ISSN: 2411-801X
e-ISSN: 2786-7374
UDC 71;72

Lviv Polytechnic National University
LLC “Scientific Journals”

ARCHITECTURAL STUDIES

International Journal about Architecture

Founded in 2014
Frequency of issue: 2 times a year

Volume 10, No. 1

Lviv – 2024

ISSN: 2411-801X
e-ISSN: 2786-7374
UDC 71;72

Національний університет «Львівська політехніка»
ТОВ «Наукові журнали»

АРХІТЕКТУРНІ ДОСЛІДЖЕННЯ

Міжнародний науковий журнал про архітектуру

Заснований у 2014 році
Випускається 2 рази на рік

Том 10, № 1

Львів – 2024

Co-founders:
Lviv Polytechnic National University
LLC "Scientific Journals"

Year of foundation: 2014

Recommended for printing and distribution
via the Internet by the Academic Council
of Lviv Polytechnic National University
(Minutes No. 9 of February 27, 2024)

State Registration:
Media identifier R30-01841
Decision of the National Council of Television
and Radio Broadcasting of Ukraine
No. 1335, Minutes No. 26, dated 09.11.2023.

Journal is included in the List of Scientific Professional Publications of Ukraine
Category "B". Specialty's: 191 – Architecture and Urban Planning
(Order of the Ministry of Education and Science of Ukraine No. 420 of April 15, 2021;
Order of the Ministry of Education and Science of Ukraine
No. 724 of August 09, 2022 "On Changes in Scientific Journals")

Journal is presented international scientometric databases,
repositories and scientific systems:
Index Copernicus International (ICI), Professional Publications of Ukraine, Crossref,
Bielefeld Academic Search Engine (BASE), J-Gate, Vernadsky National Library of Ukraine (VNLU),
Scopus, Directory of Open Access Journals (DOAJ), GALE, Polish Scientific Bibliography, Dimensions,
UCSB Library, Google Scholar, German Union Catalogue of Serials (ZDB), University of Oslo Library,
University of Hull Library, Search Oxford Libraries Online, European University Institute,
Leipzig University Library (UBL), Cambridge University Library, WorldCat,
Open Ukrainian Citation Index (OUCI), Zendy Research Library

Editors office address:
Lviv Polytechnic National University
79013, 12 Stepan Bandera Str., Lviv, Ukraine
E-mail: info@arch-studies.com.ua
https://arch-studies.com.ua/en

Співзасновники:
Національний університет «Львівська політехніка»
ТОВ «Наукові журнали»

Рік заснування: 2014

Рекомендовано до друку та поширення
через мережу Інтернет Вченою радою
Національного університету «Львівська політехніка»
(протокол № 9 від 27 лютого 2024 р.)

Державна реєстрація:
Ідентифікатор медіа R30-01841.
Рішення Національної ради України
з питань телебачення і радіомовлення
№ 1335, протокол № 26 від 09.11.2023 р.

Журнал входить до Переліку наукових фахових видань України
Категорія «Б». Спеціальності: 191 – Архітектура та містобудування
(Наказ Міністерства освіти і науки України № 420 від 15 квітня 2021 р.;
Наказ Міністерства освіти і науки України № 724 від 09 серпня 2022 р.
про зміни у наукових журналах)

Журнал представлено у міжнародних наукометричних базах даних, репозитаріях та пошукових системах:
Index Copernicus International (ICI), Фахові видання України, Crossref, Bielefeld Academic Search Engine (BASE), J-Gate, Національна бібліотека України імені В. І. Вернадського (НБУВ), Scopus, Directory of Open Access Journals (DOAJ), GALE, Polska Bibliografia Naukowa (PBN), Dimensions, UCSB Library, Google Академія, German Union Catalogue of Serials (ZDB), Бібліотека Університету Осло, Бібліотека Університету Халла, Search Oxford Libraries Online, Інститут Європейського університету, Бібліотека Лейпцизького університету (UBL), Бібліотека Кембриджського університету, WorldCat, Open Ukrainian Citation Index (OUCI), Zendy Research Library

Адреса редакції:
Національний університет «Львівська політехніка»
79013, вул. Степана Бандери, 12, м. Львів, Україна
E-mail: info@arch-studies.com.ua
https://arch-studies.com.ua/uk

Editorial Board

Редакційна колегія

CONTENTS

ЗМІСТ

Architectural Studies
International Journal about Architecture

Volume 10, No. 1

UDC 741
DOI: 10.56318/as/1.2024.09

Przemysław Baster*
Doctor of Engineering and Architecture
University of Agriculture in Krakow
31-120, 21 Adam Mickiewicz Ave., Krakow, Poland
https://orcid.org/0000-0002-9781-1373

Iryna Pohranychna
PhD in Architecture
Lviv Polytechnic National University
79000, 12 Stepan Bandera Str., Lviv, Ukraine
https://orcid.org/0000-0002-4164-6110

Polish calligraphic parks in the countryside

Abstract. In the second half of the 19th century, Polish architects actively joined the pan-European trend of finding new solutions in landscape art and created a large, but relatively unknown to the general public, group of Polish manor parks, which can be considered as a specific type of naturalistic style. In modern landscape design, more and more attention is paid to the protection of cultural heritage, in particular, the reconstruction and conservation of historical buildings, gardens, parks, and green areas. From the standpoint of protecting cultural heritage and revalorising historical projects, it is advisable to conduct a study of calligraphic parks as an important group of projects separated from the naturalistic (landscape) style. This confirms the relevance and practical focus of this study. The purpose of the study was to analyse the calligraphic manor and palace parks that are numerous in the territories of present-day Poland and Ukraine. To fully disclose the topic, a research methodology was developed that was based on general scientific and special scientific methods. Based on the analysis and comparison of samples of landscape gardening, the prerequisites for the transition from clear geometric forms to refined, smooth forms in various branches of art, including landscape art, were identified. Based on graphic comparison and architectural and planning analysis, the most characteristic compositional features were identified, including the calligraphic contour of lines, the way trees and other types of greenery are decorated, various types of landscapes, and architecture (including, in particular, the residence and its immediate environment). This study revealed the patterns of "calligraphic parks" through one of their most important features – a characteristic smooth system of paths that evokes clear associations with Polish calligraphic writing. Although, at first glance, their space seems quite natural, nevertheless, it is created according to strict rules of composition. The practical significance of this study lies in the fact that the principles of environmental protection activities, recommendations for conservation and basic provisions for the reconstruction of such objects are proposed to recreate the characteristic features of calligraphic parks

Keywords: history of garden art; naturalistic park; palace complex; manor house

INTRODUCTION

The end of the 18th and beginning of the 19th centuries is characterised as a difficult period in the history of Poland: three divisions of the Polish-Lithuanian Commonwealth and the loss of independence prompted the establishment of its own national style. The palace and garden complex – a noble estate – was one of the main features of "Polishness", a

Suggested Citation:
Baster, P., & Pohranychna, I. (2024). Polish calligraphic parks in the countryside. *Architectural Studies*, 10(1), 9-16. doi: 10.56318/as/1.2024.09.

Journal homepage: https://arch-studies.com.ua/en#
Architectural Studies, 10(1), 9-16
Received: 21.02.2024 Revised: 22.05.2024 Accepted: 20.06.2024

*Corresponding author

kind of "fortress" of Polish tradition and culture. In previous studies, I. Pohranychna (2019) and E. Rosłon-Szeryńska *et al*. (2020) note that a park becomes a balancing element in the residence of estates built in the territories of modern Ukraine and Poland. The artistic appearance of the park environment of the palaces has never been repeated. Residences were powerful economic systems and at the same time an exceptional cultural and historical phenomenon of the region. A major role in the development of palace and garden complexes was played by noble families – carriers of culture, who built high-art estates and residences with the participation of artists, architects, and sculptors of the highest level of classical art. The researchers determined that among the 16 thousand manor houses that existed before 1939, only 3,433 objects remained, including 1965 – residential parks without a dominant in the form of buildings. It was established that numerous studies and activities were carried out to preserve, restore, maintain, and adapt these facilities to current needs. However, parks require special attention and detailed study.

A description of individual palace and garden complexes and recommendations for the preservation of such architectural examples can also be found in the papers by M. Yasinsky & I. Zhmut (2019) and O. Khorosha & A. Subin-Kozhevnikova (2021). It was determined that due to significant transformational processes of socio-political structure and changes in the general social requirements of the population, palace and garden complexes have lost their original function and require comprehensive programmes to preserve park areas. M. Omilanowska (2019), analysing the palace and garden complexes of Poland and Lithuania, determined that when designing calligraphy parks, planners used Western European experience and spatial solutions. Along with local manors and palaces that were noble residences located in the countryside, Polish calligraphy parks are considered the most beautiful form of naturalistic parks in Poland.

Due to its associations with Polish calligraphy, the terms "calligraphy of forms", "calligraphy parks" or even "calligraphy style" are often used in modern literature when analysing the group of manor parks under consideration. They presented the same character as in the way the lines were formed. "The beginnings can be found in the intricate knot of paths in English books, the completion of development in French concepts and the modern continuation in national and regional directions", concluded Professor J. Bogdanowski (2000), a leading Polish researcher, specialist in landscape design and the history of landscape art. The works of Polish planners who designed calligraphy parks were accurately summed up by Professor E. Jankowski (1923), a Polish expert in rural landscape design of the interwar period, who wrote: "Although we did not create our own style, these gardens, created from local elements of the landscape, trees and shrubs, bear the imprint of preferences and concepts of beauty in the nature of the Polish people […]. Indeed, although the layout was similar and built on foreign models, but the views of the surrounding nature, villages and churches, hills, canyons and our fields give them a special beauty. In addition, home trees contribute to the fact that they are always the basis for each cluster".

The purpose of the study was to analyse palace and garden complexes to confirm the rule of using Polish calligraphy as a characteristic national accent when creating gardens and parks around magnate residences of the late 19th century in the territories of present-day Poland and Ukraine.

MATERIALS AND METHODS

To achieve the goal, a research methodology was developed based on general scientific and special research methods. During the processing of scientific literature and determining the level of research on the topic, collecting iconographic and cartographic materials, the following general scientific methods were used: analysis, systematisation, and generalisation of the accumulated materials. At the next stage, special methods of scientific research were used, namely: the method of full-scale research (for visual inspection of the monument and determination of the state of preservation), typological classification (for highlighting typical schemes of parks), stylistic analysis and historical periodisation (for conducting architectural, planning and compositional analysis of objects), and graphic comparison (for designing schemes of parks with the imposition of letters of calligraphic writing).

When studying parks in the system of palace and garden complexes, the method of analysis (based on primary sources) was used, which helped to determine compositional and planning characteristics and to reveal the patterns of "calligraphic parks". The use of the method of comparative analysis (for different-time cartographic materials) established the prerequisites for the transition from clear geometric shapes to refined, smooth forms in various fields of art, including landscape gardening. Based on graphic comparison and stylistic analysis, the most characteristic compositional features were identified, including the calligraphic contour of lines, the way trees and other types of greenery were decorated, various types of landscapes, and architecture (including, in particular, the residence and its immediate environment).

Iconographic materials and descriptions of parks, that is, the material base of the study, mainly consisted of data from the papers by Z. Czartoryski (1896), R. Aftanazy (1994) and G. Ciołek (1978). A more recent study by W. Brzezińska-Marjanowska (2010) also helped to supplement the knowledge about the historical development of garden and park art in Ukraine and Poland, and to deepen the understanding of the chosen field of research. L. Majdecki (1964) showed that since the 1800s, a new attitude has been developed towards historical urban centres and monuments of landscape art. The preservation of palace and garden objects of architecture, which has its roots in the protection of monuments, covers the heritage space as a whole, forms legislative provisions, and often influences the development of new methods and technologies for

the preservation of gardens and parks. In addition, archival documents and a large number of papers in periodicals from different countries were also considered in this study.

RESULTS AND DISCUSSION

In the 19th century, Polish designers made an active contribution to the Europe-wide trend of searching for new solutions in garden design. In the 1880s, they developed their own variety of this trend in the similar way to the most countries of the European continent. The significant influence of mentioned French creative thinking on Polish designs is indisputable – Edouard André – French botanist and landscape architect (Fig. 1). He has even designed the private gardens (in present Lithuania and Poland) in Połąga, Landwarów, Honorówka and Zatrocze (André, 1879; Texier, 2001; Majdecki, 2008).

