowa Sarzyna, Podkarpackie Province; Poniatowa, Lubelskie Province). These were established in basic locations as factory residential estates for large industrial investments of the Second Republic (1919–1939), and eventually, they transformed into self--sufficient urban units. The cores of these cities are estates consisting of multi-storey apartment blocks without strictly formed enclosed interiors [11, 12].

3. Relations between functional/spatial zones in selected small cities of the Podkarpackie Province

In order to identify landscapes in relation to their location and type of multi-family development in the spatial structure of small cities, cartographic materials such as orthophoto maps were analysed and field inventory procedures were conducted.

The research identified the following four basic types of multi-family development in small city structures of the Podkarpackie Province (Table 1):

- single 'islands' located outside the main core of the city, which remains historical and traditional;
- boundary development present in quarters designated by the historical urban street layout, which complements previously integrated frontages;
- large groups of housing estates (structural units), which dominate over small tenement or single-family detached architecture;
- development which is the core of a settlement unit (the oldest part, a city-forming factor).

The above-mentioned types of development are the most common and reflect typical relations of functional/spatial zones. During the examination of small city structures in the Podkarpackie Province, one can also find conglomerate units of various types, and also cities where multi-family development is absent or too limited to affect the cityscape.

Table 1. Basic types of multi-family development in small city structure (own study)

	Type	Characteristics of the	City
I	island	single 'islands' located outside the main core of the city, which remains historical and traditional	Sokołów Małopolski Głogów Małopolski Kańczuga
II	frontage	boundary development present in quarters designated by the historic urban street layout, which complements previously integrated frontages	**Dukla** Błażowa Kolbuszowa
III	housing estate	large groups of housing estates (structural units), which dominate over small tenement or single-family detached architecture	**Ropczyce** Łańcut Przeworsk Leżajsk
IV	core	development which is the core of settlement unit (the oldest part, city formation factor)	**Nowa Dęba** Nowa Sarzyna

For the purpose of this study, drafts of selected small cities have been prepared (Sokołów Małopolski, Dukla, Ropczyce and Nowa Dęba), with the indication of possible view openings that are directed towards parts of urban structures with a multi-family development character. Urban units selected for this simplified visual analysis vary in terms of their natural, cultural, communicational and compositional conditions. Above all, they are represented in relation to spatial structures and reflect all four types of spatial structure connections.

The cityscape of Sokołów Małopolski (Fig. 1 – I) is dominated by the ordered pattern of small tenement houses and single-storey houses that form frontages. The central part of this compact urban structure, which is listed in the heritage registry, is a large market

square (around 150 x 150 m), which is unfortunately overgrown with plants. The eastern frontage is the most transformed. Outside of the square, but in its immediate vicinity, there is a Roman Catholic church in the south, which forms the main dominant feature of the system. North of the square there is a building of a former synagogue, and next to it there are modernist department stores clearly standing out of the surrounding. Buildings of larger dimensions are located only on the northern periphery on the outskirts of the city, about 600 m from the market square and include schools, a swimming pool, a food discount store, a furniture warehouse and a small group of four apartment blocks built in a comb layout. The 40-m-long blocks are constructed in large slab technology and consist of five storeys and five staircases each.

The island of multi-family development is, by its size, clearly distinguishable from the background of small single-family houses and similar-scale service facilities. Due to its location next to a national road that goes through the city, these buildings become the second plan of 'the gate to the city' (Fig. 1, view A), and in the case of further perspectives, they become the main plan (Fig. 1, view C). Currently, the main transit route is national road, while on the west side of the city, a ring road is under construction. After completion of the investment, the island of multi-family blocks will be the most important dominant feature and landmark of the city, which will significantly affect the skyline of this old settlement.

Dukla (Fig. 1 – II) is a city located in a mountain landscape, which affects the spatial exposure of its structural elements. The urban structure together with the market square is located in the valley and only one national road leads to the city. Dukla does not have a ring road. The central part of the city is a small market square (around 90 x 55 m), with the city hall in the middle. The square is surrounded by two-storey tenement houses. The entry road to the city is also lined with two-storey tenement houses, which gives the town the impression of importance. Despite its urban layout, it is not protected by any form of legal protection, the city structure is dominated by order and harmony. This is evident on the example of the existing blocks of multi-family development, which are oriented in such a way that they imitate the walls of a quarter development. The multi-family development is located in the southern part of the city, and consists of two- and five-storey buildings from different periods. The southernmost buildings have sculpted facades, which makes them seem visually more interesting.

Distant scenic exhibitions are virtually impossible. The buildings are raised in accordance with a quarter development layout and have **frontages** covered with plants. Due to the local topography, the observer can see only close plans (Fig. 1, views D, E, F) and the multi-family development being practically unnoticeable fits perfectly into the cityscape.

In the case of another city, Ropczyce (Fig. 1 – III), the local topography also influences the perception of its cityscape, especially with regard to external sceneries. The settlement of Ropczyce belongs to larger settlement units in the category of 'small cities'. It is located on a hilly and varied terrain. The traditional spatial layout, much like Dukla, is located in the valley, but the modern urban structure has grown to such an extent that the buildings have spread over nearby hills. There are very few historical buildings in the city and those that

are preserved (the Roman Catholic church and several residential and service buildings) are scattered and do not form any group. The majority of the urban structure is comprised of objects constructed after World War II. The reason for this situation is that the majority of pre--war buildings in Ropczyce were wooden buildings and they have not survived. The historical spatial layout (recognisable in the street layout) includes a market square, which does not seem to be an important spot for the observer, due to the random modernist and postmodernist buildings surrounding it. Moreover, the shape of the market square is disturbed by expanding its scope up to the dominant features of the layout (a church). Multi-family development groups are located both in the urban structure (in the western part) and on the hills on the outskirts – such as the Górka Ropczycka. In the city centre structure, they have the island character, whereas in the higher parts of the city, the buildings form **housing estates** in the landscape style. Long five-storey blocks are built in lines and their layout follows the terrain in cascades. In between them, there are lines of tower blocks of similar height.

Ropczyce is a unit that is sufficiently large and dispersed for multi-family buildings to be analysed with regard to both internal and external sceneries. In the case of internal sceneries (Fig. 1, view K), the islands of multi-family development form a certain breach in the landscape, but the spatial chaos of the city in question is so evident that they do not diverge from the surroundings. In the case of external sceneries, view openings at the western entrance to the city were studied (Fig. 1 – I), where the multi-family development creates a gate and makes the observer unaware that they are entering the small city. The distant plan views from the ring road

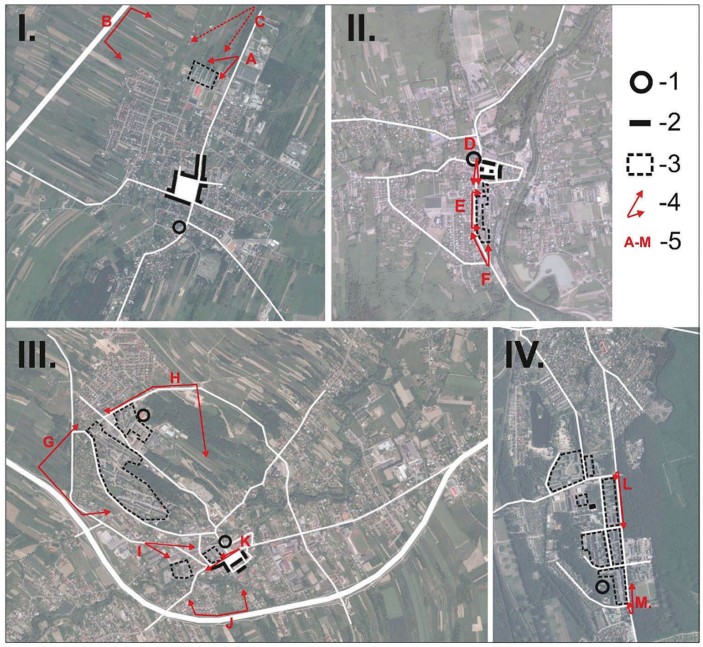

Fig. 1. Outlines of selected small cities, I – Sokołów Małopolski, II – Dukla, III – Ropczyce, IV – Nowa Dęba. Markings: 1 – the main dominant feature of the system, 2 – market square frontages, 3 – multi-family housing development areas, 4 – view openings, 5 – views described in the text (own elaboration based on orthophoto maps taken from the geoportal, 2019)

(national road) (Fig. 1, views H, J, G) were also studied. Distant plan views on the cityscape are often intended for passers-by. In this case, due to the local topography and the location of buildings on the hills, the development dominates over the small buildings of the city, overwhelming and obscuring them. The multi-family development in the landscape style, forms a kind of wall that makes the city seems to be uninteresting and not worthy of attention.

An entirely different type of city is Nowa Dęba (Figs. 1 – 4). This modern city owes its existence to the regaining of the independence of Poland and to the location of the Central Industrial District in the eastern part of the country (central Poland at the time). The industrial plant and the first apartment blocks were built in the interwar period, but the defined urban structure and its specific quasi-quarters were laid out in the period of socialist realism. Meandering-quarter patterns of five--storey residential buildings form the **core** of the city, which is also its oldest part and is usually associated with old tenement houses and a centrally located market square. In the case of Nowa Dęba, the square was formed secondarily by transforming the fragment of the Municipal Forest, which explains the lack of characteristic frontages and makes the interior rather objective. Apart from the core, the city consists of residential estates built in subsequent years in comb and comb--fan layouts. The multi-family core of the city is surrounded by modern single-family development. The typical feature of cities that were established in basic locations, as a part of COP investment, is their location in dense forest areas, which clearly limits the boundaries of the development.

The location of the city in the forest causes limitation of its visibility from distant schemes. The city does not have a ring road, so the main view openings are located at the entrances to the dense urban structure (Fig. 1, views L, M). From these perspectives, multi-family development systems seem to be attractive. The organised modernist and socialist realism complexes, including service shops on the ground level, are rhythmical, calm and have static composition. The curve of impressions of such patterns is not very diverse, but it can be an asset in ubiquitous contemporary spatial chaos.

4. Summary

The multi-family housing development within the structure of small cities has existed for many years. Literature concerning small cities has mainly offered publications on their origin, history and spatial changes over different historical periods, where small cities are identified with picturesque market squares and organic development. Multi-family buildings appear as single units or in groups, and similar to large commercial buildings, are sometimes considered dysfunctions or a source of harm to the cityscapes of small settlement units. Undoubtedly, an incorrectly located group of objects that have significantly different sizes or contrast with the existing cityscape and dominant features of the city may negatively affect the spatial perception of the city. This also means that such a situation may have an impact upon economic relations, local marketing as well as on living standards of the city. This article was an attempt to identify various systems of urban structures where one of the elements is a group or a single object of multi-family housing development. After examining the scenic relations, it was found that it is feasible to determine the type of relationship between positive and negative elements, depending on

the location and nature of the development, and the distances and locations of the view points and view plans see above note re use of 'plans'. Further research in this respect may lead to the development of methods of functional, compositional and spatial shaping of urban structures, which may allow the controlled creation of the harmonious landscape of the small city.

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A short historical overview of wind characteristics and wind pressure for design in Romania

Krótki przegląd historyczny charakterystyk i ciśnienia wiatru z projektu badawczego w Rumunii

Abstract

This paper provides an overview of wind observations in Romania with historical data, particularly after the establishment of the national meteorological network in 1884. Data on wind directions and velocities is presented, focusing on a sample of fourteen cities including the capital Bucharest. The historical evolution of national zonation maps for wind pressure is shown. A statistical description of the maximum annual wind velocity data is also presented.

Keywords: wind direction, wind velocity, wind pressure map, wind code, meteorological station

Streszczenie

Atrykuł przedstawia zbiór danych z obserwacji wiatru w Rumunii wraz z zapisami z poprzedniego stulecia, dokładnie zbieranymi od momentu ustanowienia krajowej sieci meteorologicznej w 1884 roku. Przedstawiono dane dotyczące kierunków i prędkości wiatru. Skupiono się na próbie czternastu miast, w tym stolicy – Bukaresztu. Pokazano historyczną ewolucję map krajowych stref obciążenia wiatrem. Przedstawiono również statystyczny opis danych dotyczących maksymalnej rocznej prędkości wiatru.

Słowa kluczowe: kierunek wiatru, prędkość wiatru, mapa ciśnienia wiatru, norma wiatrowa, stacja meteorologiczna

1. Introduction

Located in the East of Europe, Romania is a country with a transition temperate--continental climate [1]. Its territory spreads from 43.55° to 48.28° N and from 20.25° to 29.83° E.

Ovid (Publius Ovidius Naso, 43 BC – AD 17/18), an exiled Roman poet from ancient Tomis (present day Constanța) made, in his *Poems of Exile* [2], some of the oldest written mentions (AD 8-12) on the hard winters and the cold strong winter winds on the Romanian Black Sea coast, winds that were even causing damage to the built environment:

> […] Snow falls, and, once fallen, no rain or sunlight melts it,
> since the north wind, freezing, makes it permanent.
> […] The power of Aquilo's* northern gales is such
> it razes high towers, and blows away the roofs.
> […] The Danube itself, no narrower than lotus-bearing Nile, […]
> congeals, the winds hardening its dark flow,
> […] and, like the snow the rainy south wind melts,
> […] Zephyrus* lessens the cold, now the past year's done,
> […] Here's the source of the north wind, Boreas, and this coast
> is his home, and he gains power from the location.
> But Notus*, the south wind, blows warm from the opposite
> pole, is far from us, is rarely experienced, and is feeble.
> […] and though Boreas* roars and thrashes his wings,
> there's no wave on the besieged waters.
> The ships stand locked in frozen marble,
> […] Whether the savage power of wild Boreas
> freezes the sea-water or the flowing river,
> as soon as the Danube's levelled by dry winds […]
> *Aquilo – the North wind, as a god he is Boreas; Auster – the south wind; Eurus – the east wind; Zephyrus – the west wind.