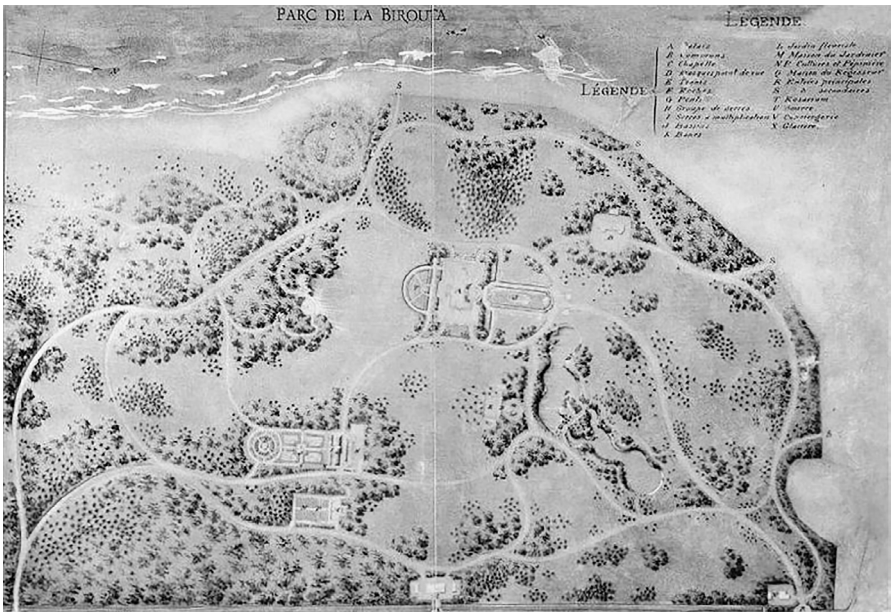


Figure 1. Layout of the park Biruty in Połąga, the only existing layout of Polish park, designed by Edouard Andre, 1898 (?)

Source: M. Omilanowska (2019)

Within their work, the Polish planners were successfully trying to join several dominating trends. On the one hand, they followed achievements and experiences of Western European garden art to a large extent. In their designs, they considered foreign models successfully used in previous styles even taking some solutions from geometric gardens. However, on the other side, they were putting specific conditionings of local tradition and national culture on Europe-wide phenomena which were the focus, the factor that streamlined the search for optimal solutions. Estates that resulted from permeability of current European trends with local tradition of everyday life in the countryside and the appreciation the natural beauty of this area were created. Divergence of Polish calligraphic parks resulted both from visible differences in the form of created parks but also different development of theoretical rules of composition. The basic factor was the shape of a drawn line and the reference to the Polish calligraphic writing. Such characteristic system of lines – calligraphic – is currently considered a special, clearly visible on the plans, dominant feature of the described designs. It was consistently drawn up on the plans-projects of parks, but also visible in the reality. Thereby, a new opinion on the theory of creating gardens and parks was born.

It was frequently emphasised in Polish treaties that park estates should present the harmonious structure, almost perfection of created seemingly natural forms (Stepinska, 1977). There were also notes about striving for maximal elegance of drawn paths' lines. That is why, among other things, searching for the sources was started in the Polish history and the form that was well known for the majority of educated society – calligraphy. Progress of calligraphic forms in Polish garden design went almost perfectly hand in hand with development and promotion of calligraphic writing. Precise coincidence in time of the "golden age" of calligraphy and creation of calligraphic estates and their popularity occurred. In the history of gardens, the calligraphic style predominated for several dozen years and the model of calligraphic writing was used even longer. This is calligraphy that created beauty standards in the art of drawing lines – it was its essence, indeed (Baster, 2012). The famous Polish calligrapher J. Czernecki (1903) wrote about a formed model of Polish writing: "nobody can deny exceptional simplicity to this model and which is even more important – unusual clarity and legibility, these most important benefits of really good writing". In the 17th, 18th and 19th centuries, Poland was one of precursors of creating national writings,

determining the rules of building and drawing individual letters. Polish calligraphic writing maintains optic balance between straight and round lines which is one of the most important features that distinguish Polish writing model from the remaining European ones (Tatuch, 1927). Its beauty was not searched in quantity or variety of ornamental elements. On the contrary – it presented frequently repeated motives and fragments of letters by which its harmony and pleasant text fluency can be assumed (Fig. 2).

Figure 2. Construction of various letters of Polish calligraphic writing based on the same basic elements
Source: S. Tatuch (1927)

A drawing-layout of a calligraphic park was characterised by extensive similarity to calligraphic writing. While in previous styles greater importance was attached to the fact of existence of natural plant forms itself or proper artefacts and their arrangement in space, in case of calligraphic parks, properly exposed and underlined system of park lines was of paramount importance. The course of paths underlined by the shape of a pond or stream should have created waving lines with an elegant form and harmonious arrangement. It was only necessary to join park design and calligraphic art in interacting integrity and systematising of this tendency into a homogenous and covered by clear principles ideational model.

It is difficult to overestimate the activity of Joseph Strumiłło, Lithuanian theoretical gardening pioneer, who planted a huge scientifically managed garden near Vilnus (present Lithuania). His contribution was elaborating the rules of composition of the native landscape, including searching for individuality of garden and park designs, which he expressed in the title of his seven times published and supplemented treaty (Strumiłło, 1883). Discussions led for more than half of a century resulted in precise determining principles of calligraphic parks and creating their ideal theoretical model/layout (Fig. 3). Joseph Strumiłło's model became an inspiration and a certain reference point in the design of hundreds of subsequent implementations, which largely referred to it. Thus, the unequivocal is opinion of J. Bogdanowski (2000), that: "Strumiłło should be considered the nestor and main promoter of calligraphic style in Poland". Although Polish calligraphic parks are the crowning achievement of the naturalistic style, they created the first Polish garden style where geometric and fluid elements were successfully joined together. The layout of Joseph Strumiłło presents the residence surrounded by regular and symmetric forms. From the one side of the building, there is a driveway – an access road in the shape of a circle. From the other side – a flower floor shaped as a regular ellipse where the most beautiful ornamental plants are planted. Connection of these three geometric forms: a driveway – a residence – a flower floor, this is so-called "geometric core of the park", from which the naturalistic surroundings were developing. Actually, it was taking various forms and sizes and sometimes was occupying almost half of the area.

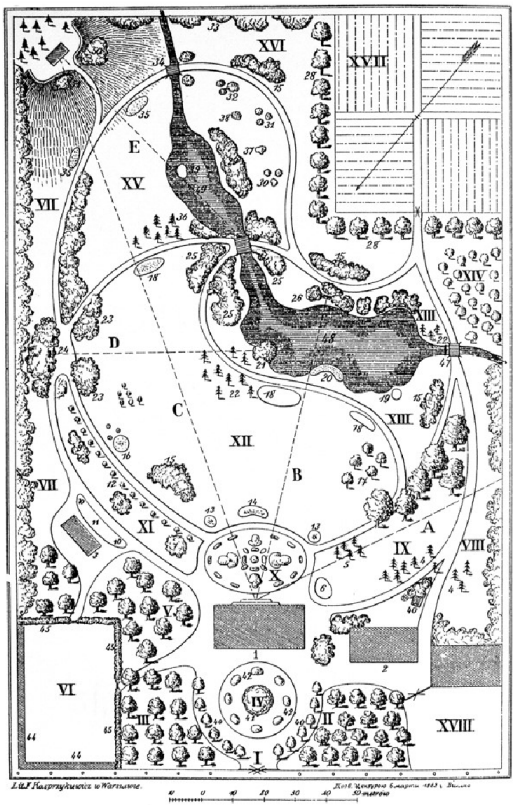


Figure 3. Theoretical model
of calligraphic manor park of Joseph Strumiłło
Source: J. Strumiłło (1883)

The discussed ideal layout presents in detail the whole property being a real proof of the possibility of creating parks according to similar guidelines, improved and unified in many respects – general character, park elements, and view connections. It presents almost calligraphic system of paths that lead with fluid curves through the park. It draws attention to water elements – the dark, almost black pond and the stream floating through it with banks also shaped as fluid lines. Such shape of lines creates the most important distinguishing feature and character of this model. It is also clearly visible in Polish calligraphic parks, for example in Czesławice – the most famous and well-known one (Fig. 4a). The arrangement of lines with fluid calligraphic system was at the same time connected compositionally

with trees. The paths' junctions were masked by situating them between trees – compact forest stands within the estate and groups in the middle of the park. In Czesławice and the other precisely designed parks, there are no junctions of paths visible from the above, as they are all covered by the tree canopies. Basic views to be designed were also marked on the discussed layout; three of them were drawn up from the residence: the short view, the long view leading through the whole park in the direction of a little building, and an outside view that shows the area beyond the park. In addition to the above-mentioned views, there is the one joining the pond with the little building. Trees are located in so called "blind spots" – the places where they not only do not cover up the above-mentioned prospects but they trace them enclosing their both sides and thereby creating their backstage. Variety of tree species takes attention with the most interesting ones situated in the middle of the park, so that they could be better admired. These rules of composition can be also seen in Czesławice park (Fig. 4b).

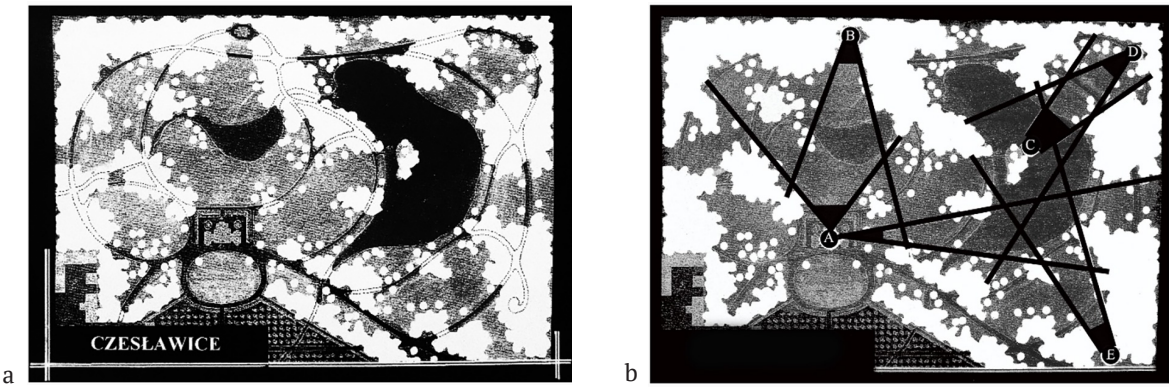


Figure 4. Czesławice park: "the geometric core of the park"
Notes: a – calligraphic shape of paths, masking of paths' connections in forest stands the most; b – important viewpoints: from manor (A), little building in the park (B), little island on the pond (C), corner of the park/forest stands (D, E)
Source: developed by the authors

The arrangement of paths and the remaining elements of the system creates the shapes which are so similar to these presented in Polish calligraphy that the shapes of the whole letters can be read on the projects of the parks. On the theoretical model of Strumiłło, there is possible to write in a letter "J" (Fig. 5) as it was in case of specific designs such as in the park in Goszczyno – "P" (Fig. 6) or Czesławice – "F" and "D" (Fig. 7).

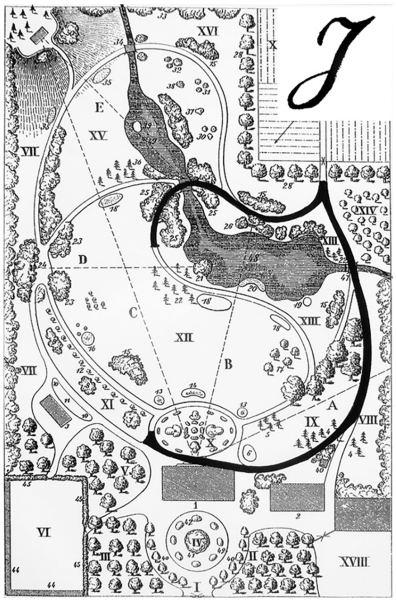


Figure 5. Calligraphic letter "J"
drawn in the model park of Joseph Strumiłło
Source: J. Strumiłło (1883)

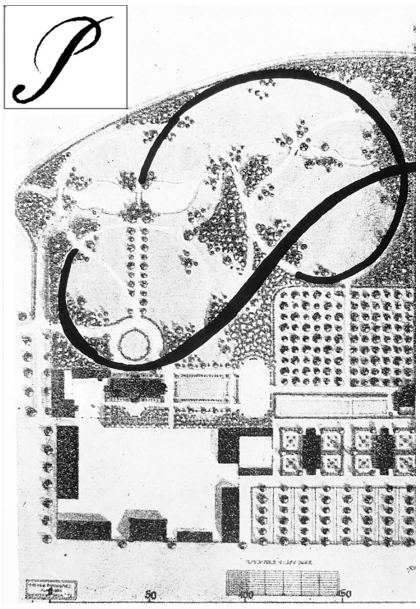


Figure 6. Calligraphic letter "P"
drawn in the layout of the park in Goszczyno
Source: S. Rogowicz (1920)

Figure 7. Calligraphic letters "F" and "D" drawn in the layout of the park in Czesławice
Source: W. Kronenberg (1886)

Shaping the system of park paths in the way that they resemble a certain letter of Polish alphabet is not a key point. The way of leading the lines using the described rules of Polish calligraphy is much more important. In the post-war period, in terms of the fight against aristocratic tradition and culture, most of Polish calligraphic parks were nationalised and ruined – the manors were devastated, the trees were cut down, and park elements were destroyed. Moreover, they were deprived of protection which led to unconditioned overgrowing and destruction of these parks (Barbasiewicz, 2007). Indeed, they presented the space based on carefully considered and joined together rules of composition being at the same time extremely fragile. Vanishing over time of even single elements of the composition prevented, as in "the domino effect", from interpreting the whole idea of park. For instance, when the park path has disappeared, the observer could not reach the place with the especially drawn up view outside the estate and they could not see the designed sequence of interiors inside the estate. When some trees have grown as self-seedings in an unexpected place, they were limiting or completely covering the prospect which was primarily leading the view through the whole estate, etc. In consequence, just about hundreds of such parks survived until the end of the 20th century, both in Poland and Ukraine, presenting various degrees of conservation (Baster, 2013). Only historical plans and descriptions in written sources testify to the location and lost beauty of the other ones.

After analysing the research on this topic, it can be stated that many papers are devoted to the study of palace and garden complexes on the territory of modern Ukraine and Poland. The papers highlight the features of such objects (Aftanazy, 1994), the components of complexes (Barbasiewicz, 2007), and the compositional features of the construction of the complex as a whole (Brzezińska-Marjanowska, 2010). However, previous publications did not cover what territorial features or compositional techniques of building the park were used in general, and also did not consider specific parts of the park through the prism of Polish calligraphy.

In previous studies, I. Pohranychna (2022) identified the features of classical palace and garden complexes built according to the projects of Polish architecture Jakub Kubicki, analysed ancient images and forms in the architecture of palaces of the late 18th-early 19th centuries. It was noted that the architectural and artistic system of classicism, preserving and repeating stable ancient images and forms, was established in the compositional solutions of palace structures on the territory of Ukraine and Poland, which for a long period of time preceded, coexisting in parallel with other stylistic trends. The development of stylistic trends of classicism in palace architecture developed in the context of the pan-European architectural school and reflected its ideological and artistic diversity. But all previous studies of the researcher relate mainly to palaces, and attention was not paid to a detailed study of parks.

A similar approach to the analysis of the monument of palace and gardening art can be seen in the paper by M. Yasinskyi & I. Zhmut (2019). The paper demonstrates the state of preservation and features of modern use of the palace of Strachocki in Mostyska (Rudniki). However, the park is a special component of the complex, it deserves separate research and publications. Therefore, the authors analysed papers devoted to the study of gardens and parks as components of palace and garden complexes. In the earlier studies by A. Alphand (1885), E. Jankowski (1923) and G. Ciołek (1978), the palace and garden were defined as natural components of the complex, features of compositional construction were highlighted, and a general picture of the development of palace and garden art of the 18th-19th centuries was developed. H. Petryszyn *et al*. (2015) studied the monument of garden and park art of the end of the 19th century on the St. Yuriy Square in Lviv. It was noted that large parks of the city are under state protection, but smaller ones, designed as squares, boulevards, gardens near villas, are constantly being rebuilt and destroyed. However,

these works do not focus on the laws of building a park through the prism of calligraphic writing.

In general, the authors determined that it is necessary to develop concepts for preserving monuments of garden and park art, because these objects are subject to destruction the fastest. A special feature of palace and garden complexes are their parks. The territories of such objects are suitable for organising public spaces, which will allow them to be included in the cultural environment of settlements and create an opportunity for contemplating the architectural monument as a whole. Properties of this type are also attractive for investors. They are small in scale and are admired for their interesting composition and variety of small architectural forms.

CONCLUSIONS

Polish calligraphy parks occupy an important place in the history of landscape art in the country due to their composition and almost perfection in their establishment. At first glance, random smooth lines are built according to a clear compositional scheme, which is based on Polish calligraphic writing (this is confirmed by the diagrams of the parks with the letters of the Latin alphabet). In addition, these were the first Polish parks that developed a "complex" style, that is, a stable and constantly repeating combination of geometric forms of the estate and other buildings of the complex and smooth, free forms of walking alleys. The advantages of this style led to its popularity in practical application in the design of Polish residences, and during the division of the Polish-Lithuanian Commonwealth, that is, during the loss of independence, Estates and their calligraphic parks were one of the ways to preserve national culture and traditions, and became an important component of authenticity in the Polish Cultural Heritage.

As of 2023, it is important to study and record these objects. Calligraphic parks are subject to faster destruction than palace and garden complexes in general, and therefore, according to the protection of cultural heritage, they require the development of a comprehensive system to preserve an important group of projects of naturalistic (landscape) parks. Notably, Polish calligraphic parks of the late 19th century can be used as analogues in the design of the modern landscape, in which geometric forms often appear together with free asymmetric forms (calligraphic style was the first Polish style to combine geometric and smooth naturalistic lines). The subsequent studies will be devoted to highlighting the principles for fixing the existing state and preserving Polish calligraphic parks, developing detailed projects for revalorisation (recomposition) of several separately selected calligraphic parks, and developing the principles for composing the discussed parks in use for modern landscape design.

ACKNOWLEDGEMENTS

None.

CONFLICT OF INTEREST

None.

REFERENCES

[1] Aftanazy, R. (1994). *History of residences on the former borderlands of the Republic of Poland*. Wroclaw, Warsaw, Krakow: Ossolinski National Institute.
[2] Alphand, A. (1885). *The garden art. Parks, gardens, promenades*. Paris.
[3] André, E. (1879). *The garden art. The treaty about the composition of parks and gardens*. Paris: G. Masson.
[4] Barbasiewicz, M. (2007). *Radziejowice Theatrum. History of the Residence*. Radziejowice: House of Creative Work in Radziejowice.
[5] Baster, P. (2012). Functions and structure of the trees in calligraphic parks; application of Western European ideas to Polish designs. In I. Dymitryszyn, M. Kaczyńska & G. Maksymiuk (Eds.), *The power of landscape* (pp. 431-435). Warsaw: European Council of Landscape Architecture Schools.
[6] Baster, P. (2013). The location and conditions of the calligraphic parks in Matwijowce, Horodyszcze i Rybczyńce in Ukraine. *Geomatics, Landmanagement and Landscape*, 3, 17-25. doi: 10.15576/GLL/2013.3.17.
[7] Bogdanowski, J. (2000). *Polish decorative gardens: The history and problems of the renovation*. Warsaw: Arkady.
[8] Brzezińska-Marjanowska, W. (2010). Classical palace architecture in Wolyn ca. 1780-1831. In W. Walczak & K. Łopatecki (Eds.), *State of research on the multicultural heritage of the former Republic of Poland* (pp. 273-299). Białystok: Institute for European Heritage Studies.
[9] Ciołek, G. (1978). *Polish gardens*. Warsaw: Arkady.
[10] Czartoryski, Z. (1896). *Polish „national style" in the rural architecture*. Poznan: J.K. Żupański Bookshop.
[11] Czernecki, J. (1903). *Calligraphy or Chancery from 1695 by Stanisław Serafin Jagodyński*. Lviv: Union Printing House in Lviv.
[12] Jankowski, E. (1923). *The history of gardening*. Warsaw: Polish Academy of Arts and Sciences.
[13] Khorosha, O., & Subin-Kozhevnikova, A. (2021). Analysis on the state of preservation of classical palace heritage of Vinnytsia region. *Scientific Bulletin of Construction*, 104(2), 120-126.
[14] Majdecki, L. (2008). *The history of gardens: The transformation and renovation of their form*. Warsaw: PWN Scientific Publishing House.
[15] Majdecki, L. (Ed.). (1964). *The register of Polish gardens*. Warsaw: National Scientific Publishers.
[16] Omilanowska, M. (2019). Private gardens of the Tyszkiewiczs, Bnińskis, and the Potulickis designed by Édouard André in Poland and Lithuania. *RIHA Journal*. doi: 10.11588/riha.2019.0.69969.

[17] Petryszyn, H., Kryvoruchko, O., Lukashchuk, H., & Tupis, S. (2015). The park in St. Yuri (St. George) square – the jewel in the emerald necklace of the city of Lviv. *Technical Transactions: Architecture*, 10-A(16), 3-20. doi: 10.4467/2353737XCT.15.150.4187.
[18] Pohranychna, I. (2019). *The architecture of Jakub Kubicki's palaces in the late 18th and early 19th centuries*. (Doctoral dissertation, Lviv Polytechnic National University, Lviv, Ukraine).
[19] Pohranychna, I. (2022) Antique images and forms in palace architecture of the late 18th and early 19th century. *Bulletin of Lviv Polytechnic University. Series: Architecture*, 4(2), 140-146. doi: 10.23939/sa2022.02.140.
[20] Rosłon-Szeryńska, E., Łukaszkiewicz, J., & Fortuna-Antoszkiewicz, B. (2020). Manor parks in Poland – costly heritage or potential for the development of rural communes. *Sustainability*, 12(22), article number 9422. doi: 10.33szer90/su12229422.
[21] Stepinska, K. (1977). *Palaces and castles in Poland. Past and present*. Warszaw: National Publishing Agency.
[22] Strumiłło, J. (1883). *Northern gardens by Joseph Strumiłło*. Vilnius: Wydawnictwo Józefa Zawadzkiego.
[23] Tatuch, S. (1927). *Teaching and learning the calligraphy*. Lviv: State Publishing House of School Books.
[24] Texier, S. (Ed.). (2001). *The parks and gardens in urban planning of Paris in 19th and 20th centuries*. Paris: Artistic Action of the City of Paris.
[25] Yasinsky, M., & Zhmut, I. (2019) Architecture of romantic palaces of the Lviv region XIX - beginning of XX cent. (for example the palace of strahocki in Mostyska). *Bulletin of Lviv Polytechnic University. Series: Architecture*, 1(1), 141-148. doi:10.23939/sa2019.01.141.

Пшемислав Бастер
Доктор інженерії та архітектури
Сільськогосподарський університет у Кракові
31-120, просп. Адама Міцкевича, 21, м. Краків, Польща
https://orcid.org/0000-0002-9781-1373
Ірина Погранична
Кандидат архітектури
Національний університет «Львівська політехніка»
79000, вул. Степана Бандери, 12, м. Львів, Україна
https://orcid.org/0000-0002-4164-6110

Польські каліграфічні парки в сільській місцевості

Анотація. У другій половині 19 століття польські архітектори активно долучилися до загальноєвропейської тенденції пошуку нових рішень у садово-парковому мистецтві та створили численну, але відносно невідому широкому загалу, групу польських садибних парків, які можна розглядати як специфічний різновид натуралістичного стилю. У сучасному ландшафтному дизайні все більше уваги приділяється охороні культурної спадщини, зокрема, реконструкції та консервації історичних будівель, садів, парків і зелених зон. З точки зору охорони культурної спадщини та ревалорізації історичних проектів, доцільно провести дослідження каліграфічних парків, як важливої групи проектів, відокремлених від натуралістичного (ландшафтного) стилю. Це підтверджує актуальність і практичну спрямованість даного дослідження. Метою роботи є проаналізувати каліграфічні садибно-палацові парки, численні на територіях нинішніх Польщі та України. Для повного розкриття теми було розроблено методику дослідження, яка базувалася на загальнонаукових та спеціальних наукових методах. На основі аналізу і порівняння зразків садового мистецтва було виокремлено передумови для переходу від чітких геометричних форм до вишуканих, плавних форм у різних галузях мистецтва, у тому числі садово-паркового. На основі графічного зіставлення та архітектурно-планувального аналізу виокремлено найхарактерніші композиційні риси, що включають каліграфічний контур ліній, спосіб оформлення дерев та інших видів зелені, різних типів краєвидів, архітектури (включаючи, зокрема, резиденцію та її найближче оточення). Дане дослідження дало можливість розкрити закономірності «каліграфічних парків» через одну з найважливіших їхніх особливостей – характерну плавну систему доріжок, що викликає чіткі асоціації з польським каліграфічним письмом. Хоча, на перший погляд, їхній простір здається цілком природним, проте, він створений за суворими правилами композиції. Практична цінність даного дослідження полягає в тому, що запропоновано принципи природоохоронної діяльності, рекомендації щодо збереження та основні положення при реконструкції таких об'єктів задля відтворення характерних рис каліграфічних парків