More evidence of strong winds and storms is found in documents dating from the Middle Ages especially from foreign travellers. For example, in 1720–1723, captain Friedrich Schwanz von Springfels travelled to the southern part of Romania and noted the following with regard to the mountain crossing: "no road could be done because of the high and big mountains and because of the storms […] if such a storm catches up someone, it almost blinds men and cows and throws them down the cliffs, and, unfortunately there are many sad examples as every year people and animals are dying in this way" [3]. In 1786, the German merchant Jenne Lebprecht travelled in the Romanian territories and noted: "After 10 p.m. the silence changed into a terrible storm from SE […] after midnight the storm changed into a heavy rain and in the morning the NE winds got stronger and it was one of the strongest storms I can recall […] at 3 p.m. the rain changed into snow […] the NE wind blew during the snow […] At 8 a.m. in the morning the NE wind got again stronger […]" [4].

Meteorological observations were sparse, random and unmethodical until the second half of the nineteenth century. The start of these observations was presented by Hepites in 1886 [5]: the first organised reports were available for the city of Iași for the years

1839 and 1840, but no data on the instruments and/or methodology are known; the first meteorological station to be properly organised was in Sulina on the Black Sea coast from the network organised by the Danube European Commission in 1859; measurements were also performed in Bucharest in the period 1857–1869 and occasionally in Brăila and Galați. The national network was organised at the initiative of the Minister of Agriculture, Commerce, Industry and Territories. The Meteorological Institute of Romania was created in 1884 and started to provide data on 1st July of the same year. At the beginning of 1885, there were five stations in operation: Bucharest, Sulina, Galați, Giurgiu and Strehareț. In the same year, another six stations were established: Turnu-Severin, Balota, Constanța, Craiova, Pâncesci--Dragomiresci and Iași. According to Hepites' detailed report [5], twelve measurements per

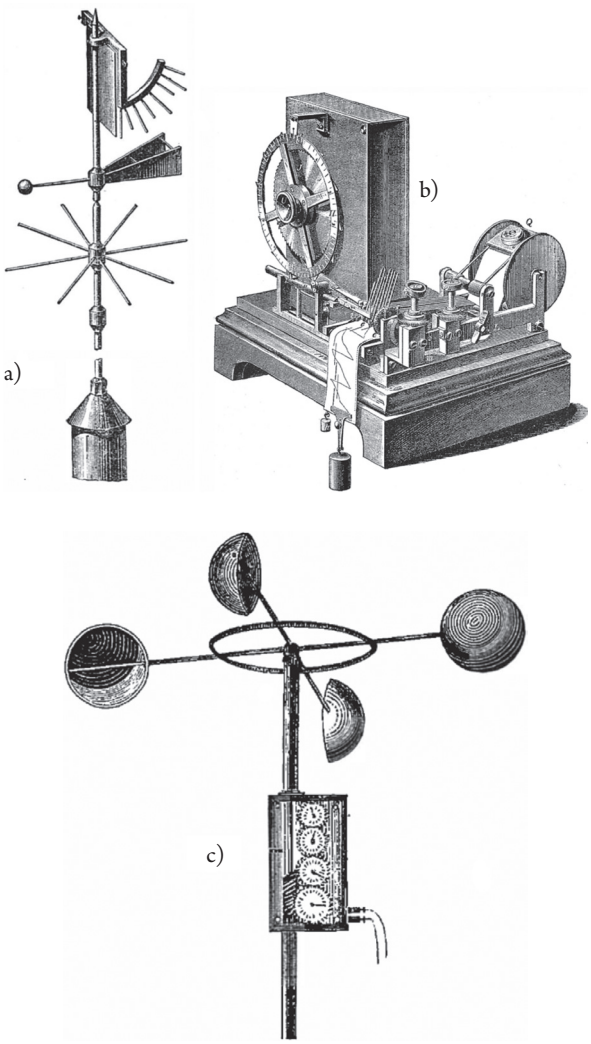


Fig. 1. Wind measurement equipment at the first Romanian meteorological stations (1885): a) Wild weathervane, b) Sprung anemometer and recorder, and c) Robinson anemometer [5]

day were performed with a Wild weathervane (Fig. 1a), a Sprung anemometer and recorder (Fig. 1b) and a Robinson anemometer (Fig. 1c) with cups located at a height of around 15 m above the ground.

The meteorological network developed rather quickly: 1887 – 30 stations, 1899 – 50 stations, 1906 – 66 stations [7], 2013 – 258 stations [1].

In the present day, the National Meteorological Administration [1], is officially in charge of meteorological observations. It operates 160 automated stations: 71% of the stations are in lowlands, 12% are in hilly areas, 4% are on the coast and 13% are in mountains. Some stations are located at high altitudes, such as Ceahlău Toaca (1897 m) and Călimani (2021 m), the highest station being Vărful Omu, located at 2504 m.

On 3rd July 1948, Romania joined the convention of the World Meteorological Organisation [6] (created in Washington on 11th of October 1947). The Romanian meteorological network is part of the permanent world survey, Region VI – Europe, of the World Meteorological Organisation.

2. Wind characteristics in Romania

2.1. Wind directions

In Romania, wind directions are influenced by regional air movement and by the Carpathian Mountains. On the open mountain heights, the dominant wind direction is from the west, which is characteristic for temperate latitudes [7]. A good example is provided by the highest meteorological station at Vârful Omu (altitude 2504 m) for which the west winds (SW, W, NW) account for a total of 57.9% of the annual frequency. Other stations on mountain tops display similar frequencies, sometimes even higher than 60%. The frequency of calm conditions for these stations is approximately 11%.

Local landforms strongly influence the wind direction at lower altitudes in the mountain area. In the centre and south of the Romanian Plain, the main wind directions are from the west and the east. In western Romania, the predominant wind direction is from the south. A certain directional frequency variability was observed on both a monthly and seasonal basis over the duration of one year, and for different time intervals.

A sample of fourteen stations has been selected (geographically distributed as shown in Fig. 2), and their directional mean wind frequencies are presented in Table 1 with data from two time intervals: 1941–1955 [8] and 1961–2000 [7]. Some graphics based on Table 1 data are given in Fig. 3 (note that this does not include data relating to calm conditions).

The data from Constanța confirms the ancient observations of the poet Ovid who noticed the predominance of strong north winds in the winter. This is also indicated Hepites [9] the predominance of North winds for Constanța region in 1901: N – 35%, S – 24%, W – 22% and E – 13%, calm – 6%. Data from 1961–2000 [7] indicates a similar distribution: N – 36.1%, S – 29.5%, W – 16.4% and E – 6%, calm – 12%, as does the data from 1941–1955 [8]: N – 42%, S – 24%, W – 12.7% and E – 6.1%, calm – 15.2%.

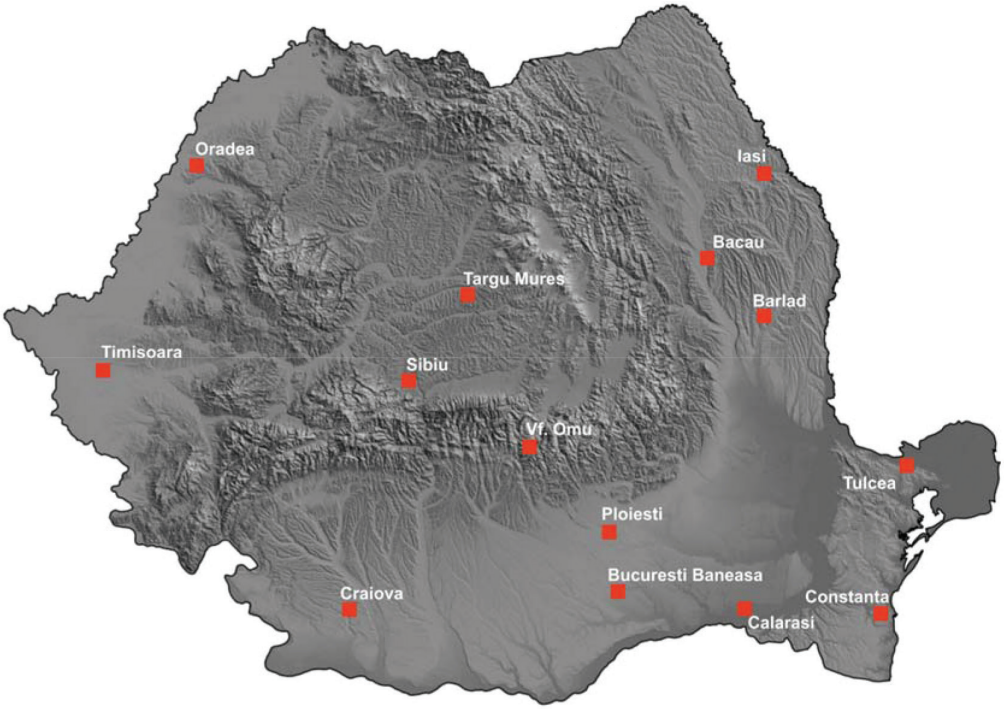


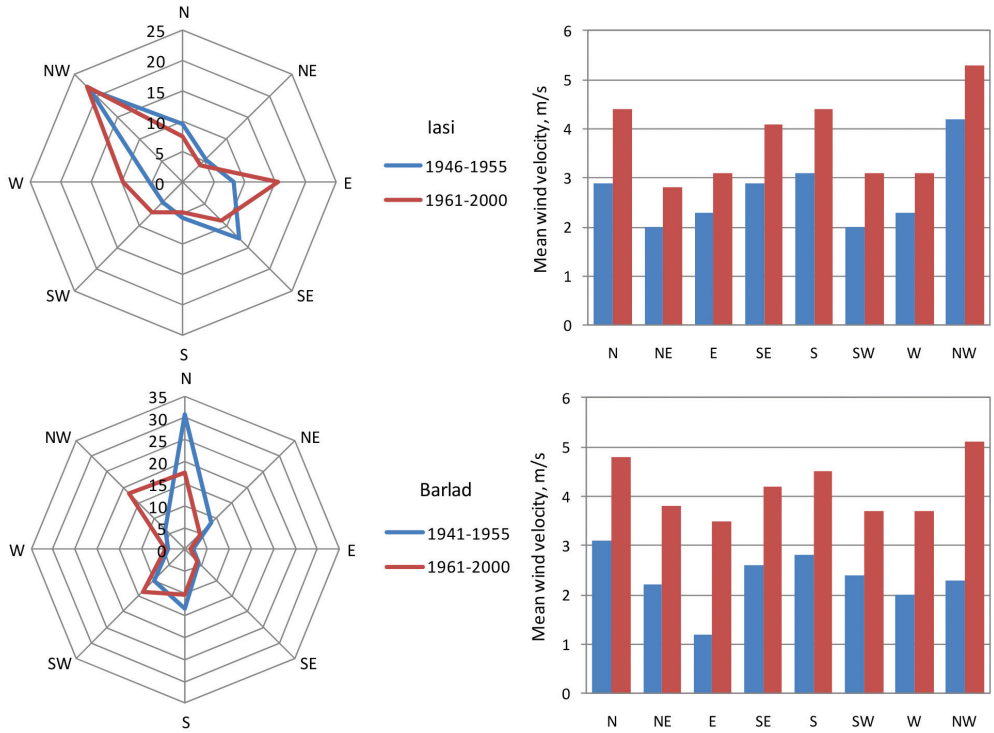
Fig. 2. Geographical distribution of the selected sample of fourteen meteorological stations in Romania

Table 1. Examples of mean frequencies (%) of wind directions (data from [8, 7])

Meteorological station	Time period	Direction								
		N	NE	E	SE	S	SW	W	NW	Calm
1	2	3	4	5	6	7	8	9	10	11
Iași	1946–1955	9.5	5.3	8.3	13.0	5.7	4.6	5.5	21.5	26.6
	1961–2000	7.6	4.0	15.4	8.7	4.8	7.0	9.7	22.1	20.7
Bacău	1941–1943; 1945–1955	19.4	4.0	2.0	13.4	13.6	4.0	3.4	17.5	22.7
	1961–2000	16.4	0.9	0.5	7.6	16.0	2.0	3.1	12.3	41.2
Bârlad	1941–1955	30.9	8.5	1.8	4.4	13.5	10.1	4.0	6.3	20.5
	1961–2000	17.6	4.8	1.2	3.8	10.4	13.7	4.4	17.9	26.2
Tulcea	1946–1955	3.2	5.5	9.7	3.3	1.6	3.5	13.9	17.1	42.2
	1961–2000	12.3	7.5	5.6	8.1	9.7	5.8	9.8	17.4	23.8
Constanța	1941–1955	21.5	11.7	6.1	8.7	9.4	5.9	12.7	8.8	15.2
	1961–2000	13.1	12.0	6.0	10.5	11.9	7.1	16.4	11.0	12.0
Călărași	1941–1955	14.8	13.3	8.0	9.8	4.6	12.4	16.4	7.8	12.9
	1961–2000	9.2	16.6	10.2	8.7	5.7	9.6	17.4	5.7	16.9

Tab. 1 (cont.)