Ключові слова: історія садово-паркового мистецтва; натуралістичний парк; палацовий комплекс; садиба

Architectural Studies
International Journal about Architecture

Volume 10, No. 1

UDC 726
DOI: 10.56318/as/1.2024.17

Roman Frankiv*
PhD in Architecture
Lviv Polytechnic National University
79000, 12 Stepan Bandera Str., Lviv, Ukraine
https://orcid.org/0000-0003-1100-0930

"Perfect presence space": Theoretical and practical aspects of the concept

Abstract. Due to the potential for creating immersive spaces in which the "function" of attracting and retaining attention replaces traditional calculations of climatic conditions, safety, gravity, etc., there is a need for terms for broader generalisation and evaluation. The purpose was to argue the expediency of using the term "perfect presence space", as one that can collectively determine the value level of various design attempts to spatially express media and communicative realities, including comparing them with the experience of traditional architectural styles. The main method is a comparative analysis of specially selected architectural phenomena. On the basis of a brief historical retrospective, the tendency to gradually replace the functionalist "rational" substantiation of elements of space (associated with everyday life) with the attraction "irrational" (associated with non-ordinary life) is shown; the presence of experience in the materialisation of non-ordinary states in the architecture of different eras and purposes. Further, a review of several content frameworks that led architectural design to the interpretation of an exceptional or perfect presence is carried out, such as urban-social utopias of "ideal cities", objects of religious pilgrimages and narrative stories, places of exceptional aesthetic qualities of the natural environment outlined by "paradise" metaphors, and representative and solemn squares of capital cities. The potential of the term "perfect presence space" is shown, which allows effectively operating with the motivational foundations of creating a modern space, which are based on attracting and retaining attention and stay; it provides a conceptual basis for evaluating offers of visual and spatial stay (non-virtual and virtual). The assumption is made about the mechanism of "idealisation" of presence, which is developed through the interaction of three components: person – attention – stay. The practical significance of the study is the opportunity, based on succinct, meaningfully clear and universal terms, to facilitate the perception of the architectural environment and improve the involvement of a wider range of stakeholders and participation groups in the study of design

Keywords: terminology; architecture; attention; concepts of living space; idealism

INTRODUCTION

Until about the second half of the 20th century, the structure of architectural history looked like a sequence of "styles" that followed each other. Often, it was only about changing the style of decoration and in a smaller – spatial organisation (Imene & Saliha, 2022). So-called historicism, for the first time relativised the category of time and allowed markers of different eras to exist as actual realities, however, all of them were static in nature and, in general, excluded the possibility of searching for a conceptual alternative (Remizova, 2020). Since the 1960s, the development of postmodernism opened the way for unlimited generation of semantic programmes and their material embodiments in architecture (Farrell & Furman, 2019). Over time, this process has been enhanced by computer-aided

Suggested Citation:
Frankiv, R. (2024). "Perfect presence space": Theoretical and practical aspects of the concept. *Architectural Studies*, 10(1), 17-23. doi: 10.56318/as/1.2024.17.

Journal homepage: https://arch-studies.com.ua/en#
Architectural Studies, 10(1), 17-23
Received: 15.12.2023 Revised: 05.04.2024 Accepted: 20.06.2024

*Corresponding author

design, parametric and generative shaping methods (Caetano *et al.*, 2020) and, ultimately, the prospect of expanding the architectural experience with elements of virtual and mixed realities (Song *et al.*, 2021). Consequently, along with the great intensity of the change in the "stylistic" and functional programme (Setti, 2021), competition between offers of various forms of presence increased, the main driving force of which was the motive of avoiding the mundane and striving for an attractive interaction between the individual and the architectural work (Heidari *et al.*, 2018).

In this regard, there is a need to search for an adequate conceptual framework that can universalise the terminological field of modern architecture theory, reflecting the motivational foundations of certain phenomena. One of them is closely related to the nature of the information age and its core value – attention (Lane & Atchley, 2021). The architectural and design organisation of a space aims to turn it into an expressive event (Tyc, 2020) with a long-lasting attractive ability that can hold a person's attention for as long as possible, preserving their presence. The significance of this feature is reinforced by the prospects for the development of immersive environments that can increase competition between residence spaces (Parker *et al.*, 2018). Consequently, there is a need to introduce a term that could reflect such a state when the factors involved in retaining attention and staying in a certain space perfectly fulfil their role. In the future, this will help to build a more complete theoretical system for understanding and evaluating the phenomena of creating life space in its various manifestations – non-virtual, virtual, using generative and algorithmic design methods, artificial intelligence, etc.

The purpose of the study was to substantiate the theoretical and practical aspects of the concept of "perfect presence space" (PPS), which is able to reflect a complex of phenomena and trends related to the acquisition of spatial dimension by media and communication environments. This paper used a method that compares individual phenomena of architecture and man-made development of the environment, which are associated with the materialisation of non-ordinary states. Special emphasis is placed on those ways that allow achieving long-term immersion – that is, the relationship of associative properties of the environment with the personal qualities of the observer and his identity and "Self-image". A number of social and environmental cultural phenomena were taken as an empirical basis, for which their belonging to the immersion of a special presence was previously substantiated.

THE NON-ORDINARY STATE AS AN OBJECT OF MATERIALISATION

The diversity of phenomena and trends inherent in the architecture of the beginning of the 21st century (Morrogh, 2002) and the lack of an unambiguous "time style" are associated with the characteristic features of the information age, primarily the patterns of perception and distribution of media, which formed the basis of individual and collective consciousness. According to M. McLuhan (1964), in addition to the information directly carried by the media, they have become meaningful categories in their own right. This is the beginning of the modern "objectification" of the media space as a self-sufficient place of stay and presence.

The concepts and categories associated with the attractive properties of space and the "media perception" of architectural projects originate from reflections on postmodernism. The "rich library of images" formed in the mind of an ordinary person based on media, was described by C. Jencks (1987), who proposed to understand the architectural form as a message (communicative action). However, the theme of spaces that give the viewer a special state or status has a much broader reflection and can be divided into several parts. The first of them operates with the categories of ideal and utopian in architecture and is often associated with visions of a perfect social structure. Examples include the study of modernist utopias (Coleman, 2005), the vision of utopia as a method rather than a goal (Levitas, 2013), and the study of utopian perception mechanisms (Fedak, 2022). S. Contandriopoulos (2013) and A. Picon (2013) examined the development of utopias in the 21st century and noted the important role of social media in the spontaneous creation of idealistic interpretations of one's own living spaces. Often, such utopias do not have the usual large-scale character and focus on the "micro level".

The second one examines the phenomenon of sacredness and emotional attachment, when certain places have an exceptional status for representatives of a particular identity – for example, religious or ethnic. These can be the tombs of saints, locations of major battles, locations of founders of religious teachings, or key figures of national narratives, etc. This includes studies that show that, albeit in a transformed form, sacred spaces remain relevant. An example of this is the Oakland Cathedral in California, which is confirmed in the paper by T. Barrie (2012), and on the examples of church construction in Ukraine in the paper by Y. Kryvoruchko (2018). S. Mazumdar & S. Mazumdar (2004) shows how a sacred object increases the valorisation of the environment – increases its value in the perception of observers. D. Carmichael *et al.* (2013) investigated the development of a belief system through which certain communities begin to consider certain places sacred. L. Jones (2007) investigated the mechanisms of ritualisation of the sacred – in particular, spatial. E. Bastéa (2004) speaks of a sense of sacredness in creating the phenomenon of national memory and identity.

The third category includes reflections on a more general understanding of the features of a place, considering its outstanding visual and attractive qualities, among which natural features occupy a significant place. Scientific terminology is not clearly defined here, so many studies use poetic and metaphorical definitions. For example, L. Horton (2019) used the expression "heavenly places" to describe natural features in a global perspective. W. McClung (1983) used the word "paradise", limiting himself to traditional architecture in England. The metaphor of paradise was also used by C. Daswatte (1997)

in the analysis of tropical recreation complexes. S. Robinson (1997) examined it in relation to the historical architecture of Spain. More generally, the place of the Eden narrative in Western culture was explored by N. Yazdani & M. Lozanovska (2016).

In addition, the "perfect presence space" can also be seen in places dedicated to state, national, or ideological representation, which is most typical of metropolitan cities. In particular, some studies relate to the transformation associated with the search for identity after the collapse of the "socialist camp". P. Nientied & B. Aliaj (2018) investigated this process on the example of the Balkan countries, B. Cherkes & J. Hernik (2021) – on the example of several metropolitan cities in Eastern Europe. G. Fesenko (2022) revealed the transformation of spatial materialisation of identity on the example of the central square of Kharkiv. In a slightly broader context, solemn representation in metropolitan cities was explored by M. Minkenberg (2014).

The above review of sources shows that the "perfect presence space" has been the object of practical and theoretical interest for many epochs and had different motivations for ways of expression. Over time, this commonality has become more apparent due to the growing diversity and variability of architectural trends in modern environmental design, for which it has become, in fact, the only unifying factor. Despite this, in terminological terms, and in the sense of evaluation categories, the gravitational attraction of architecture to methods of manipulating attention remains undefined. Some terms can be taken from other fields, such as "attentionalism" (Doke, 2022), or developed in parallel to such a field as "attention economics" (Franck, 2019), but it should be assumed that the goal of architecture theory, in this context, should be to develop its own specific discourse with a self-sufficient chain of categories and conceptual connections. This will open up the opportunity to consider current and promising phenomena not retroactively, as a reflection of what happened, but to provide the theory of architecture with the necessary tools for creating new concepts of life space.

PERCEPTION AND FORMS OF PERFECT PRESENCE

The focus of architectural theory on understanding the purpose of human living space is marked by a duality of its constitution. On the one hand, the key is the need for Vital fitness – physical protection from the unfavourable environment associated with climatic conditions (cold or hot climate, precipitation, etc.), social risks (protection from intruders, interference in personal life, etc.). On the other hand, it is an expression of one's own individuality, status, and the poetics of being. The first case refers to the attraction to the "rational" understanding of shaping, and the second – to the "irrational" one. Traditionally, a successful architectural solution meant a harmonious combination of these two components (Vitruvius, 2001). In the modern era, the morphological apparatus of architecture was rationalised by linking form to function (Sullivan, 1896). The value of the stay was determined by the reasonableness of the environment, which was constantly improved due to technological progress. However, in fact, valorisation of the environment was associated with demonstrating effective vital fitness. "Irrational" aspects were classified as profane (Loos, 2019), and they were revived only in the era of postmodernism. Criticism of modernist architecture is mainly associated with the emergence of the information society, which gave a new impetus to visual culture and the role of attention (Hogan, 2001). Interpretation of the architectural form as a "language" (Jencks, 1987) showed that it enters into a complex communicative connection with the viewer, the purpose of which is the subjective experiences of each person.

The gradual return of attractive charisma is also expressed in the spaces of immersive presence, where, in general, there are no vital motives for form-making (Bauman & Games, 2011). The emerging demand for the environment is created only on the motivation to attract and retain attention – the efforts of designers are focused not so much on the needs of the body, but on the needs of consciousness. Consequently, the question arose about effective techniques that will provide the desired result in different states of presence (Lanier *et al*., 2019). Although, as mentioned earlier, the culture of the information society began with a critique of modernism, however, it should be perceived rather not as an alternative to it, but as a continuation. Minimisation of domestic employment, which was one of the main priorities of functionalism (Greenhalgh, 1997), in the end, led to the topic of filling the released time, and therefore, the non-ordinary space. The complex development of postmodernism and deconstructivism creates buildings-events that attract attention and evoke a communicative response, spaces supplemented by virtual reality, facilitate communication, and enrich the experience. Designing an environment where there is no need for a welcome adaptation becomes an experience of organising a "non-ordinary presence", which, according to the logic of media, is aimed at retaining attention for as long as possible. In this sense, the opposition of the goals of the two constitutive foundations of architecture can be noted. If for the first "rational" state of the conditional ideal is associated with maximum minimisation and, ultimately, the absence of everyday employment, then for the "irrational" on the contrary – conditionally ideal state means being in an environment where non-ordinary impressions last indefinitely, it can be called the space of perfect presence.

It is worth noting that similar tasks in one form or another were solved within the framework of historical architecture, for example, when materialising such categories as sacredness, solemnity, conviviality, harmony, etc. One of the closest phenomena in terms of content here can be called, characteristic of different eras and especially the Renaissance, the search for the "perfect city" (Nevola, 2019), and project embodiments of social utopias. In these cases, it is possible to note the com-

bination of the dream of a fairer property and status system with symmetrical geometricism, which since antiquity has been associated with perfection, proportionality of the whole and general (Osborne, 1986). Visual order could demonstrate the confidence that pre-modern man lacked – not protected from many natural and artificial dangers. The stay in this static space was supposed to give a sense of the immutability of the achieved perfect state, when the perfection of the whole depends on the perfection of each of the components.

Non-ordinary qualities obviously belong to places that are associated with sacredness and emotional attachment. In this case, the direct material characteristics of space do not have a primary value. Often, pilgrimage and memorialisation centres are located in everyday places in terms of their natural location or other possible visual features. The specificity of being present in such places is associated with a sense of personal involvement in events of exceptional significance that took place here (Kim & Chen, 2021). In the case of attracting the category of sacredness, presence gives the individual a sense of maximum approximation to their highest existential purpose, serves as proof of the transition from ordinary and profane to sacred exaltation. The qualities gained from being present in the sacred space give a person special attribute, such as the honorary title of "Haji" (الحاجي), for those Muslim pilgrims who have made a pilgrimage to Mecca (Ruthven, 1997). Such environments are perceived as experiences of being contrasted with everyday life, which passes far from direct contact with holiness. Objects related to the subjects of literary masterpieces, such as the habitats of Romeo and Juliet, or Sherlock Holmes, can also be attributed to the same kind of spaces. In various life situations or corporate circles, they can acquire a significant value weight, which is transferred to the persons present there (Barke & Taylor, 2022).

Places of highly aesthetic natural landscapes also have pathos of ideality (idyllicity), which in Abrahamic cultures are often designated by metaphors of the "garden of Eden", or "earthly paradise". Tropical islands, Mediterranean coasts, richness of spectacular elements of the environment, create an analogy with the perfection and fullness of being. Consequently, "paradise" metaphors are actively used as a marketing ploy to attract tourists or real estate buyers (Costa, 1998). The idyll of evergreen, warm and beautiful environments is based on the illusion of a wide range of pleasurable opportunities, effortless, carefree, working in contrast to life in more monotonous colder or hotter climates. Subjective feelings of solemnity and uplift, when they become the object of spatial interpretation, also create a perfect presence space. These can either be temporary objects – for example, dedicated to exhibitions or festivals (McRae *et al.*, 2011), or stationary structures – for example, intended for holding sports competitions, parades, celebrations during public holidays, etc. (Boese, 2018).

The above examples of situations of special or perfect presence, despite their differences, have a common feature associated with admiration and attention. They try, each through their own means, to interact with the individual in such a way as to give it a sense of exceptional fullness of their own being. Thus, the space satisfies the personal idealistic programme through impressions (for example, delight) and attraction (experiencing oneself as an integral part of the idyll). Therefore, one of the possible options for delineating the above phenomenon can be the term "perfect presence space", which connotatively reflects the content of the idealising relationship between space and the visitor.

The use of the term "perfect presence space" allows distinguishing the category of specific value, which is important in conditions of singular accumulation of offers of visual-spatial stay (non-virtual and virtual). From a practical standpoint, the introduction of this term will make it possible to introduce an evaluation base for various presence proposals, as a kind of abstract generalisation of projects that consider the form from the standpoint of attention. The above examples and theoretical considerations show that the perfect presence space is not a static phenomenon, but a dynamic system in which three components interact and interdependence: person – attention – stay. Since the perfect presence implies a constant presence, it must provide for a certain mechanism within which all components are in constant re-activation of each other. Well-attracted attention promotes stay, stay encourages personal engagement, and personal engagement updates the ways to attract attention – thus, stay becomes virtually unlimited in time.

CONCLUSIONS

The term "perfect presence space" is substantiated as a means of universalising the theoretical discourse around architecture in the information age, when media and communication networks also receive a spatial dimension. PPS is seen as an abstract state where the factors involved in maintaining attention perfectly fulfil their role and the desirability of being present in a particular environment is not interrupted by anything. Consequently, this term reflects a shift in understanding the value of space, which is determined not by the improvement of everyday life (the functionalist and rational aspect of life), but by the constant confirmation of non-ordinary life (the attraction and irrational aspect).

Based on the historical retrospective, examples of interpretation of spacious entities aimed at the perfect presence are shown, such as: futuristic visions of an ideal city, often based on a particular social utopia; sacred places associated with religious or narrative feelings; exceptional landscapes articulated by "paradise" and "Eden" metaphors; environments of elevation and solemnity of the representative nature of metropolitan cities. An important factor in reducing presence is the experience of personal involvement in the non-ordinary through being in a certain way formed and perceived environment.

It is suggested that the "perfect presence space" is a dynamic phenomenon that consists of the interaction of

three components: person – attention – stay. In a hypothetically perfect PPS, as an abstract category, all components are in constant mutual re-activation: attention gives rise to stay, stay promotes personal participation, and it updates the ways of attracting attention. The objectification and detailing of this interaction can be used as the basis for further research in this area, which will provide practical tools for improving the competitiveness of architectural and spatial formations of different realities.

ACKNOWLEDGEMENTS

The author expresses gratitude to Professor Yulia Idak for her attention to this study, Associate Professor Maxim Yasinsky for his work on the publication of this collection, and anonymous reviewers for their significant assistance in improving many aspects of the text.

CONFLICT OF INTEREST

None.

REFERENCES

[1] Barke, M., & Taylor, P.J. (2022). Narrative heroes and civic builders in Newcastle city region during the nineteenth century. *Urban History*, 49(1), 88-107. doi: 10.1017/S0963926820001042.
[2] Barrie, T. (2012). Sacred space and the mediating roles of architecture. *European Review*, 20(1), 79-94. doi: 10.1017/s1062798711000330.
[3] Bastéa, E. (2004). *Memory and architecture*. Albuquerque: University of New Mexico Press.
[4] Bauman, E.B., & Games, I.A. (2011). Contemporary theory for immersive worlds: Addressing engagement, culture, and diversity. In A. Cheney & R. Sanders (Eds.), *Teaching and learning in 3D immersive worlds: Pedagogical models and constructivist approaches* (pp. 248-270). Pennsylvania: IGI Global. doi: 10.4018/978-1-60960-517-9.ch014.
[5] Boese, I.A. (2018). *Stadiums and sports entertainment districts on the landscape: An urban sports-anchored entertainment development model*. (Doctoral thesis, University of Missouri-Columbia, Columbia, USA).
[6] Caetano, I., Santos, L., & Leitão, A. (2020). Computational design in architecture: Defining parametric, generative, and algorithmic design. *Frontiers of Architectural Research*, 9(2), 287-300. doi: 10.1016/j.foar.2019.12.008.
[7] Carmichael, D.L., Hubert, J., Reeves, B., & Schanche, A. (2013). *Sacred sites, sacred places*. London: Routledge.
[8] Cherkes, B., & Hernik, J. (2021). *Identity in post-socialist public space: Urban architecture in Kiev, Moscow, Berlin, and Warsaw*. London: Routledge. doi: 10.4324/9781003201427.
[9] Coleman, N. (2005). *Utopias and architecture*. London: Routledge.
[10] Contandriopoulos, C. (2013). Architecture and utopia in the 21st-century. *Journal of Architectural Education*, 67(1), 3-6. doi: 10.1080/10464883.2013.771021.
[11] Costa, J. (1998). Paradisal discourse: A critical analysis of marketing and consuming Hawaii. *Consumption, Markets and Culture*, 1(4), 303-346. doi: 10.1080/10253866.1998.9670305.
[12] Daswatte, C. (1997). The architecture of paradise. *The Sri Lanka Architect*, 101(20), 13-21.
[13] Doke, G. (2022). Review of Jonardon Ganeri, attention, not self. *Phenomenology and the Cognitive Sciences*, 21, 461-467. doi: 10.1007/s11097-021-09761-y.
[14] Farrell, T., & Furman, A.N. (2019). *Revisiting postmodernism*. London: Riba Publishing. doi: 10.4324/9780429346125.
[15] Fedak, A. (2022). *Utopia in architecture and urban planning: Its concept and mechanism of implementation*. (Doctoral dissertation, Lviv Polytechnic National University, Lviv, Ukraine).
[16] Fesenko, G. (2022). Freedom square in Kharkiv: Localisation of national and local memory. In *Multidisciplinary academic notes: Theory, methodology and practice* (pp. 112-121). Prague: International Science Group. doi: 10.46299/ISG.2022.1.27.
[17] Franck, G. (2019). The economy of attention. *Journal of Sociology*, 55(1), 8-19. doi: 10.1177/1440783318811778.
[18] Greenhalgh, P. (1990). *Modernism in design*. London: Reaktion.
[19] Heidari, A., Sahebzadeh, S., Sadeghfar, M., & Taghvaei, B.E. (2018). Parametric architecture in it's second phase of evolution. *Journal of Building Performance*, 9(1), 13-20.
[20] Hogan, E.A. (2001). The attention economy: Understanding the new currency of business. *Academy of Management Perspectives*, 15(4), 145-147. doi: 10.5465/ame.2001.5898765.
[21] Horton, L. (2019). Heavenly places on Earth: Religion and architecture in early modern Europe. *Armstrong Undergraduate Journal of History*, 9(2), article number 3. doi: 10.20429/aujh.2019.090203.
[22] Imene, K., & Saliha, A. (2022). Learning styles of architecture and interior design students: A review of the literature. *Technium Social Sciences Journal*, 37, 88-100.
[23] Jencks, C. (1987). *The language of post-modern architecture*. London: Academy Editions.
[24] Jones, L. (2007). Eventfulness of architecture: Teaching about sacred architecture is teaching about ritual. In C. Bell (Ed.), *Teaching ritual* (pp. 251-272). Oxford: Oxford University Press.
[25] Kim, B., & Chen, Y. (2021). The effects of spirituality on visitor behavior: A cognitive-affective-conative model. *International Journal of Tourism Research*, 23(6), 1151-1162. doi: 10.1002/jtr.2474.
[26] Kryvoruchko, Y. (2018). *The phenomenon of sacred development of cities and territories (based on the experience of Ukraine)*. (Doctoral thesis, Kyiv National University of Construction and Architecture, Kyiv, Ukraine).