1	2	3	4	5	6	7	8	9	10	11
Ploiești	1946–1955	11.6	14.9	13.3	4.9	6.3	10.4	6.0	6.8	25.8
	1961–2000	14.6	16.0	9.5	2.8	2.5	7.8	9.2	5.6	32.0
Bucharest Băneasa	1941–1955	5.0	21.6	19.7	5.0	3.3	16.8	13.8	4.9	9.9
	1961–2000	3.4	16.4	10.3	1.8	1.5	11.7	9.2	2.3	43.4
Craiova	1941–1955	3.4	9.1	24.6	3.0	1.9	3.4	18.7	9.6	26.3
	1961–2000	2.5	12.0	21.1	4.0	2.9	4.6	20.2	5.6	27.1
Timișoara	1941–1955	16.9	8.7	15.0	7.4	8.4	6.6	7.0	9.1	20.9
	1961–2000	7.2	5.5	5.7	3.9	9.1	6.4	9.4	12.7	40.1
Oradea	1947–1955	11.0	8.9	7.9	5.7	13.3	12.1	3.4	7.0	30.7
	1961–2000	9.3	4.8	7.3	11.3	18.2	14.6	6.1	5.0	23.4
Târgu Mureș	1946–1955	7.8	10.8	6.2	9.2	4.9	7.3	6.9	12.4	34.5
	1961–2000	15.1	9.2	3.0	4.8	4.6	10.4	12.3	14.4	26.2
Sibiu	1941–1955	7.9	3.2	9.5	21.4	5.2	4.0	6.1	18.5	24.2
	1961–2000	2.0	0.9	4.2	8.1	2.6	2.5	8.4	11.2	60.1
Vârful Omu	1941–1955	4.6	7.9	6.0	7.1	8.4	17.2	21.5	25.6	1.7
	1961–2000	6.9	9.3	4.5	2.9	6.6	20.8	20.9	17.8	10.3



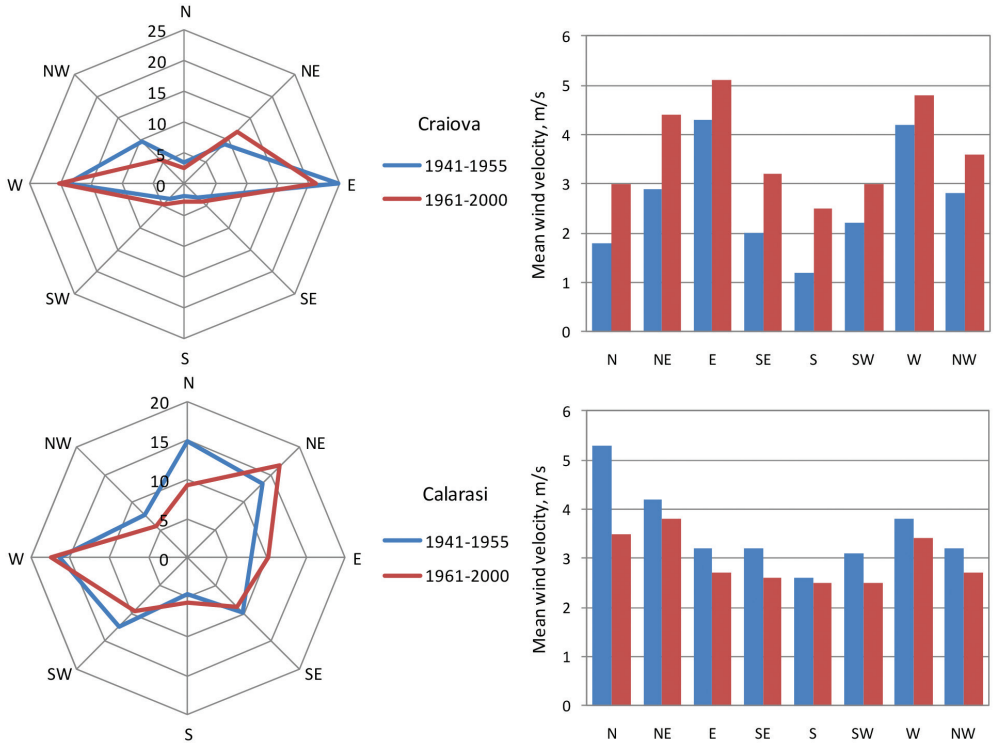


Fig. 3. Examples of mean frequencies of wind directions (%) – left, and of directional mean wind velocity (m/s) – right

2.2. Wind velocity

The highest directional mean wind velocities are generally observed on the directions with higher frequencies. In Table 2 are presented the directional mean wind velocities based on data from two time intervals: 1941–1955 [8] and 1961–2000 [7]. One may observe that except for two stations (Călărași and Tărgu Mureș), the mean wind velocities are higher in the 1961–2000 period than in the 1941–1955 period. Some graphs based on Table 2 data are presented in Fig. 3.

Table 2. Examples of directional mean wind velocity (m/s) [8, 7]

Meteorological station	Time period	Direction							
		N	NE	E	SE	S	SW	W	NW
1	2	3	4	5	6	7	8	9	10
Iași	1946–1955	2.9	2.0	2.3	2.9	3.1	2.0	2.3	4.2
	1961–2000	4.4	2.8	3.1	4.1	4.4	3.1	3.1	5.3
Bacău	1941–1943, 1945–1955	3.8	1.8	1.2	3.8	3.8	2.9	2.8	4.1
	1961–2000	4.8	3.2	2.5	4.5	4.1	4.5	5.0	4.8
Bârlad	1941–1955	3.1	2.2	1.2	2.6	2.8	2.4	2.0	2.3
	1961–2000	4.8	3.8	3.5	4.2	4.5	3.7	3.7	5.1

Tab. 2 (cont.)

1	2	3	4	5	6	7	8	9	10
Tulcea	1946–1955	0.8	2.6	3.2	2.3	0.8	1.5	2.3	3.4
	1961–2000	4.2	3.9	3.5	4.7	5.1	4.1	3.3	3.9
Constanța	1941–1955	4.3	3.8	2.4	3.4	3.6	3.6	4.0	3.1
	1961–2000	6.5	6.4	4.6	4.2	4.0	3.5	4.0	4.5
Călărași	1941–1955	5.3	4.2	3.2	3.2	2.6	3.1	3.8	3.2
	1961–2000	3.5	3.8	2.7	2.6	2.5	2.5	3.4	2.7
Ploiești	1946–1955	2.3	3.1	3.1	2.6	2.8	2.9	2.6	2.3
	1961–2000	2.3	3.0	3.4	2.9	2.8	3.3	3.1	2.4
Bucharest Băneasa	1941–1955	2.6	4.5	3.8	2.4	2.2	3.1	3.4	2.3
	1961–2000	2.7	4.0	3.7	2.7	2.7	3.3	3.4	2.5
Craiova	1941–1955	1.8	2.9	4.3	2.0	1.2	2.2	4.2	2.8
	1961–2000	3.0	4.4	5.1	3.2	2.5	3.0	4.8	3.6
Timișoara	1941–1955	3.4	2.2	2.2	2.6	3.8	2.6	2.8	2.9
	1961–2000	3.7	2.4	2.3	2.8	3.6	3.2	3.2	3.4
Oradea	1947–1955	3.2	3.1	2.2	2.6	4.0	3.8	2.6	2.8
	1961–2000	4.1	3.9	3.1	2.8	4.2	4.2	3.4	3.3
Târgu Mureș	1946–1955	2.2	1.8	2.3	2.6	2.2	2.4	2.6	3.1
	1961–2000	1.7	1.8	2.3	2.4	1.9	2.1	2.3	2.6
Sibiu	1941–1955	0.8	2.6	3.4	2.3	0.7	1.5	2.3	3.4
	1961–2000	2.8	2.6	3.4	4.4	4.9	3.1	4.1	3.9
Vârful Omu	1641–1955	5.1	4.7	4.5	5.7	7.2	7.2	6.6	8.1
	1961–2000	9.0	10.0	9.3	10.6	11.1	9.7	9.1	10.6

The study of the Meteorological Institute [8] indicates maximum wind velocities of 29 m/s in the south and east of Romania, and of 23–27 m/s in the west. In Central Romania, wind velocity extremely rarely reached 20–25 m/s. At Vârful Omu, wind velocity exceeds 30 m/s almost every year; on 9th December 1955, a maximum of 43.8 m/s was recorded.

A more recent study of the National Meteorological Administration [7] indicates that the annual maximum wind velocity was ≥40 m/s at all the mountain stations in open terrain in most of the Moldavia region, north of Dobrogea and on the Black Sea coast. In a few areas in the Transylvania plateau and in the protected mountain areas, the annual maximum wind velocity was lower than 20 m/s, while in the rest of the territory it was 20÷30 m/s.

2.3. Wind direction and velocity in Bucharest

Bucharest, the capital city of Romania, is located in the southern part of the Romanian Plain; its altitude varies between ~60 m and ~100 m.

Perhaps the oldest methodical observations on wind directivity in Bucharest are those made by Lessmann in 1870 (data presented by Hepites in 1904 [11], based on manuscripts).

Lessmann documented the storms and strong winds over the whole year, for each month. In total, he noticed 43 storms (from which 24 were from the north-east direction, 10 were from the east and 6 were from the west) and 24 strong winds (from which 8 were from the north--east and 13 were from the east and south-east).

Wind directivity has a rather constant pattern. In Fig. 4 different mean frequencies of wind direction (in %) are graphically presented for two time-intervals, 1941–1955 (data from [8]) and 1961–2000 (data from [7]), and for individual years, 1885 (data from [5]), 1902 and 1903 (data from [10]). The calm conditions are not included.

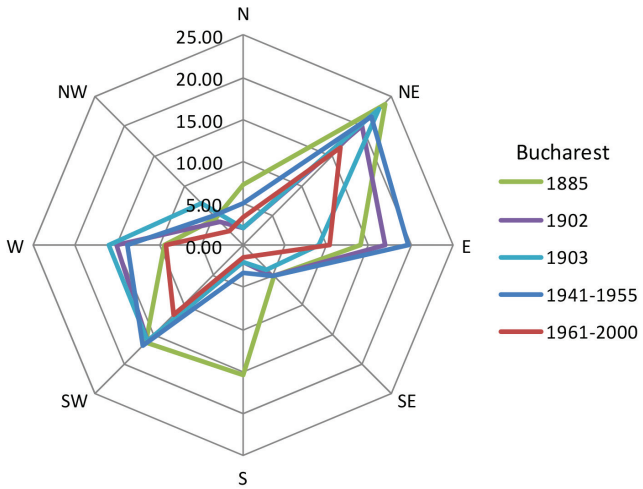


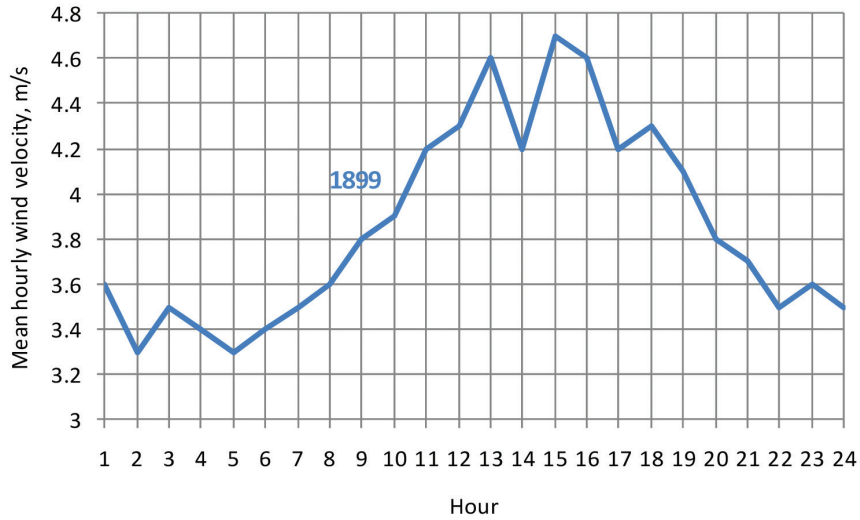
Fig. 4. Mean frequencies of wind directions in Bucharest (in %)

Probably the oldest data on wind speed in Bucharest was presented by Hepites in 1886 [5]: the 1885 annual mean wind speed was 3.9 m/s and the maximum wind speed was 24 m/s (on 19th January 1885). The same annual mean wind speed was reported by Hepites [11] for the year 1899. In the same study, Hepites presented data on the 24 h variation of mean hourly wind speed in 1899, a graphical representation is presented in Fig. 5 (top image). The data from 1902 and from the time period 1885–1900 display the same pattern, Fig. 5 (bottom image, [10]).

For the year 1903, Hepites [9] indicated that strong winds had velocities between 13 and 18 m/s, and he reported a storm on 25th July when the maximum wind velocity reached 22 m/s.

Murat [12] studied the winter of 1906/1907. For comparison, after analysing 23 winters, he evaluated the mean winter wind velocity in Bucharest as 4.3 m/s with a range of between 3.0 m/s in 1906 and 5.6 m/s in 1893. Murat indicated the range of hourly mean wind velocity in the winter months: December – min. 9.7 m/s in 1887, max. 26 m/s in 1897; January – min. 10.7 m/s in 1904, max 24.8 m/s in 1895 and February – min. 9.6 m/s in 1905 and max. 22.5 m/s in 1890. For the winter 1906/1907, he indicated the monthly maximum daily mean wind velocity: 6.8 m/s in December, 6.1 m/s in January and 9.8 m/s in February; and the maximum hourly mean wind velocity: 11 m/s in December and 12 m/s in January and February.

The maximum wind velocities recorded in Bucharest are also presented [10]: the overall maxima at that time were – 28.0 m/s (27th November 1890), 1902 maxima 22.7 m/s (5th December) and 1903 maxima 15.5 m/s (13th December). Significant values were recorded in 1954 – 35 m/s (3rd of February) and in 1962 – 38 m/s (30th and 31st January) [8]. The study of the Meteorological Institute [8] indicated the mean annual wind velocity at Bucharest for the period 1896–1955: 2.0 m/s, varying between 1.2 m/s in 1942 and 1950 and 2.8 m/s in 1904.