[27] Lane, S., & Atchley, P. (Eds.). (2021). *Human capacity in the attention economy*. Washington: American Psychological Association.
[28] Lanier, M., Waddell, T.F., Elson, M., Tamul, D.J., Ivory, J.D., & Przybylski, A. (2019). Virtual reality check: Statistic alpower, reported results, and the validity of research on the psychology of virtual reality and immersive environments. *Computers in Human Behavior*, 100, 70-78. doi: 10.1016/j.chb.2019.06.015.
[29] Levitas, R. (2013). Utopia as architecture. In *Utopia as method* (pp. 197-220). London: Palgrave Macmillan. doi: 10.1057/9781137314253_10.
[30] Loos, A. (2019). *Ornament and crime*. London: Penguin Classics.
[31] Mazumdar, S., & Mazumdar, S. (2004). Religion and place attachment: A study of sacred places. *Journal of Environmental Psychology*, 24(3), 385-397. doi: 10.1016/j.jenvp.2004.08.005.
[32] McClung, W.A. (1983). *The architecture of paradise: Survivals of Eden and Jerusalem*. California: University of California Press.
[33] McLuhan, M. (1964). The medium is the message. In *Understanding media: The extensions of man*. Cambridge, Massachusetts: The MIT Press.
[34] McRae, K., Heller, S.M., John, O.P., & Gross, J.J. (2011). Context-dependente motion regulation: Suppression and reappraisalat the Burning Manfestival. *Basic and Applied Social Psychology*, 33(4), 346-350. doi: 10.1080/01973533.2011.614170.
[35] Minkenberg, M. (2014). *Power and architecture: The construction of capitals and the politics of space*. New York: Berghahn Books.
[36] Morrogh, E. (2002). *Information architecture: An emerging 21st century profession*. London: Pearson Education.
[37] Nevola, F. (2019). Ideal cities (Renaissance). In *The Wiley Blackwell encyclopedia of urban and regional studies* (pp. 1-5). Hoboken, New Jersey: John Wiley & Sons. doi: 10.1002/9781118568446.eurs0153.
[38] Nientied, P., & Aliaj, B. (2018). The public in search of identity: New symbolismin urban spaces. A study of central squares of Balkan capitals. In M. Finka, M. Jaššo & M. Husár (Eds.), *The role of public sector in local economic and territorial development* (pp. 203-237). Cham: Springer. doi: 10.1007/978-3-319-93575-1_12.
[39] Osborne, H. (2020). Symmetry as an aesthetic factor. *Computers & Mathematics with Applications*, 12(1-2), 77-82. doi: 10.1016/0898-1221(86)90140-9.
[40] Parker, C., Jenek, W., Yoo, S., & Lee, Y. (2018). Augmenting cities and architecture with immersive technologies. In *Proceedings of the 4th media architecture biennale conference* (pp. 174-177). New York: Association for Computing Machinery. doi: 10.1145/3284389.3303997.
[41] Picon, A. (2013). Learning from utopia: Contemporary architecture and the quest for political and social relevance. *Journal of Architectural Education*, 67(1), 17-23. doi: 10.1080/10464883.2013.767120.
[42] Remizova, O. (2020). Architectural memory and forms of its existence. *Journal of Architecture and Urbanism*, 44(2), 97-108. doi: 10.3846/jau.2020.13053.
[43] Robinson, C. (1997). Seeing paradise: Metaphor and vision in taifa palace architecture. *Gesta*, 36(2), 145-155. doi: 10.2307/767234.
[44] Ruthven, M. (1997). *Islam: A very short introduction*. Oxford: Oxford University Press.
[45] Setti, G. (2021). Architectural diversity in contemporary contexts. The role of design between time and scale. In *UIA 2021 Rio. All the worlds. Just one world. Architecture 21* (pp. 441-447). New York, Washington, DC: ACSA Press.
[46] Song, Y., Koeck, R., & Luo, S. (2021). Review and analysis of augmented reality (AR) literature for digital fabrication in architecture. *Automation in Construction*, 128, article number 103762. doi: 10.1016/j.autcon.2021.103762.
[47] Sullivan, L.H. (1896). The tall office building artistically considered. *Lippincott's Magazine*, 403-409.
[48] Tyc, G. (2020). The great pretenders. New incarnation of expressionist architecture. In A. Mielnik (Ed.), *Defining the architectural space – the truth and lie of architecture* (Vol. 9; pp. 121-130). Wroclaw: Wrocławskie Wydawnictwo Oświatowe. doi: 10.23817/2020.defarch.9-11.
[49] Vitruvius, P. (2001). *Vitruvius: 'Ten books on architecture'*. Cambridge: Cambridge University Press.
[50] Yazdani, N., & Lozanovska, M. (2016). The design philosophy of Edenic gardens: Tracing 'Paradise Myth' in landscape architecture. *Landscape History,* 37(2), 5-18. doi: 10.1080/01433768.2016.1249719.

Роман Франків
Кандидат архітектури
Національний університет «Львівська політехніка»
79000, вул. Степана Бандери, 12, м. Львів, Україна
https://orcid.org/0000-0003-1100-0930

«Середовище ідеальної присутності»: теоретичні та практичні аспекти поняття

Анотація. Через потенційну можливість творення імерсивних просторів, в яких «функція» привернення уваги і її утримання заміщує традиційні розрахунки кліматичних умов, безпеки, гравітації тощо, виникає необхідність у термінах для ширшого узагальнення та оцінки. За мету було взято аргументування доцільності використання терміну «середовища ідеальної присутності», як таке, що здатне сумарно визначати ціннісний рівень різних проектних спроб просторового вираження медійних та комунікативних реальностей, в тому числі порівнюючи їх із досвідом традиційних архітектурних стилів. Головним методом виступає порівняльний аналіз спеціально виділених явищ архітектури. На основі короткої історичної ретроспективи показано тенденцію до поступового заміщення функціоналістичного «раціонального» обґрунтування елементів простору (пов'язаного із буденністю) до атракційного «ірраціонального» (пов'язаного із небуденністю); присутність досвіду матеріалізації небуденних станів у архітектурі різних епох та цільових призначень. Далі здійснено огляд кількох змістових рамок, які приводили архітектурне проектування до інтерпретації виняткової або ідеальної присутності, як то урбаністично-соціальні утопії «ідеальних міст», об'єкти релігійних паломництв та наративних історій, місця виняткових естетичних якостей природного середовища, що окреслені «райськими» метафорами, репрезентативно-урочисті площі столичних міст. Показано потенціал терміну «середовища ідеальної присутності», якийдозволяє ефективно оперувати мотиваційними основами творення сучасного простору, які засновані на привернення та утриманні уваги та перебування; надає концептуальну базу для оцінки пропозицій візуально-просторового перебування (невіртуального і віртуального). Висунуто припущення про механізм «ідеалізації» присутності, який складається через взаємодію трьох складових: особа – увага – перебування. Практичну цінність дослідження складає можливість на основі ємких, змістовно ясних та універсальних термінів, полегшити сприйняття архітектурного середовища та покращити залучення до вивчення проектування ширших кіл зацікавлених осіб та партисипаційних груп

Ключові слова: термінологія; архітектура; увага; концепти життєпростору; ідеалізм

Architectural Studies
International Journal about Architecture

Volume 10, No. 1

UDC 72.03
DOI: 10.56318/as/1.2024.24

Olga Volichenko
Doctor of Architecture
Kyrgyz State Technical University named after I. Razzakov
720044, 66 Ch. Aitmatov Ave., Bishkek, Kyrgyz Republic
https://orcid.org/0000-0002-1403-8021

XiaoYu Huang
Doctoral Student
Kyrgyz State Technical University named after I. Razzakov
720044, 66 Ch. Aitmatov Ave., Bishkek, Kyrgyz Republic
https://orcid.org/0009-0004-6813-6198

Wei Xiong
Doctoral Student
Kyrgyz State Technical University named after I. Razzakov
720044, 66 Ch. Aitmatov Ave., Bishkek, Kyrgyz Republic
https://orcid.org/0009-0001-0991-1658

Fei Wu
Doctoral Student
Kyrgyz State Technical University named after I. Razzakov
720044, 66 Ch. Aitmatov Ave., Bishkek, Kyrgyz Republic
https://orcid.org/0009-0003-9597-3218

Azyk Orozonova*
PhD in Economics, Associate Professor
Jusup Balasagyn Kyrgyz National University
720033, 547 Frunze Str., Bishkek, Kyrgyz Republic
Musa Ryskulbekov Kyrgyz Economic University
720033, 58 Togolok Moldo Str., Bishkek, Kyrgyz Republic
https://orcid.org/0000-0001-6877-7674

Typology and architectural characteristics of trade complexes on historic trade routes: Analysis on the example of the Great Silk Road caravanserai

Abstract. Studies on the typology and architectural features of trade complexes located on historical routes, caravanserais of the Great Silk Road, remain relevant in the modern world, as these structures not only represent historical heritage but also have the potential to understand the impact of trade and cultural exchange on the formation of the urban environment. The study aims to identify the typology and architectural features of trade complexes located on historical routes, with an in-depth study of the Great Silk Road caravanserais. The study includes the application of an analytical approach, classification method, functional analysis, statistical methods, synthesis method and other

Suggested Citation:
Volichenko, O., Huang, X., Xiong, W., Wu, F., & Orozonova, A. (2024). Typology and architectural characteristics of trade complexes on historic trade routes: Analysis on the example of the Great Silk Road caravanserai. *Architectural Studies*, 10(1), 24-34. doi: 10.56318/as/1.2024.24.

Journal homepage: https://arch-studies.com.ua/en
Architectural Studies, 10(1), 24-34
Received: 04.01.2024 Revised: 13.05.2024 Accepted: 20.06.2024

*Corresponding author

methodological approaches. The peculiarities and differences in the typology and architectural characteristics of shopping centres located on historical routes were identified. The analysis of changes on the example of caravan trade routes that stretched across medieval Asia and Eurasia is necessary to assess the evolution and challenges throughout their development. The expediency of using the analysis on the example of caravanserais of the Great Silk Road is considered, limitations in the process are identified, and the impact of limitations on the result is analysed. During architectural studies based on archaeological research, attention was paid to the excavations of large urban centres located along the routes. The practical significance of the study lies in the application of the results obtained to eliminate errors in improving the typology and architectural characteristics of trade complexes on historical routes, and the reliability of the analysis on the example of caravanserais of the Great Silk Road, considering various factors, is considered, which will serve as a basis for providing recommendations for the use of the obtained data on the typology of caravanserais

Keywords: archaeological research; cultural exchange; analysis of intercultural interactions; recommendations for development and improvement; excavations of large urban centres

INTRODUCTION

Caravan trade routes were a network of paths and trails along which goods and culture were exchanged extensively between different regions, especially in Asia and Eurasia during the Middle Ages. One of the most famous and significant caravan routes was the Great Silk Road. This trade route was active from around the first century to the 17th century and connected different parts of Asia, Europe and Africa. The main goods transported along the Silk Road were silk fabrics, spices, valuable metals, masterpieces of ideology, and even technology. The relationship between economic development and road networks in the Eurasian continent is an important aspect that has attracted the attention of researchers. This relationship is usually considered in the context of the impact of transport route infrastructure on various aspects of the economy. Road networks facilitate the movement of goods between regions and countries, facilitating international trade and increasing transit volumes.

According to D.P. Berdiev (2023), caravanserais, baths and the bazaar square, surrounded by fortress walls, complemented the shopping street, forming the central commercial and social complex of the city. In modern times there is an urgent need to further study the typology and architectural features of caravanserais, these structures, being public buildings or complexes, are designed for temporary accommodation and service of caravans and travellers, this study will provide a better understanding and preservation of historical and cultural heritage, as well as to apply the acquired knowledge in modern architecture and urbanism to create functional and comfortable public spaces. Furthermore, located along the shopping street, they provided easy access for trade caravans and customers, which promoted trade and exchange in the region. This allowed not only to meet the needs of travellers but also to create favourable conditions for the development of economic activity and cultural exchange (Almaganbetovna *et al.*, 2023).

Following S. Adilkhodzhaeva (2023), trade centres and caravanserais emerged along the route, these are special structures for rest and trade for caravan travellers. The analysis carried out on the example of caravanserais of the Great Silk Road determined relevance and underlines the importance of analysing similar phenomena and processes in the present context. According to R.T. Darmenov (2023), public baths in the vicinity of caravanserais were an important social and hygienic centre in medieval cities. But the study does not sufficiently address the importance of places located near caravanserais and the market square, these places provided not only convenience and comfort for travellers but also served as important centres of social activity for the local population, given their role in shaping public space and community cohesion. It is important to give them due consideration in urban infrastructure development and planning strategies.

Following M.K. Khabdulina & T.V. Koshman (2023), the Multani and Bukhara caravanserais, located close to the Maiden Tower and facing the Shemakha Gate, were important in shaping the planning composition of the public centre. Nevertheless, the proximity of these caravanserais to the Maiden Tower is worth exploring in more detail, their strategic importance in the urban layout of the city may indicate that they occupy a key position, creating important links between the various architectural and historical elements of the city, and given their spatial location, it can be assumed that this is not a coincidence but a conscious decision aimed at strengthening the social and cultural significance of the area.

D.Z. Salokhiddinova & F.F. Soliev (2022) note that the Multani and Bukhara caravanserais oriented towards the Shemakha Gate are likely to be of key importance in the layout of the city's public centre. It is also worth noting that studies focusing on the location of these caravanserais may determine the role of these sites in shaping the axial composition of urban space or serve as a reference point for the direction of urban flow, and additional research in this direction may shed light on the architectural and functional aspects that influence the organisation of space around these sites and their importance in the urban environment. According to S. Shonazarov (2023), caravanserais play not only a practical role in providing services and space for travellers but also have significant importance in shaping the architectural and socio-cultural environment of the public centre of the city.

The study aimed to provide a systematic and in-depth analysis of the architectural, cultural and trade aspects of caravanserais distributed along the Great Silk Road. The research task was to define the role of these structural elements in the formation and maintenance of ancient trade and cultural links between different civilisations. It is worth noting that the historic trade route has existed for several centuries since antiquity and has had a significant impact on the exchange of goods, cultural transitions and interactions between different civilisations.

MATERIALS AND METHODS

A theoretical framework was initially developed, which served both as a basis for the subsequent analyses and as a foundation for the formulation of conclusions. The analysis method was sued in the study to determine and highlight problems related to the functioning and structural features of shopping complexes on historical trade routes, as well as the consideration of the role and essence of comparative typological and architectural-planning analysis of caravanserais along the Silk Road route, with the identification of their advantages and disadvantages. The statistical method was used to address the volume and causes of errors in the process of improving trade complexes on historical trade routes, which is the basis for ensuring sustainable development, improving the efficiency of these complexes, as well as the prospective use of the Great Silk Road.