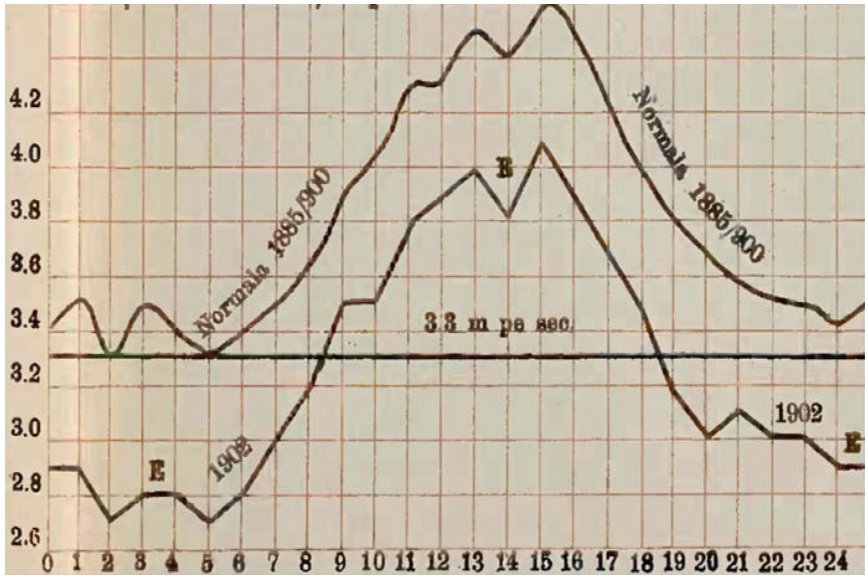


Fig. 5. 24 h variation of mean hourly wind speed in 1899 (top image, data from [11]) and in 1902 and in the period 1885–1900 (bottom image, [10])

Seasonal mean wind velocities are presented in the Bucharest Year Book of 1906 [10], Table 3.

Table. 3. Seasonal mean wind velocity in Bucharest

Season/year	1885–1900	1902	1903
winter	4.4	4.6	3.7
spring	4.5	3.7	3.7
summer	3	2.5	2.4
autumn	3.3	2.8	3.3
average	3.8	3.4	3.3

3. Evolution of wind pressure maps for design

The first provisions for design for wind action were included in the Romanian Standard STAS 946 from 1956 [13] together with those for snow and temperature. It included the 2-zone wind pressure map shown in Fig. 6.

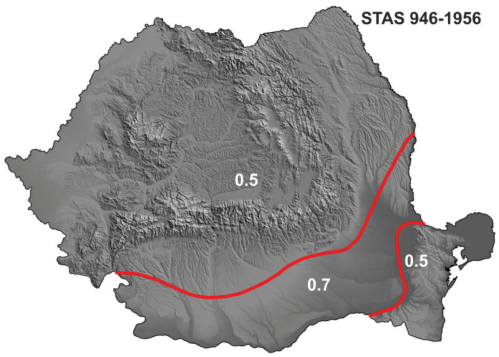


Fig. 6. Wind pressure zonation map in STAS 946-1956 (kN/m²)

STAS 10101/20 from 1975 [14] and 1978 [15] were entirely devoted to wind actions. The two standards contained the same new five-zone wind pressure map, Fig. 7.

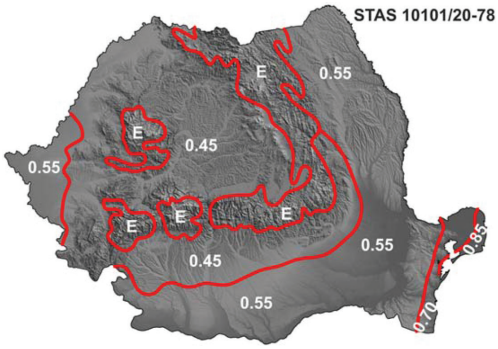


Fig. 7. Wind pressure zonation map in STAS 10101 from1975 and 1978 (kN/m²)

The STAS 10101/20-1990 [16] included a revised zonation map (Fig. 8), based on reference wind velocities with a 10-year mean return period (the probability distribution model is unknown).

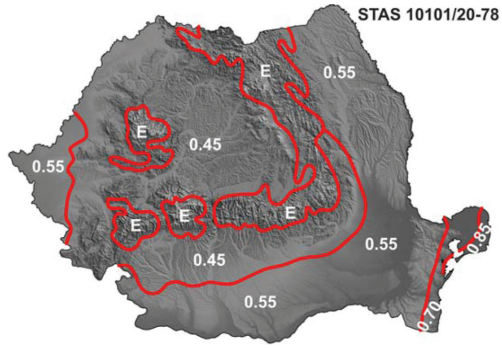


Fig. 8. Wind pressure zonation map in STAS 10101-1990 (kN/m²)

Before joining the EU in 2007, a mandatory code for wind action was issued: NP-082-2004 [17], as a transition towards Eurocodes. The wind pressure map, Fig. 9, had 5 zones and a special mountain area region where wind pressure is ≥ 0.7 kN/². The 50-year mean return period reference wind velocities were computed with a lognormal probability distribution model [18, 19].

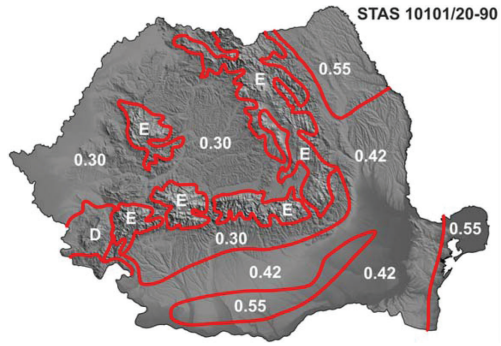


Fig. 9. Wind pressure zonation map in NP-082-2004 (kN/m²)

4. CR-1-1-4/2012 design code

The 2012 edition of the wind code [20] follows the EN 1991-1-4 [21] provisions, it is mandatory and was enforced by the Ministry of Regional Development and Tourism. As the European Standard, the Code applies to buildings and civil engineering works with heights of up to 200 m and to bridges with no span greater than 200 m, provided that they satisfy certain criteria with regard to their dynamic response. The basic (reference) wind velocity and pressure have the same definitions as in the EN. The Code provides

a national zonation map (Fig. 10) for the reference wind pressure; this is computed from the fundamental value of the basic wind velocity, which is the characteristic wind speed averaged over 10 minutes, at a height of 10 m above flat open country terrain, having a 2% annual probability of exceedance. The map is to be used for altitudes lower than 1000 m. Based on the zonation map, the Code provides a table with reference wind pressure values for 337 localities.

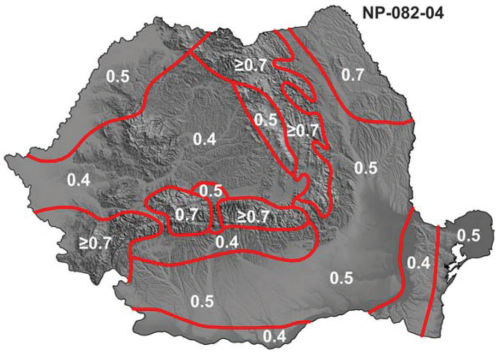


Fig. 10. Wind pressure zonation map in CR-1-1-4/2012 (kN/m^2)

For the region in the south-west of Romania (where the reference wind pressure is ≥ 0.7 N/m^2) and for the mountain areas at an altitude ≥ 1000 m, the use of data from the National Meteorological Administration is recommended in order to establish the wind pressure.

Annex A (normative) indicates that the reference wind velocity pressure for sites at altitudes higher than 1000m may be determined with the following equation:

$$q_{b,z>1000\,\mathrm{m}} = c_{z>1000\,\mathrm{m}} \cdot q_b \tag{1}$$

where :

$q_{b,z>1000\,\mathrm{m}}$ – the reference wind velocity pressure for a site at an altitude of $z > 1000$ m;
q_{b} – the reference wind velocity pressure for the site in the zonation map;
$c_{z>1000\,\mathrm{m}}$ – the altitude coefficient estimated by the formula

$$c_{z>1000\,\mathrm{m}} = 1 + 1.6 \cdot \left(\frac{z}{1000} - 1 \right) \tag{2}$$

Statistical analysis and probabilistic modelling of the maximum annual wind velocities were performed for developing the zonation map. Data from the National Meteorological Administration was available at 145 stations, with records from a period of between 35 and 75 years, up to 2005.

The Gumbel for maxima probability distribution was used for computing the characteristic values of wind velocity with a 2% annual probability of exceedance (mean return period of 50 years).

Gumbel distribution [22] is the probability distribution recommended by EN 1991-1-4 [21] and is used within the EU (for example [23] and [24]), and was also used for modelling wind velocity in other countries around the world, for example, in India [25], Korea [26], Japan [27], Canada [28], Philippines, and Sri Lanka.

The same extreme value distribution for the maxima model is recommended by the Joint Committee on Structural Safety (Lungu and Rackwitz [29]) and ISO 4354, Wind Actions on Structures [30].

For the selected sample of meteorological stations in Romania, the statistical characteristics of maximum annual wind velocities are presented in Table 4 [31].

Table 4. Statistical characteristics of maximum annual wind velocities [31]

Location	Years of records	Observed maxima, m/s	Mean, m/s	Coef. of var.	Characteristic velocity $T = 50$ yr., m/s
Iaşi	44	33.6	16.6	0.31	29.9
Bacău	44	33.6	14.1	0.32	26.0
Tulcea	44	28.6	16.6	0.31	30.1
Constanța	44	23.5	15.8	0.18	23.3
Călărași	44	27.7	14.6	0.29	25.8
Ploieşti	44	23.5	14.9	0.22	23.5
Bucharest Băneasa	42	23.5	14.0	0.26	23.4
Craiova	43	28.6	18.0	0.23	28.9
Timişoara	45	24.4	14.8	0.32	27.1
Oradea	44	21.0	13.4	0.19	20.0
Târgu Mureş	44	18.5	12.4	0.18	18.1
Sibiu	44	28.6	17.5	0.23	27.9

A graphic representation of the maximum annual wind velocity database is presented in Figs. 11–14. Figure 14 indicates that Gumbel distribution is reasonably good; however, the presented data cloud induces the need for a detailed study on the most appropriate probabilistic model.

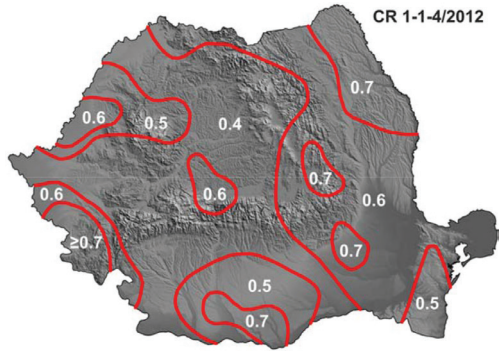


Fig. 11. Standard deviation vs mean annual maximum wind velocity – Romanian data

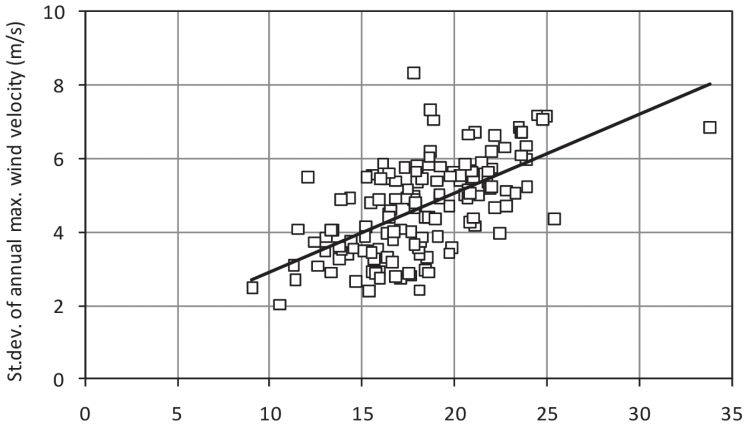


Fig. 12. Coefficient of variation vs mean annual maximum wind velocity – Romanian data

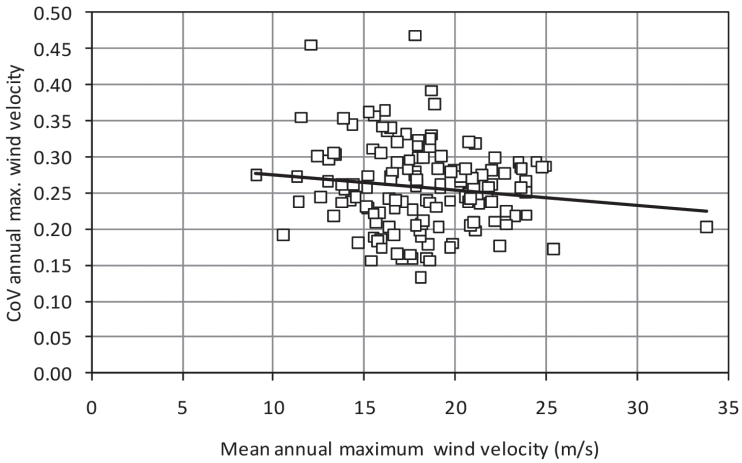


Fig. 13. Skewness vs mean annual maximum wind velocity – Romanian data

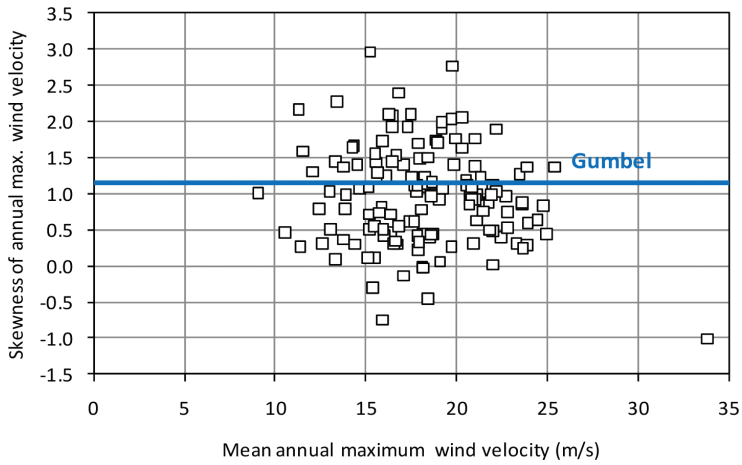


Fig. 14. Skewness vs coefficient of variation of annual maximum wind velocity – Romanian data

The wind pressure for design is established in the Romanian code CR 1-1-4/2012 in the same way as in the Eurocode, with the same approach, coefficients and provisions. However, a supplementary factor is considered: the wind importance-exposure factor γ_{Iw}.

The importance-exposure building categories are defined in the Romanian code CR-0/2012 'Basis of constructions design' [32]. The classification considers the human and economic consequences that may be induced by major natural and/or anthropic hazards and their role and importance in post-disaster activities.