The structural-functional method was employed to address, trends, factors and patterns to assess the structural features of caravanserais, such as building materials, architectural styles, and general layouts, to identify key components and elements, identifying effective options and analysing the functional features of caravanserais, such as shopping areas, living spaces, recreational facilities, and their relationship to architectural features, improving the impact of the caravanserais on the caravanserai's livelihood, and improving the quality of the caravanserai's life. The deduction method was used to study the features of the functioning of complexes that include material culture, indicating extensive inter-regional links, these features are the basis for the existence of the caravanserai trade, by identifying the key elements needed to fully analyse the operation and problem solving of this process.

For practical implementation of the study, computer modelling of the formation of the Daewoo-kala caravanserai (11^{th}-13^{th} centuries) and the Taylakhan-ata caravanserai (11^{th}-14^{th} centuries) using the specialised AutoCAD software was employed. This stage involved an analysis of the basic principles of the complexes' functioning, including those reflecting material culture and indicating broad interregional interrelationships, using computer modelling techniques. The advantages and disadvantages of these complexes were also analysed, as well as their interaction in the context of the overall caravan trade. An important stage of the study involved examining the prospects for the utilisation of the caravan trade. The study also analysed the operation of the process to improve the typology and architectural characteristics of trading complexes on historic trade routes. The employed methods aim to avoid possible errors in the process of improving the analysis of caravanserais of the Great Silk Road, including computer modelling methods, analytical approach, comparative analysis methods, and statistical methods. This is relevant for a more accurate assessment of development effectiveness.

The synthesis method was used to summarise the obtained indicators of theoretical analysis and practical experience to formulate recommendations for the use of data on the typology of caravanserais. They aim to solve problems and achieve progressive growth in the process. Particular attention was devoted to the improvement of the quality of caravanserai development, and predictive models and design solutions are presented. Logical and functional analysis methods were applied, providing a more detailed consideration of the concept of "Typology and architectural characteristics of shopping complexes on historical trade routes", this, in turn, contributed to the parsing of situations. The methods were used to characterise the features and functioning principles of the Silk Road caravanserais within the analysis, additionally analysing the complexity of shopping complexes on historical trade routes in the process of functioning, as well as considering scenarios in which there are difficulties in the application of these complexes.

RESULTS

Caravanserais in Central Asia often had a typical oriental style of architecture, with open courtyards, domed ceilings and delicate patterns on the walls. This style of architecture often incorporated elements of Persian, Turkmen and Mongolian design, reflecting the rich cultural heritage of the region. Efficient transport infrastructure facilitates market integration by reducing transport costs and creating a favourable environment for businesses and consumers to interact (Mohimani & Nabavi, 2022). Caravanserais were special structures designed to provide temporary accommodation and rest for travellers and to protect them from threats during the journey. These structures usually included buildings for human and livestock accommodation, warehouses for goods, animal stalls, and walls or fortifications for security.

Caravanserais were often built of brick, stone or clay, depending on the available resources in a particular region. Roofs were covered with ceramic tiles or wooden beams to protect from sun and precipitation (Darendeli & Binan, 2021). Inside the caravanserai, rooms were usually provided to accommodate merchants and travellers, as well as spaces for storing goods and feeding animals. Public spaces were also an important element, where travellers could rest, exchange information and make contacts for future transactions. Caravanserais were built with the comfort of travellers in mind. They usually had comfortable areas for camels and other animals to park, and ventilation systems to keep them cool on hot days. Some caravanserais were equipped with baths, mosques and shops for the convenience of visitors.

The diversity of languages, religions, arts and sciences flourished due to the interactions that took place along these routes. This contributed to the formation of cultural ties between East and West (Kostopoulou *et al.*, 2022). Aultepe was the first caravanserai opened in Sogd on the route from Shakhrisabz to Kesh (Erkurgan site). Several facts testify to its recognition as a caravanserai. Firstly, the absence of a stylobate platform, which is a characteristic feature of castles. Secondly, the absence of a large ceremonial, reception hall, which is different from castle architecture. Thirdly, an absence of cooking hearths in the living rooms, except the utility room in the central planning core. Fourthly, along the perimeter of the outer walls, there are blocks consisting of a living room and a utility room, which is a characteristic feature of the planning organisation of the caravanserai known as rabat. These features testify to the functional specificity and structural features of Aultepe, confirming its role in the system of caravan trade on the Silk Road.

Caravanserais were not just architectural structures, but also economic centres where goods, ideas and cultural influences were exchanged between different peoples and civilisations. Their location on key trade routes made them an integral part of medieval trade and exchange (Deljavan & Çinar, 2023). Tash-Rabat, a feudal caravanserai, is located in the Chon-Kemin valley of Kyrgyzstan, in the Chatyr-Kel district. It is one of the most unique and interesting architectural constructions in Central Asia. It dates to the 15th century and its uniqueness lies both in the use of stone as a building material and in its composition (Niknam Asl *et al.*, 2022). One of the main features of Tash Rabat is its building material – stone. At a time when most caravanserais were built of clay or brick, the use of stone made Tash Rabat unique in its kind. This gives the structure not only durability but also a special appearance (Abedi *et al.*, 2023). Tash Rabat has a square shape with an inner courtyard. Its architectural composition includes majestic walls, up to 10 m high and 1.5 m thick. Inside the caravanserai, there are various rooms for the accommodation of travellers, storage for goods and livestock, as well as halls for meetings and trade. Externally, the structure appears imposing and monumental, embodying the grandeur of medieval architecture in Central Asia (Ergashev, 2023). As a typical caravanserai, Tash-Rabat served as a resting place and security for caravans and travellers passing through the region. It also played the role of a trading centre where goods and cultural ideas were exchanged between different ethnic groups and cultures.

The process of dissecting the caravanserai building volume into individual elements, called morphemes, is a method of analysis, that provides a more detailed analysis of its structure. These morphemes may include architectural details, structural units, decorative elements and other features that characterise the main components of the building. Once the morphemes have been identified, their interrelationships and organisation into structural groups are analysed. This allows to reveal of spatial regularities in the organisation of the caravanserai, such as interrelations between different parts of the building, the sequence of its elements, their functional purpose and interaction. This method visualises not only the internal structure of the caravanserai but also its functional and aesthetic aspects. It allows researchers to better understand the organisation of space within the building, its use and its importance to travellers and traders on the Silk Road and other trade routes (Latham-Sprinkle, 2023). When the Arab Caliphate established itself in Maverannahr, the use of kyoshkas (feudal castles before the Islamic period) and ribats (rabats), fortresses, gradually evolved into their use as inns for caravans. These structures provided security, comfort and shelter for caravan travellers and their animals. Tash Rabat represents an important historical heritage of Kyrgyzstan and Central Asia as a whole. Its unique architecture and history of use make it an object of study for researchers and tourists, as well as a symbol of the cultural wealth of this region.

Caravanserais of circular shape, which represent a unique phenomenon, are found predominantly in Khorezm (e.g. Deu-kala, Orta-kuyu, Talaykhan-ata, Ak-Yayla) and functioned on the routes from Asia to the Volga region and the Caucasus in the 11th-13th centuries. They were distinguished by the outer contour of walls made of raw brick about 2 m thick, creating a circle with a diameter of 50-60 m. In the centre of the circle, there was a square courtyard with a well. The planning structure of the premises around the courtyard was complex and varied (Fig. 1).

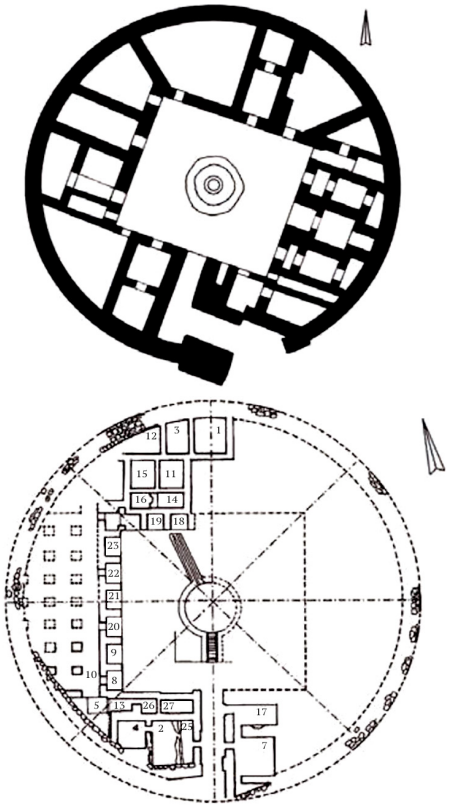


Figure 1. Deu-kala caravanserai (11th-13th centuries), and Taylakhan-ata caravanserai (11th-14th centuries)
Source: M.M. Andrews & S.G. Bernard (2020)

The construction of Tash Rabat from unfinished slabs of mountain blue and red slates with rough cement masonry is a unique example of an architectural style that characterises the local building traditions of that time and place. The blue and red oil shales used in the construction of Tash Rabat were local materials available in the surrounding mountains. Oil shale is a durable and fracture-resistant material, making it an attractive choice for construction. It is possible that the slates may not have been processed or finished by hand, preserving their natural appearance and texture. This could have been done either because of limited resources and facilities or to preserve the natural beauty of the material.

Caravanserais, which served as housing and trading posts for caravans and travellers, had their own design and planning features. Caravan routes in Syria were strategically placed near key trade routes and settlements. They provided travellers and traders with convenient points for resting and exchanging goods. Caravan routes in Syria usually passed through important trading cities such as Damascus and Aleppo. Many caravanserais in Syria included defensive elements, such as walls and towers, to provide security for travellers against various threats, including robber raids. Caravanserais were often built of brick, stone or other strong materials, providing resilience and creating stable structures. Many caravanserais had a courtyard that served as a place for resting and parking animals. This created a space for travellers to exchange and meet. Inside the caravanserais, special premises were provided for trade and exchange of goods. This facilitated the development of trade relations along the routes. Caravanserais provided facilities for travellers, including places to sleep and food offerings. This contributed to safety and comfort during long journeys. Overall, caravanserais in Syria were an integral part of the Silk Road infrastructure, facilitating trade, and cultural exchange and providing security for travellers along the trade route.

The origin and classification of caravanserais, as well as the influence of local and regional peculiarities on their architecture and decor, are interesting aspects of the study of history and culture. Caravanserais have ancient roots and are connected with the development of trade routes and caravan trade. Their appearance is connected with the need to provide travellers with places to rest and ensure safety on long journeys. Caravanserais can be classified by size, functionality and architectural features. For example, there were large caravanserais designed to serve large caravans, as well as smaller and more isolated structures for individual travellers. Caravanserais often reflected local building traditions and used distinctive materials. For example, in desert regions clay and brick might be used, while in mountainous regions stone and wood were favoured. The interiors and facades of caravanserais may have been decorated with various decorative elements such as wood carvings, mouldings, frescoes and mosaics. These decorations may have reflected local traditions and religious influences.

Caravanserais on the Silk Road through Asia may have differed from their counterparts in other regions. East Asian caravanserais, for example, may have been influenced by Chinese architectural traditions. In regions with Muslim influence, caravanserais may have had characteristic elements of Muslim architecture such as arched entrances, columned halls and domes. The study of these aspects provides insight into how different cultural, geographical and religious factors have shaped the architectural designs and decorative elements of caravanserais throughout history. The typology of caravanserais includes different architectural forms and functional features of these structures depending on their location, historical context and role in trade. Stationary caravanserais were permanent nodes on trade routes and were usually located in strategically important places. They included living and storage areas, animal stalls and sometimes defensive structures to protect against attacks. Mobile caravanserais may have been temporary and travelled with the trade caravans. They were accommodation and resting facilities for caravans during their journey, usually consisting of tents or primitive structures. Some caravanserais were associated with religious or cultural centres and served not only as places for rest and trade but also for prayer, learning and knowledge exchange. Depending on their location and their role in trade networks, caravanserais could serve a variety of functions, including providing security, trade, accommodation for travellers and animals, and the provision of various services and goods. Each type of caravanserai had its characteristics and specificities, reflecting the needs and nature of trade and cultural exchanges in different times and regions.

The typology of Silk Road caravanserais includes a variety of forms and styles of these structures that developed along the entire route from China to Europe. Major nodes along the Silk Road route were usually protected by fixed fortresses that also served as caravanserais. These fortresses provided caravans with a haven during their journey and included living quarters, warehouses and defence structures. Some caravanserais were built as large inns or public buildings designed to accommodate and serve travellers and traders. They may have had restrooms, dining halls, baths and other facilities. Some caravanserais were associated with religious sites such as mosques, monasteries or temples. These complexes provided travellers not only places to rest but also opportunities for prayer and spiritual renewal. In some cases, caravanserais included trading pavilions and markets where traders could sell their goods and exchange goods with other travellers. These types of Silk Road caravanserais demonstrate the diversity of function and character of these structures, reflecting the richness of cultural and commercial exchange along this ancient trade route.