The importance-exposure building categories considered in Romanian practice are as follows:

- Category I – essential for society and for post-disaster intervention;
- Category II – constituting high danger for humans in the event of damage;
- Category III – current buildings and constructions (all except those from categories I, II and IV);
- Category IV – of less importance, constituting low danger for humans in the event of damage.

The wind importance-exposure factor is $\gamma_{Iw} = 1$ for Categories III and IV, and $\gamma_{Iw} = 1.15$ for Categories I and II.

The 1.15 value corresponds to an increase of the mean return period of wind pressure from 50 years to 100 years (computed within the Gumbel distribution for maxima).

Several international codes also have a similar factor, and values within a close range.

The 2005 Canadian National Building Code [33] and the Ontario Building Code (2006) [34] define the following four importance categories and associated importance factors for wind load: importance category Low – importance factor $I = 0.8$, Normal – $I = 1$, High – $I = 1.15$ and Post disaster – $I = 1.25$.

The 2014 New York City Building code [35], defines four structural occupancy/risk categories with associated wind importance factors: $I = 0.87$, $I = 1$ and $I = 1.15$.

An Indian proposal by Krishna et al. [23] considers an importance factor for cyclonic regions (k_4) related to the importance of the structure: structures of post-cyclone importance $k_4 = 1.30$, industrial structures $k_4 = 1.15$ and all other structures $k_4 = 1.00$.

In the AIK 2000 Wind Loads of Standard Design Loads for Buildings and in the Korean National Building Code [24], an *Iw* importance factor for buildings is used in relation to four categories of building importance based on occupancy, function and scale: (Extra) – $Iw = 1.10$, (1) – $Iw = 1.00$, (2) – $Iw = 0.95$ and (3) – $Iw = 0.81$.

5. Final considerations

The recent wind load code of Romania (CR 1-1-4/2012) is harmonised with the Eurocode EN 1991-1-4. The characteristic value of the maximum annual wind velocity is obtained using Gumbel for maxima distribution, and a 2% annual probability of exceedance is considered.

CR 1-1-4/2012 is accompanied by comments and examples that were published as an informative annex. A wind load application/guidebook was published by the Technical University of Civil Engineering Bucharest [36].

An update of the zonation map is necessary for considering the observed wind data from the last thirteen years. Performing a detailed analysis on the most appropriate probability model is also of interest.

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Threats of flooding of selected mining areas – repair measures

Zagrożenia powodziowe wybranych obszarów górniczych – działania naprawcze

Abstract

Terrain surface subsidence observed in mining areas results in the flattening of riverbeds and their embankments. This leads to increasingly deep erosion and siltation of riverbeds and surface currents, which causes the emergence of permanent overflow lands. This paper presents hydro – engineering solutions applied in the areas of the mining activity of JSW S.A., which serve the purpose of repairing and eliminating mining damage in the existing infrastructure. The presented repair measures make it possible to eliminate the threat of flooding in mining areas.

Keywords: mining damage, longitudinal river profile, repair measures

Streszczenie

Występujące w obszarach górniczych osiadania terenu powodują obniżenia koryt rzek i ich obwałowań. W następstwie dochodzi do zwiększonej erozji dennej lub do zamuleń koryt rzecznych i cieków powierzchniowych, co powoduje powstawanie trwałych zalewisk. W artykule przedstawiono rozwiązania hydrotechniczne stosowane w rejonach działalności górniczej JSW S.A., które służą do naprawy oraz likwidacji szkód górniczych w istniejącej infrastrukturze. Przedmiotowe działania naprawcze pozwalają na wyeliminowanie zagrożenia podtopieniem terenu górniczego.

Słowa kluczowe: szkody górnicze, profil podłużny rzeki, działania naprawcze

1. Introduction

Underground mining operations disturb the geostatic balance of rock mass and adversely affect the surface, changing its topography. This results in hydrological and natural transformations. Underground mining operations cause disruptions to river, stream and water currents, and change water and soil conditions. This can result in a drop in groundwater levels if the aquifers are not insulated well enough. When the aquifers are separated with a watertight series, excessive water accumulation in the soil can take place, as can flooding and the emergence of overflow lands [1].

Flooding means a process which leads to excessive water accumulation in the soil caused by subsidence, as well as a state resulting from this process. Flooding does not have to appear on the surface as overflow land [2]. Overflow land is an accumulation of water in an area affected by subsidence due to underground mining. The emergence of overflow land and flooding is conditional upon the extent and distribution of post – mining subsidence areas as well as upon factors related to subgrade permeability and topography [3].

The negative effects of mining in the areas of rivers or surface watercourses are expressed mainly in the form of damage to riverbed embankments and disturbances to the water flow in subsidence troughs [4]. Additionally, the riverbed is subject to increased deep erosion or siltation, which causes water to spill into the adjacent areas and form permanent overflow land. The most disadvantageous situation can be observed in forested areas affected by unrestricted exploitation where its influence on the area is controlled to the least extent, which often leads to surface degradation [3].

The occurrence of mining – induced damage to such objects as rivers and surface watercourses requires appropriate repair measures. These should be aimed at preserving the original surface features or modifying them in such a way as to maintain the conditions for the free flow of surface water [2, 5, 6].

This article presents the results of subsidence caused by long – term mining which has caused changes in water conditions in the riverbed of the Boryński stream. The problem in question also applies to the Pszczynka river, into which the Boryński stream flows, and where the mining operations resulted in embankment damage. The purpose of the repair measures presented in this paper, mainly of a construction nature, is to eliminate flooding and simultaneously restore the river condition to the previous controlled condition and the stream to a state close to natural.

2. The geological conditions in the analysed region

The analysed area surrounding the Boryński stream has a gently undulating surface and its heights ranges from around 256.0 to 280.0 m above sea level. The adjacent area features residential and commercial buildings and croplands.

The Boryński stream flows from the north – west to the south – east and is the largest tributary of the river Pszczynka. It belongs to the hydrometric network of the Vistula river catchment area.

Fig. 1. The layout plan of the analysed area showing the Boryński stream

The geological structure of the area in question has the following layers: Quaternary (Holocene, Pleistocene), Tertiary (Miocene) and Carboniferous (Orzeskie, Rudzkie and Siodłowe).

Quaternary formations belong to Holocene alluvial and Pleistocene glacial deposits. Holocene sediments are represented by fine – grained and medium – grained sands and alluvial soils. Pleistocene sediments were formed in the form of grey clays, brown and light grey dusts and clays, light yellow and grey gravels and light grey sands. The sands are either diverse in terms of grain size or are fine – grained. The gravels include sandstone, igneous rock and quartz pebbles.

Miocene formations are present in the form of clays and clay stones of a greenish hue, sanded up to a varied degree, stocked with insertions or thick layers of friable and firm dusty sands or fine – grained sandstones. The Orzeskie layers are represented by clayey and sandy sediments. The Rudzkie layers are surrounded by sandstones with claystone and mudstone insertions. The sandstones in these layers are characterised by variable grain size from fine – grain to conglomerates and clay – siliceous or clay cement. The Siodłowe layers are formed as a series of thick – bedded, large – grained and conglomerate sandstones with clay – siliceous or siliceous – clay cement.

Based on the geotechnical surveys performed in the area of the Boryński stream, the following soil layers were distinguished: yellow light – grey dust, sandy dust, light – grey loam, grey sandy clay with admixture of gravel, compact dark – yellow clay, medium light and grey sand, medium sand with admixture of gravel, thick yellow sand, light grey – yellow sand, and clayey sandy gravel (Fig. 2).

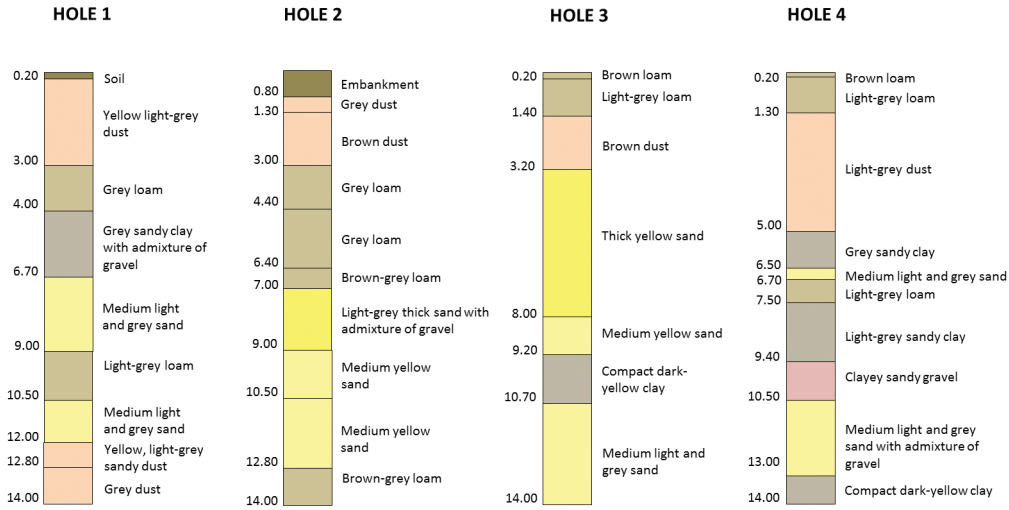


Fig. 2. The geotechnical layers in the Boryński stream area

3. The impact of mining on the rock mass and land surface

The region in which the section of the Boryński stream in question is located is in the range of the impact of previous mining and will be under the subsequent influence of the planned mining.

In the area of the Boryński stream, mining has been conducted in seventy longwalls in fourteen seams since 1972. These are: seam 357/1 of walls D1÷D2, D11÷D13, C2a, C2÷C4, C7, C9; seam 358/2 of wall E4; seam 358/2 – 3 of walls C2÷C5, C7, C9, D1a÷D2a, D2, D11a, D12÷D14, Z10b; seam 359/1 of walls E1÷E2; seam 359/3 of walls 1, C1÷C2, D1÷D3, D11a, D11÷D13; seam 360/1 of walls D1÷D6, D11a, D12÷D13; seam 361/1 of walls 1, D11a, D11÷D12; seam 362/1 – 2 of walls D1; seam 362/1 – 3 of walls D1, D3a, D3÷D4; seam 362/2 – 3 of walls D21÷D22, D24; seam 363/1 of walls D1÷D2; seam 404/1 of walls D21÷D22; seam 405/1 of walls D1÷D3, D11÷D34; seam 406/3 of wall A31. Figure 3 presents the locations and shapes of the individual mining parcels.

The height of the mined longwalls ranged from 1.15 to 3.2 m, and usually exceeded 2 m. The highest mining intensity was in the 1980s, and in this period, forty – one longwalls were mined in the area in question. Between 1990 and 2018, 22 more longwalls were mined.

The values of subsidence caused by mining in the area in question are documented by the geodetic surveys performed from October 1974 to June 2017. The article presents subsidence occurring at two characteristic measuring points 2806 and 2933 – wall benchmarks. At measuring points 2806 and 2933, the subsidence levels observed over 43 years are 3.97 and 6.98 m, respectively. These values illustrate the effect of coal mining in the referenced region. The course of subsidence over time at the selected benchmarks are presented in Fig. 4.

The mining operations of 1978 to 2019 resulted in category IV to V surface deformations. The smallest subsidence was observed in the locations of gravity flow, while the greatest occurred near a pumping station, where the hydraulic continuity of the stream was interrupted.

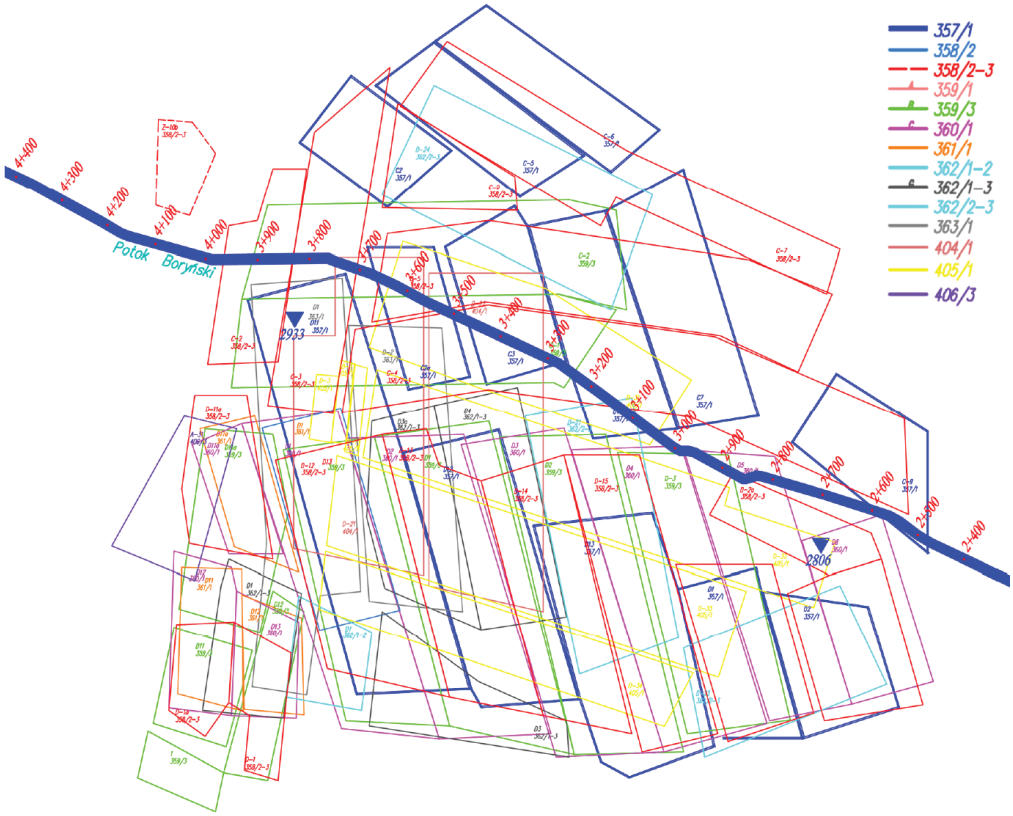


Fig. 3. Mining in the Boryński stream area in the period 1972–2018 and the location of benchmarks

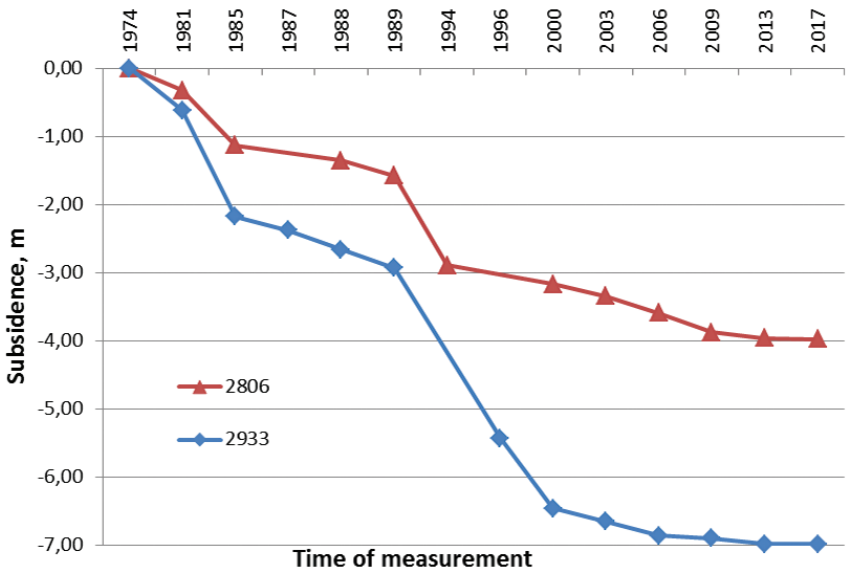


Fig. 4. The subsidence of points located in the analysed region in the period 1974–2017

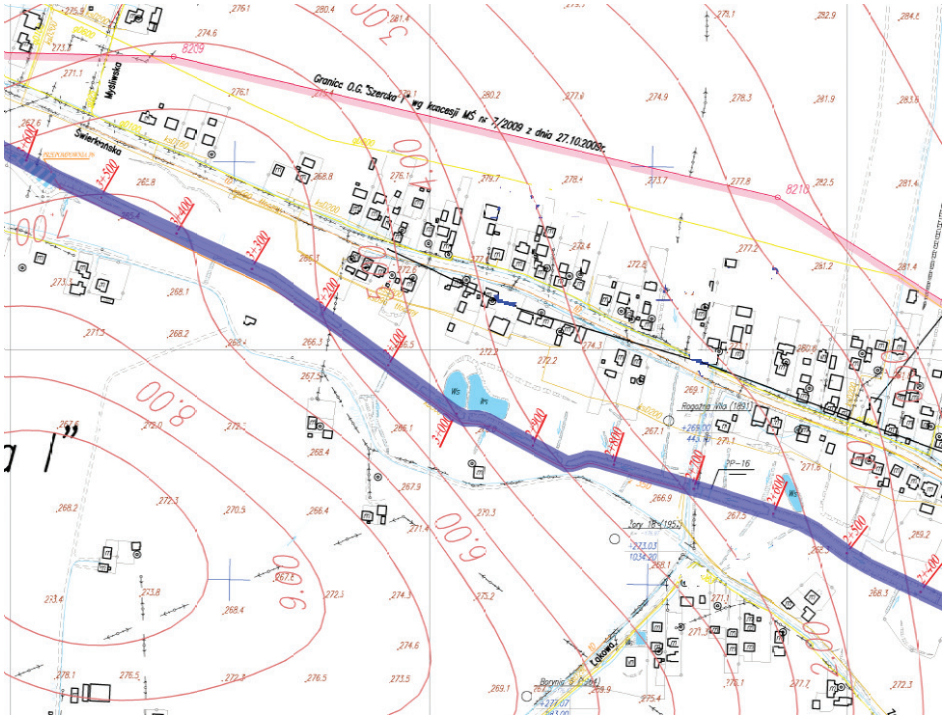
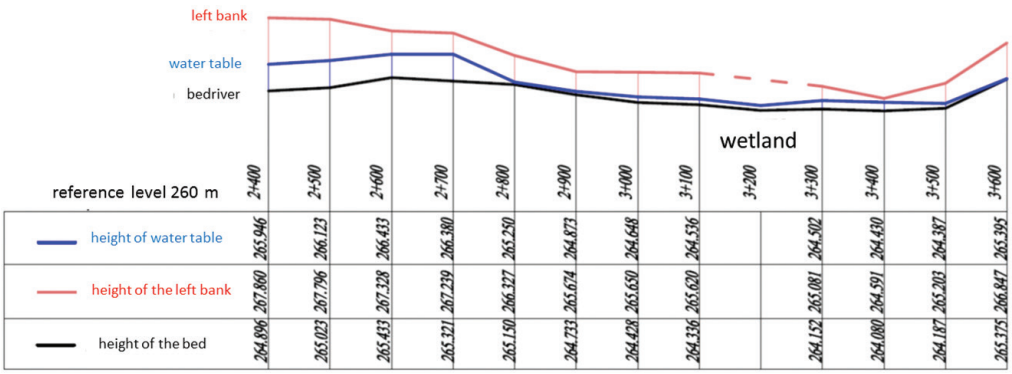


Fig. 5. Land surface subsidence trough – mining conducted in the period 1974–2017

The longitudinal section of the analysed section of the Boryński stream illustrates that the riverbed of the stream is slanted in the opposite direction to the outflow of water from the catchment area (Fig. 6). This results in no outflow from the catchment area and the emergence of overflow land. The existing pumping station is unable to effectively pump out the water flowing within the Boryński stream riverbed. The outlet of the pressure piping of this pumping station is permanently flooded due to the lack of runoff.

Further mining in this area is expected from 2019 to 2025 in seams 404/1, 405/1 and 404/1łg, which will result in the area in question depressing by 0.148 to 1.049 m.



	2+400	2+500	2+600	2+700	2+800	2+900	3+000	3+100	3+200	3+300	3+400	3+500	3+600
height of water table	265.946	266.123	266.433	266.380	265.250	264.873	264.648	264.536		264.502	264.430	264.387	265.395
height of the left bank	267.860	267.796	267.328	267.239	266.327	265.674	265.650	265.620		265.081	264.591	265.203	266.847
height of the bed	264.896	265.023	265.433	265.321	265.150	264.733	264.428	264.336		264.152	264.080	264.187	265.375

Fig. 6. The longitudinal section of the Boryński stream

4. Repair measures

The mining – induced damage which occurs in the analysed region causes interruptions in the outflow of surface water. An interior basin formed at the 2+400 to 3+600 km section of the Boryński stream riverbed. It is drained using the pumping station on Zamkowa Street. The outlet of the pressure piping of this pumping station is at 2+710 km (above Łąkowa Street level). The pumping station is unable to effectively pump out the water from the basin, especially in the case of heavy rainfall.

The analysis has demonstrated that with the expected depressions of 1.0 m, this will result in the existing basin becoming deeper and the area of the flood land expanding to 8.5 ha. This situation necessitates the reconstruction of the existing drainage system.

The condition of the existing riverbed of the Boryński stream also contributes to this hazard. The riverbed, most of which is deformed, has fragmentary vegetation – based flood management measures.

The entire section of the stream riverbed covered by the analysis is unsuitable for the drainage of storm water. It is therefore necessary to deepen the riverbed and make it slant towards the designed retarding reservoir and pumping station.

Interruptions to the outflow of water along the Boryński stream riverbed have been observed for many years. Unfortunately, the technical facilities made in 2006–2007 are becoming ineffective in the case of heavier precipitation. The interior basin which forms between the Zamkowa and Świerklańska Streets fills up with water during heavy rainfall and results in the flooding of areas and buildings adjacent to the riverbed. In order to solve this problem, it is necessary to change the subsidence trough drainage system.

In order to ensure the correct waterflow in the riverbed and to maintain appropriate technical and hydraulic parameters, appropriate construction works were planned [7] (Fig. 7), including:

- the construction of a pumping station equipped with two pumps with a capacity of $Q = 55\ dm^3/s$ and one pump with a capacity of $Q = 300\ dm^3/s$;
- the creation of a retarding reservoir in the Boryński stream riverbed with dimensions of 71 x 160 m and a volume of 27 650 m^3;
- the installation of pressure piping with diameters of 355 mm and lengths of 1210 and 1166 m along the stream riverbed, up to the location of gravity flow;
- the installation of a decompression chamber at the pressure piping outlets;
- Boryński stream riverbed improvement along a section of 1220 m;
- elevation and development of degraded area for agricultural purposes.

The designed retarding reservoir is to be located in the deepest depression of the Boryński stream riverbed from 3+318 to 3+456 km. This reservoir collects water from subcatchments located downstream of 2+400 km. Water from the reservoir will be gravitationally discharged to two wells with pumps. Up to a height of 265.00 m, the reservoir will have vertical walls of steel sheet piles topped with caps. The bottom of the reservoir will be profiled accordingly and provided with a 6‰ slope towards the axis of the Boryński stream.

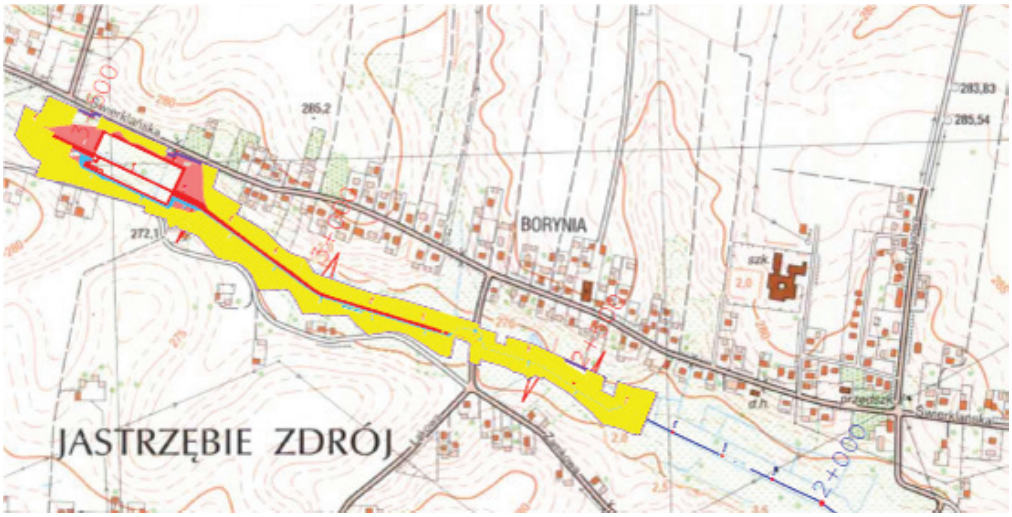


Fig. 7. A layout plan showing location of repair measures in the Boryński stream area

As part of the stream riverbed improvement, a bipartite riverbed has been designed with permanent bed and scarp reinforcements. The main riverbed will be made of double – driven sheet piling made of GW 300 vinyl sheet piles with a length of L = 4.0 m. Bieruń – type reinforced concrete prefabricated elements with a width of 1.24 m will be laid in the riverbed on geotextile and a 15 cm thick bed made of gravel or a sand – gravel mixture. The sheet piling will be topped with a vinyl cap. In the piling, at a height of 70 cm above the riverbed, filter holes with a diameter of 5 cm will be cut every 2 m, while on the ground side, the holes will be secured with geotextile (Fig. 9).

Benches and scarps above will be reinforced with 90 x 60 x 10 cm openwork concrete slabs, laid on the geotextile and a 15 cm thick bed made of gravel or a sand – gravel mixture [8]. Openings in the openwork slabs will be filled with humus with grass seeds. The scarps will be covered with humus and sown.

As part of Boryński stream riverbed improvement, five spillways are to be constructed, which will constitute passages to fields situated along the stream.

In the adjacent area not included in the analysis, below the outlet from the pressure piping, the stream riverbed has a marked slant and significant significant dimensions. The flow of water is clear. No impact of mining is expected on the surface of this area; therefore, no deterioration of water flow conditions in the stream riverbed due to mining is to be observed there.

During the works related to the riverbed improvement of the Boryński stream, construction of the retarding reservoir and pressure piping, production on grasslands and arable land within the boundary lines will be discontinued. Some of the grasslands are degraded due to constant flooding. The basin area is excessively damp, which results in the severe invasion of wetland and aquatic vegetation. The area within the basin will be elevated with mineral soil.

The repair measures taken in the Boryński stream area are not the only project performed in the mining areas of JSW S.A. in order to eliminate the threat of flooding [6].

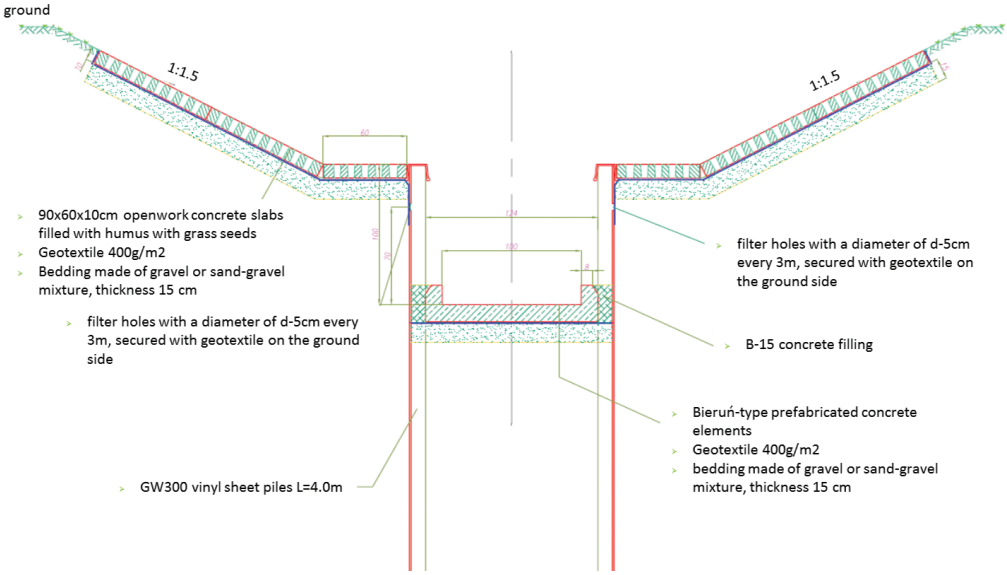


Fig. 9. Boryński stream riverbed reinforcement

Due to the formation of a stagnation area caused by the uneven subsidence of the Pszczynka riverbed, into which the Boryński stream flows, the riverbed was reinforced over a distance of 1 km [6, 9]. As part of reprofiling, the riverbed was reinforced with riprap, assuming a riverbed with a maximum bottom width of 4.0 m (Fig. 10).

The works performed in the Pszczynka riverbed focused on natural restoration and made it possible to restore the width of the riverbed to its original condition, prior to its subsidence.

Fig. 10. Works related to the incorporation of fascines and humus – covering the scarps along the Pszczynka river

5. Conclusion

Surface subsidence caused by mining operations results in, among other things, changes in water conditions. The analysed area of the Boryński stream and the Pszczynka river is influenced by multi – bed mining with caving. The transformations occurring in the bed of the river and stream require repair measures.

The riverbed improvement in the Boryński stream will result in the riverbed, along the section from 2+400 to 3+476 km, sloping towards the retarding reservoir and pumping station. An increase in sloping will increase the speed of water flow, thus improving the hydraulic flow conditions in the stream riverbed. The applied reinforcement utilising sheet piling and reinforced concrete elements guarantee the durability of the stream riverbed, even if the water flow speeds increase. The adopted maximum level of water accumulation in the retarding reservoir of 265 m above sea level will not cause overbank flooding even if the target mining prediction is met. The implementation of the adopted design solutions will enhance flood safety by preventing the occurrence of flood lands and flooding of the adjacent buildings and streets.

The threat of surface flooding in the area of mining influence can be eliminated by means of building local pumping stations to discharge rainwater to the riverbed, or potentially to the redeveloped riverbank reinforcement. However, in the case of intensive mining, flood lands can emerge. Taking into account the need to increase the water retention capacity of local areas as well as the need to improve biodiversity, it appears that expensive hydrotechnical systems should not be used in all cases.

The occurrence of flood lands can also be positive. There are many examples of flood lands becoming permanent elements of the landscape, and attempts to eliminate them are met with protests from residents and ecologists, who see natural values in the forming ecological niche. It is often proposed to protect the existing flood lands as ecological sites or natural and landscape complexes. Flood lands can also constitute alternative sources of water supply for industrial and firefighting purposes. Therefore, sometimes it would be more beneficial for the environment affected by mining operations to adapt the area for the emergence of a flood land. Such solutions are also more attractive due to the lower costs of the repair measures to be implemented.

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The design and analysis of a monolithic gripper mechanism for microscopic tests

Projekt i analiza monolitycznego mechanizmu chwytaka do badań mikroskopowych

Abstract

This paper presents the design and results of mechanism research. A lever mechanism for a gripper was made using monolith technology with constrictions in which the deformations correspond to limited rotation of the links. Unidirectional movement of the drive link is reduced and simultaneously converted into movement of the jaw clamp. Temporary centres of rotation were used to obtain the symmetrical and perpendicular movement of the two ends of the clamp in relation to its axis of symmetry. Computer simulations and tests were performed on a prototype of the gripper mechanism, confirming the adopted predictions of the device's operation.

Keywords: microgripper, kinematic analysis, prototype testing

Streszczenie

W pracy przedstawiono projekt i wyniki badań mechanizmu chwytaka. Mechanizm dźwigniowy robota wykonano w technologii monolitu z przewężeniami, w których odkształcenia odpowiadają ograniczonym obrotom ogniw. Jednokierunkowy ruch ogniwa napędowego zostaje zredukowany, a następnie zamieniony na ruch zacisku szczęk. Wykorzystano chwilowe środki obrotu w celu uzyskania symetrycznego i prostopadłego ruchu dwóch końców zacisku względem jego osi symetrii. Wykonano symulacje komputerowe i badania na prototypie robota, potwierdzające przyjęte założenia pracy urządzenia.

Słowa kluczowe: mikrochwytak, analiza kinematyczna, badania prototypu

1. Introduction

Microgrippers, devices that perform clamp movement on a selected object, are used in microscopic work in micromechanics [1] and microbiology [2].

The dimensions of prokaryotic cells (1–10 μm) and eukaryotic cells (10–100 μm) show that the accuracy of microgripper movement should be of the order of at least 1 μm. Such a level of accuracy can be obtained using microgrippers with dimensions of several dozen microns. Another possibility of achieving this accuracy is the construction of a mechanism fitted in the microscope table which reduces the movement of the drive or hand to the movement of the jaw clamp with the expected accuracy and range.

The clamping motion of the jaws should be perpendicular and symmetrical to the axis of symmetry of the held part and should linearly depend on the motion of the drive [3]. It is also desirable to have a short delay time for the reaction of the jaws in relation to the operator's starting response. A common solution in this type of device is to make a mechanical part of the microgripper in the form of a monolith in which intentionally designed constrictions deform to a greater extent than the remaining part [4]. In a monolithic construction, the movement is performed due to material deformations. If you treat constrictions as kinematic rotary pairs and other elements as links, you can determine the mobility of the system, which has a significant impact on the precision and range of motion. It is desirable to have system in which for one drive has one degree of freedom. There is then an unequivocal, sufficiently precise movement of the links which is easy to determine based on the kinematic analysis. In the case of degree of mobility less than 1, a slight movement of the mechanism in the constrictions occurs with significant buckling of the links. For degree of mobility greater than one, link motions are obtained primarily by deformations in the constrictions; they depend on the balance of drive loads and deformation resistance. In this case, the monolith manufacturing inaccuracies strongly affect the accuracy of the movement.

A small range of motion, a resistance to deformation and low durability of neckings of the monolithic mechanism are the prices that are paid to eliminate slack and to implement smooth motion at the microscale.

Piezoelectric [5], electrostatic [2] or bimetallic [6] drives that require the use of an appropriate electronic control system are used to drive the microgrippers. A desirable feature of the microgripper is the use of force feedback [7], in which the resistance of the micro-object to the jaws, after being multiplied, is perceivable on the operator's joystick. Classic kinematic analysis of the monolithic mechanism should be supported by a MES analysis of monolith deformation [8]. However, obtaining accurate material data needed for such an analysis is very difficult with the use of PLA with partial filling in 3D printing technology. The use of this easy-to-use technology is designed to test whether it is suitable for the implementation of monolithic mechanisms that require micrometric accuracy of motion.

The aim of the publication is the experimental verification of the theoretical gear ratio and symmetry of movement of the jaws in the developed monolithic gripper construction with a drive performing micro-movements.

2. Gripper mechanism construction

The gripper mechanism structure was designed and made in the form of a monolith as shown in Fig. 1. The mechanism consists of a jaw clamping system (links 1–4) and a system that reduces the displacement of a link moved by the operator's hand. There are two reduction stages based on the one-sided lever principle. The first stage consists of links 4 and 5 and the second stage consists of links 6 and 7. The drive (not shown in the picture) moves point J on lever 7. The dimensions of the mechanism are 300 x 220 mm and the displacement of the J point on the millimetre scale results in the displacement of the extreme points of the jaws Q_1 and Q_2 on the micrometre scale.

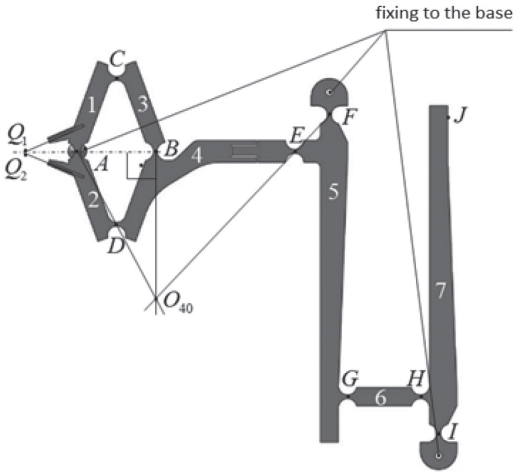

Fig. 1. Monolithic microgripper mechanism

Points Q_1 and Q_2 (Fig. 1) should move smoothly and symmetrically in the direction perpendicular to the axis of symmetry. Jaws 1 and 2 were connected to the base at joint *A*. Jaw 1, through joint *C*, is moved by double joint link 3. Jaw 2, through joint *D*, is moved by the triple joint link 4. The drive link is lever 7, the microgripper mechanism has one degree of freedom. The location of the double joint *A* on the axis of symmetry of the jaws causes the points of the ends of the jaws Q_1 and Q_2, for the planned range of motion, to move on curves of a shape similar to the straight perpendicular axis of jaw symmetry. Providing a symmetrical movement of the jaws is possible when the centre of the pivot *B* moves along the axis of symmetry of the jaws. Then a straight line perpendicular to the axis of symmetry of the jaws passing through point *B* and the straight passing through the centres of joints *A* and *D* will intersect at point O_{40} (the momentary centre of rotation of the link 4 relative to the base 0). A construction requirement is that the points *E* and *F* of the link 5 are on one straight with O_{40}.

Due to the limitation of the print surface, the reduction and clamping parts were made separately and glued between levers 4 and 5.

3. Kinematic analysis of microgripper mechanism

In the kinematic analysis of the mechanism, the same calculation schemes are used several times. The first scheme applies to the rotation of the $\hat{\boldsymbol{i}}$ unit vector by the given angle κ to the position $\hat{\boldsymbol{i}}^*$ around the unit vector $\hat{\boldsymbol{z}}$:

$$\hat{\boldsymbol{i}}^* = \hat{\boldsymbol{i}}\cos\kappa + (\hat{\boldsymbol{z}}\times\hat{\boldsymbol{i}})\sin\kappa \tag{1}$$

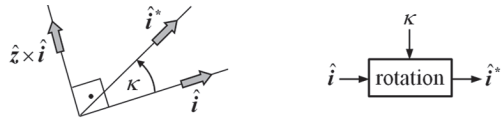

Fig. 2. Rotation of the unit vector by κ angle, symbolic rotation scheme

The second scheme applies to the designation of two unit vectors $\left(\hat{\boldsymbol{i}}_1,\ \hat{\boldsymbol{i}}_2\right)$ included in the equation of the quadrilateral [9]:

$$l_1\hat{\boldsymbol{i}}_1 + l_2\hat{\boldsymbol{i}}_2 = l_3\hat{\boldsymbol{i}}_3 + l_4\hat{\boldsymbol{i}}_4 \tag{2}$$

There are two pairs of solutions distinguished by the parameter $k = -1, 1$:

$$\left.\begin{aligned} {}^k\hat{\boldsymbol{i}}_1 &= A_1\hat{\boldsymbol{s}}_{34} + k\sqrt{1-A_1^2}\,(\hat{\boldsymbol{z}}\times\hat{\boldsymbol{s}}_{34}) \\ {}^k\hat{\boldsymbol{i}}_2 &= A_2\hat{\boldsymbol{s}}_{34} - k\sqrt{1-A_2^2}\,(\hat{\boldsymbol{z}}\times\hat{\boldsymbol{s}}_{34}) \end{aligned}\right\} \tag{3}$$

where:

$\hat{\boldsymbol{z}}$ – a unit vector perpendicular to the plane of the quadrilateral,

$$s_{34} = \left|l_3\hat{\boldsymbol{i}}_3 + l_4\hat{\boldsymbol{i}}_4\right|,\ \hat{\boldsymbol{s}}_{34} = \frac{l_3\hat{\boldsymbol{i}}_3 + l_4\hat{\boldsymbol{i}}_4}{s_{34}},\ A_1 = \frac{l_1^2 + s_{34}^2 - l_2^2}{2l_1 s_{34}},\ A_2 = \frac{l_2^2 + s_{34}^2 - l_1^2}{2l_2 s_{34}}.$$

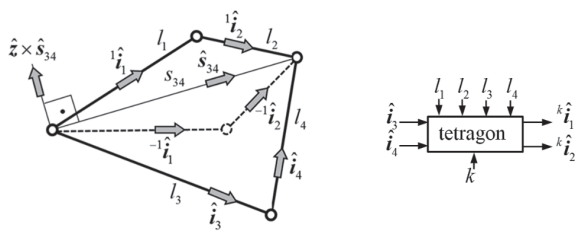

Fig. 3. Quadrilateral unit vectors, symbolic calculation scheme

3.1. Link orientations

Orientations of the links of the mechanism are represented by the unit vectors and depend upon the angular position of the drive link. The operator performs an angular movement of link 7, which is reduced by a group of two single-sided levers connected in series to form two

articulated quadrilaterals as shown in Fig. 4. An algorithm for determining the orientation of gripper mechanism links, shown in Fig. 5. developed on the basis of Fig. 4. and equations of three quadrangles was created:

$$FIHG \rightarrow l_{FG}\hat{\boldsymbol{i}}_5^* + l_{GH}\hat{\boldsymbol{i}}_6 = l_{FI}\hat{\boldsymbol{i}}_0^* + l_{IH}\hat{\boldsymbol{i}}_7 \tag{4}$$

$$ADEF \rightarrow l_{AD}\hat{\boldsymbol{i}}_2 + l_{DE}\hat{\boldsymbol{i}}_4^* = l_{AF}\hat{\boldsymbol{i}}_0 + l_{FE}\hat{\boldsymbol{i}}_5 \tag{5}$$

$$ACBD \rightarrow l_{AC}\hat{\boldsymbol{i}}_1 + l_{CB}\hat{\boldsymbol{i}}_3 = l_{AD}\hat{\boldsymbol{i}}_2 + l_{DB}\hat{\boldsymbol{i}}_4 \tag{6}$$

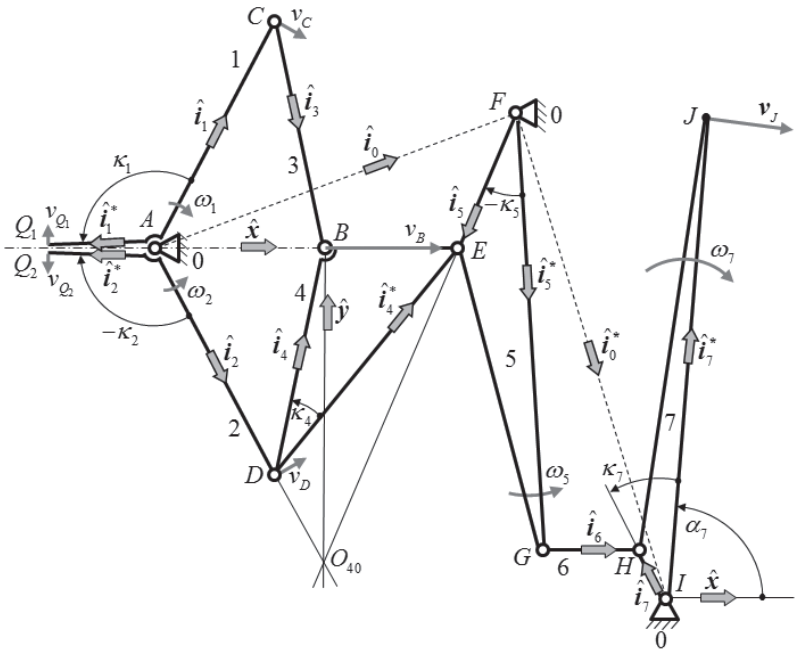

Fig. 4. Kinematic scheme, unit vector orientation and velocity vectors of the microgripper mechanism links

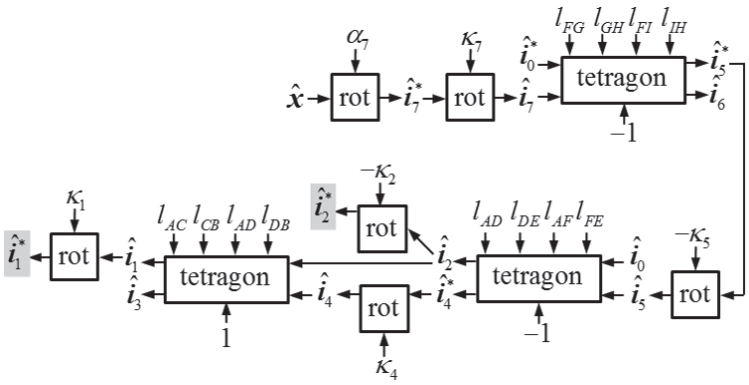

Fig. 5. An algorithm for determining the orientation of microgripper links

3.2. Gear ratio of the gripper mechanism

The angular movement ratios of the jaws k_{17} and k_{27} are the products of the gear ratio of the common part k_{57}, which is the mechanism of reduction and gear ratio of the mechanism of the upper and lower jaw clamps k_{15} and k_{25}:

$$k_{17} = k_{15}k_{57}\,,\; k_{27} = k_{25}k_{57}, \tag{7}$$

The ratio of k_{57} is obtained from the differentials components of vector equation (4) projected onto the direction $\hat{\boldsymbol{i}}_6$:

$$k_{25} = \frac{d\alpha_2}{d\alpha_5} = \frac{l_{FE}[(\hat{\boldsymbol{i}}_4^* \times \hat{\boldsymbol{i}}_5)\cdot\hat{\boldsymbol{z}}]}{l_{AD}[(\hat{\boldsymbol{i}}_4^* \times \hat{\boldsymbol{i}}_2)\cdot\hat{\boldsymbol{z}}]} \tag{8}$$

The ratio of k_{15} and k_{25} is obtained analogously from equations (5) and (6):

$$k_{15} = \frac{d\alpha_1}{d\alpha_5} = \frac{l_{FE}}{l_{AC}}\frac{[(\hat{\boldsymbol{i}}_4^* \times \hat{\boldsymbol{i}}_5)\cdot\hat{\boldsymbol{z}}][(\hat{\boldsymbol{i}}_2 \times \hat{\boldsymbol{i}}_3)\cdot\hat{\boldsymbol{z}}]}{[(\hat{\boldsymbol{i}}_2 \times \hat{\boldsymbol{i}}_4^*)\cdot\hat{\boldsymbol{z}}][(\hat{\boldsymbol{i}}_3 \times \hat{\boldsymbol{i}}_1)\cdot\hat{\boldsymbol{z}}]} + \frac{l_{DB}l_{FE}}{l_{DE}l_{AC}}\frac{[(\hat{\boldsymbol{i}}_2 \times \hat{\boldsymbol{i}}_5)\cdot\hat{\boldsymbol{z}}][(\hat{\boldsymbol{i}}_3 \times \hat{\boldsymbol{i}}_4)\cdot\hat{\boldsymbol{z}}]}{[(\hat{\boldsymbol{i}}_2 \times \hat{\boldsymbol{i}}_4^*)\cdot\hat{\boldsymbol{z}}][(\hat{\boldsymbol{i}}_3 \times \hat{\boldsymbol{i}}_1)\cdot\hat{\boldsymbol{z}}]} \tag{9}$$

$$k_{25} = \frac{d\alpha_2}{d\alpha_5} = \frac{l_{FE}[(\hat{\boldsymbol{i}}_4^* \times \hat{\boldsymbol{i}}_5)\cdot\hat{\boldsymbol{z}}]}{l_{AD}[(\hat{\boldsymbol{i}}_4^* \times \hat{\boldsymbol{i}}_2)\cdot\hat{\boldsymbol{z}}]} \tag{10}$$

The gear ratio of the linear motion of jaws Q_1 and Q_2 with reference to the movement of point J of lever 7:

$$k_{Q_1J} = \frac{dy_{Q_1}}{dx_J} = -k_{17}\frac{l_{AQ_1}(\hat{\boldsymbol{x}}\cdot\hat{\boldsymbol{i}}_1^*)}{l_{IJ}(\hat{\boldsymbol{y}}\cdot\hat{\boldsymbol{i}}_7^*)} \tag{11}$$

$$k_{Q_2J} = \frac{dy_{Q_2}}{dx_J} = -k_{27}\frac{l_{AQ_2}(\hat{\boldsymbol{x}}\cdot\hat{\boldsymbol{i}}_2^*)}{l_{IJ}(\hat{\boldsymbol{y}}\cdot\hat{\boldsymbol{i}}_7^*)} \tag{12}$$

4. Results and conclusions

The theoretical values of the gear ratios presented in Table 1 were obtained on the basis of equations (11) and (12) taking into account the measured dimensions of the printed mechanism. Graphs of transversal points Q_1 and Q_2 were measured transverse to the axis of symmetry using a digital microscope with a magnification of 200 as a function of the displacement of point J, the motion of which was forced and simultaneously measured by

a micrometre screw. Measurements were made during closing and next during opening the jaws. The coefficients of inclination of the trends lines presented in Figs. 6 and 7 were adopted as the values of the measured ratios.

Table 1. Gear ratios

	Upper jaw k_{Q_1J} [–]	**Lower jaw k_{Q_2J} [–]**
	Theoretical	
	$4.473\ 10^{-3}$	$-4.397\ 10^{-3}$
	Measured	
closing jaws	$3.026\ 10^{-3}$	$-2.990\ 10^{-3}$
opening jaws	$2.867\ 10^{-3}$	$-2.932\ 10^{-3}$

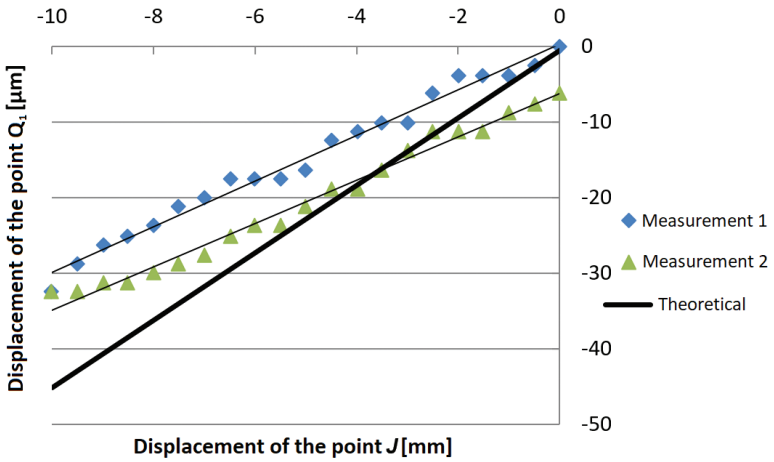

Fig. 6. Movement of the upper jaw point Q_1 as a function of point J of lever 7

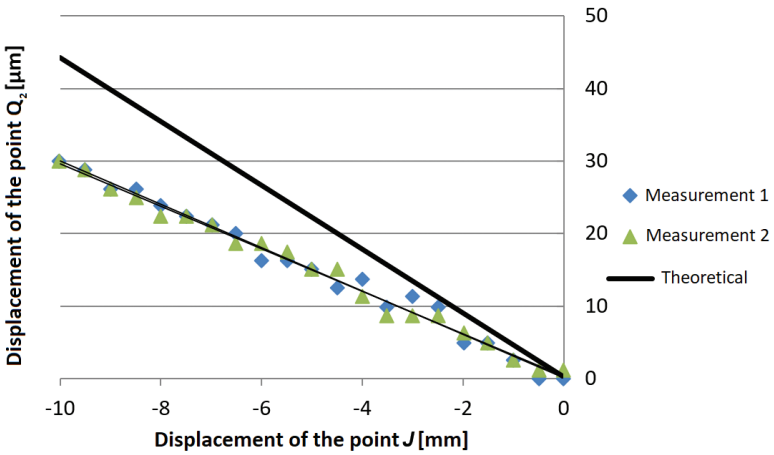

Fig. 7. Movement of the lower jaw point Q_2 as a function of junction point J of lever 7

Figure 8 presents a graph of the transverse differences between the coordinates of the pair of jaw points Q_1 and Q_2. As a measure of the symmetry error of movement of the jaws, the largest distance of the measured difference from the trend line parallel to the axis of abscissae was assumed:

$$\delta = \max\left|\left|Q_{1i}^{y} - Q_{2i}^{y}\right| - const\right| \tag{13}$$

where:

$i = 1 \ldots n$, n – number of measurements.

For distance change between the points of jaws Q_1 and Q_2 in the range of 90 μm, the error of movement symmetry is $\delta = 1.6$ μm.

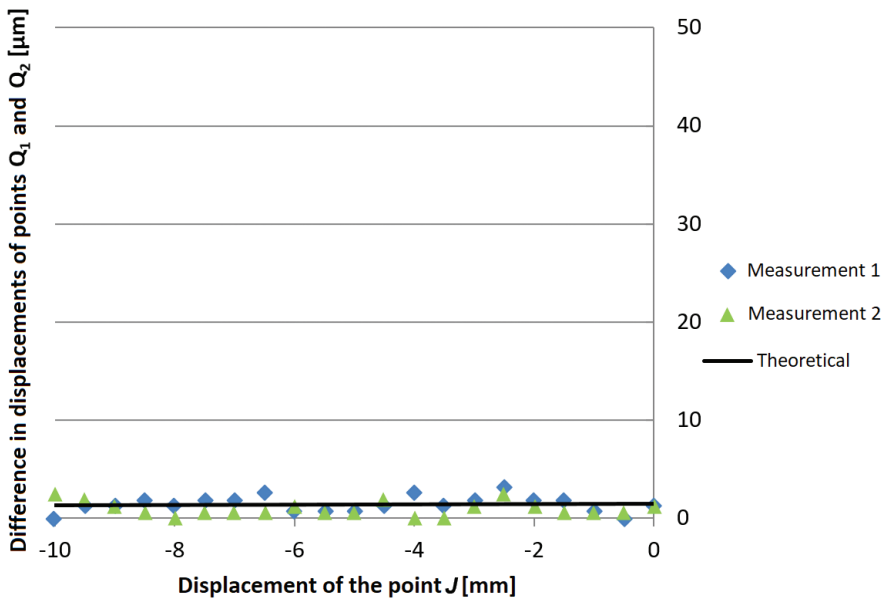

Fig. 8. Differences in the displacement of jaw points Q_1 and Q_2 as a function of point J displacement (lever 7)

The monolithic gripper mechanism is described as a lever mechanism with rotary joints in the constrictions. For the theoretical calculations, a constant distance between the centres of joints and negligibly small deformations of the lever were assumed. Theoretical gear ratios for the gripper jaws points depend on the variable products of the unit vectors. Mixed products thus formulated appear in the numerators and denominators of expressions into gears ratios, showing the influence of relative angular settings of the unit vectors on the gear ratios. Similarly, one can assess the influence of the dimensions of the levers forming the gripper mechanism.

The small range of movement of the mechanism causes the variable gear ratio functions to have a practically constant value. It has been found that changes in the measured displacements of the gripper jaw points are almost linear, but their values are clearly lower than the theoretical

values. Taking into account the material from which the mechanism was made, this is the expected effect, considering the relatively high susceptibility of the material. A short delay in the mechanism activation was found; this could not be measured by the available equipment.

The highest percentage deviation of the centre between the points of the gripper jaws from the trend line, related to the maximal opening of the jaws is equal 1.8%.

The use of PLA material is convenient as it is easy to manufacture and is suitable for prototype structures, the task of which is to qualitatively confirm the properties of the mechanism. The next stage of work will be the assessment of the performance of a monolith made of a material with greater homogeneity, e.g. steel. With more precise material parameters, it is possible to make precise quantitative calculations based on FEM analysis.

In the case of future constructions, it seems advisable to introduce the regulation of the permanent narrowing positions as this will enable the compensation of monolith errors.

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