Morphological analysis at the local level examines the structural elements and architectural solutions used in the formation of the volumetric and spatial composition of the object (e.g. a platform-stylobate, 1 m high, with a caravanserai on top); exterior and interior walls are made of pahsa

blocks adjacent to raw brick masonry; The box vaults are made of square bricks; the cantilevered sails are made of bricks laid at an angle to form stepped arches; the arches of the doorways are wedge-shaped; the corner towers project three-quarters of the facades and have a diameter of 3.2 m at the base; entrance portal protrudes from the wall by 2.8 m; aivan portals are located in the courtyard. At the structural level, the relationship between the structural elements is revealed due to their functional purpose and load. The outer walls are reinforced with massive towers and buttress pylons, and the north wall has an entrance portal with high pylons and a wide entrance arch. The main facade is decorated with "paired half-gables" extending to the bottom, with perspective arches above (Fig. 2).

Figure 2. Chaldovar Caravanserai

Source: K.F. Hmood & J. Goussous (2022)

The Chaldovar Caravanserai is a historical site that is one of the many caravanserais located along the Great Silk Road. It is an architectural complex that was used to temporarily house caravans travelling along this ancient trade route. Chaldovar has distinctive architectural features typical of the caravanserais of the Great Silk Road. It usually consists of a large building surrounded by walls, sometimes with towers for security. Inside the complex, there was usually a courtyard where caravans could leave their animals and goods, as well as spend the night and rest. In addition, the caravanserai may have had various commercial establishments such as shops and restaurants that provided services for travellers. Caravanserais like Chaldovar played an important role in trade and cultural exchange between East and West. They were not only places of recreation and trade, but also centres for the exchange of ideas and cultural influences. As of 2024, these historical complexes are often sites of tourist interest and help to preserve the historical legacy of the Silk Road.

The typology of caravanserais is divided into three main types: covered caravanserais resembling a kioshk (ribat, rabat); aivan-type composition with one courtyard, which according to the principle of placing rooms around the courtyard was subdivided into gallery type (gallery around the perimeter of the courtyard), sectional (groups of vaulted rooms adjoin the courtyard by their ends) and sectional-gallery type (combination of the first and the second); multi-courtyard composition consisting of 4 identical courtyards, of one central (through) courtyard and small courtyards on the perimeter, T-shaped arrangement of courtyards (Table 1).

Table 1. Typology of caravanserais

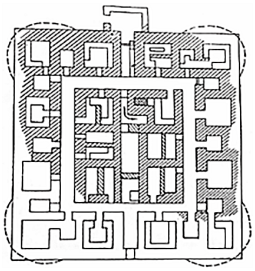
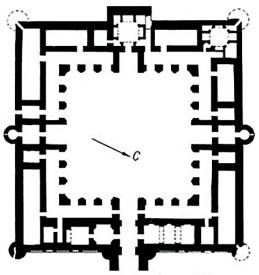
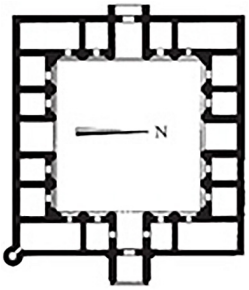
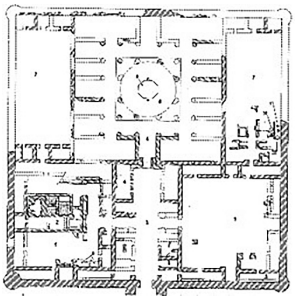
Type	Layout	Characteristic	Caravanserais
1. Covered (no courtyard)	 Aultepe, 5th-6th centuries	Ribat or Rabat fortress. Central core – group of household rooms; bypass corridor; perimeter rooms – repetition of the section – large room with soufs (residential) + small room (storage)	Aultepe, 5th-6th centuries; At-Tahmalaj, 9th-10th centuries; Tash-Rabat, 11th century; Zindan-i Harun al-Rashid, 10th-11th centuries
	Gallery-style		
2. One courtyard	 Dayahatyn, 12th century	Courtyard; four-haywan composition; columned gallery around the perimeter of the courtyard; corridor-shaped rectangular rooms; four round corner towers + two in the middle of the north and south walls	Dayahatyn, 12th century; Chaldavar (Manakeldy), 10th-12th centuries

Table 1. Continued

Type	Layout	Characteristic	Caravanserais
	Block-style		
2. One courtyard	 Rabat Suran	Courtyard; four-haiwan composition; vaulted living rooms are arranged in groups of two on either side of the iwan on the north and south sides; on the western and eastern sides – one on each side of the iwan	Rabat Suran, 11th-12th centuries; Sary-Bulun, 11th-12th centuries; Al-Asker, 10th-12th centuries; Southern and Eastern Caravanserais in Misriana, 10th-12th centuries
3. Multi-yard composition (2 or more courtyards)	 Rabat-e-Malik	5 courtyards – 3 in the northern part (front, residential), 2 in the southern part (household); two-part composition; mosque (central passage); bathhouse (south-western courtyard); corrugated decoration of external walls; domed rotunda (central northern courtyard)	Rabat-i-Sharaf, 11th-12th centuries; Akcha-Kala, 11th-12th centuries; Rabat-i-Malik, 11th-12th centuries; Aqir-Tash, 10th century; Kunya-Kala, 10th century

Source: compiled by the authors

Aultepe is an ancient caravanserai that was built in the 5th and 6th centuries. This caravanserai is a significant historical site that served as an important stop on the trade routes of the time. Architecturally Aultepe was a typical representative of the caravanserais of its time, consisting of covered galleries or aivans surrounding a courtyard. The interior may have been used as a place of rest and lodging for caravans and travellers. As one of the stops on the Great Silk Road or other trade routes, Aultepe may have served not only as a resting place but also as a trading centre where merchants and caravaners could exchange goods and commodities. Caravanserais, which provided shelter for travellers as well as a hub for the exchange of both material goods and intellectual information, have become a symbol of the history of the Silk Road. They were not only stopping points for rest and exchange but also key hubs for trade and distribution of goods in the remote and impassable sections of the route. The architecture of caravanserais, corresponding to general requirements and laws, was uniform and developed synchronously in different countries connected by trade routes. It represented a unified model for a temporary stay of travellers with caravans. The common structural norms and rules, as well as the widely accepted architectural system in building practice, were characterised by stability and mass reproducibility. The architectural forms of caravan posts reflected the influence of cultural traditions and the peculiarities of the building art of each region while retaining their uniqueness.

The presented classification of caravanserais is based on the characteristic principles of planning organisation due to the insufficient preservation of the ruins of their structures, which leaves out aspects of their form, time of creation and semantic significance. The layout of the Chaldovar (Manakeldy) caravanserai correlates with similar structures in Central Asia, such as the caravanserais in Dehistan, Daya-Khatyn, Beleuli in Khorezm (Turkmenistan), which also have a common compositional scheme, including a courtyard with surrounding rooms, corner towers and intermediate buttresses, as well as a single entrance and so on. Despite this, the Chaldovar caravanserai stands out among its counterparts by its distinct organisation of functional and procedural relations, having no direct parallels with other structures. The decorative design of the main facade of the Chaldovar caravanserai, consisting of complicated corrugations, for example, in the form of two half corrugations separated by a shallow straight niche, was also used in the design of the facade of the steppe palace of Rabat-i Malik (Uzbekistan). However, a significant difference in the application of this architectural decoration should be noted. In the case of the Chaldovar caravanserai, the facade plastic of rhythmically repeating elements covers the entire surface of the facade, in contrast to Rabat-i Malik, where this technique was not used on such a scale as it was in earlier constructions, for example, of the 6th-8th centuries.

DISCUSSION

The internal walls of the building are up to 1.4 m thick and are built on alabaster in Tash Rabat, indicating serious construction and the use of durable materials to create this structure. This significant thickness was chosen to ensure the strength and resistance of the building to external influences such as winds, earthquakes or other natural factors, as well as to provide thermal insulation and safety for those living or staying inside. Alabaster was used as a

material for masonry walls. Alabaster is a mineral that when mixed with water forms a strong bonding mortar which then hardens and strengthens the wall (Shumka *et al*., 2020). This construction method produces strong and durable walls by providing good adhesion and stability. Alabaster has several advantages as a building material. It is readily available, making it a cost-effective choice. In addition, alabaster has good strength and resistance to a variety of conditions, making it ideal for use as a bonding material for large and thick walls, as in the case of Tash Rabat. The use of alabaster to bind the walls of Tash Rabat ensures not only their strength but also the durability of the structure for years to come. This allows the structure to stand the test of time and retain its architectural value and historical significance.

Following recent studies by R. Lin *et al*. (2024), the network of trading town centres and caravanserais, also known as road stations, played a key role in maintaining a lively commercial activity for many centuries until the 15th century. These commercial complexes served as important nodes on historic trade routes, providing a variety of functions. Town centres provided places for the exchange of goods, trade and interaction between merchants and travellers. Currently, improvements in the quality of various methods and devices are required, characterised by a variety of structural and architectural features, these methods and devices have been specifically adapted to the needs of caravans and trading communities. After scrutinising the functioning of caravanserais, or road stations, they played an important role in the supply system. The results of this study concur with those of the researchers in that indeed caravanserais played the role of an artery supporting commercial activities along the entire Silk Road route.

Following R.W. Alnaemy (2024), the outer walls of the caravanserai of Tash Rabat form a square at the base, the side of which is 32 m. These walls are not only the boundary for the caravanserai itself but are also private walls for the adjacent cells, rooms and corridors. The base of the caravanserai is square in shape, which is typical of many oriental-style architectural structures, including caravanserais. This fact confirms that the author's research is in line with current trends in architecture, the square shape provides not only compactness but also symmetry of the structure, which is an important aspect in creating functional and aesthetically pleasing buildings, in this case, the use of a square base of 32 m allows for optimal distribution of the interior of the caravanserai, providing convenience for its visitors and efficient use of space. There has not been sufficient mention in this study of the importance of external walls to the architectural appearance of the Tash Rabat caravanserai, these walls play a key role in the architectural design, providing not only its structural strength and security but also serving as the basis for its functionality, they define the contours and boundaries of the structure as well as providing privacy and protection for those living and inside, their importance as a fundamental element influencing the overall aesthetics and functionality of the entire caravanserai complex is emphasised.

S. Hafeez *et al*. (2024) identified that mazars are shrines in Asian culture that often have a recognisable architectural appearance. They can be places of worship, mausoleums, or places of remembrance for famous individuals. The appearance of a caravanserai compared to a mazar indicates its religious and cultural significance. To ensure that these caravanserais function more effectively, the use of rough-hewn stone for the construction of the facades gives the buildings a traditional and authentic appearance which is important for the preservation of the historical value and cultural heritage of the region, this style of stonework can also provide additional strength and durability to the building which is necessary for its long-term use in the context of intensive trade and cultural exchange on the caravan routes, thus an appearance reminiscent of ancient buildings. Notable for its focus on the significance of the style of stonework that gives the caravanserai an authentic appearance and sense of historical durability, this study also emphasises the need for careful analysis of the data to gain a full understanding of the architectural features and cultural context of these structures.

R. Kana'an & A. Shalem (2024) note that the mention of an Asian mazar indicates that the caravanserai conforms to the traditional architectural styles of the region. This may include elements of ancient Asian architecture that are characteristic of the culture and history of the place. The mazar appearance of the building may carry symbolic meaning and be an important element of the cultural heritage of the region (Kemelbekova *et al*., 2023). The results of this study indicate that caravanserais not only represent a place of temporary accommodation for travellers but also have significant cultural and historical significance that inspires respect and admiration, these structures play an important role not only in providing convenience and safety for travellers but also in preserving the cultural heritage and traditions of the region. It is also important to note that the caravanserai of Tash Rabat was undergoing intensive development at this stage, this description emphasises its uniqueness, cultural richness and connection with the traditional architectural styles of the region, moreover, it highlights its religious and historical significance, emphasising its role in shaping the cultural heritage and identity of this region.

H. Osni (2024) demonstrated that the second stage, falling between the 7th and 10th centuries, was characterised by the strengthening and expansion of the trade route. During this period, major cities, centres of trade and cultural exchange began to appear and flourish along the Silk Road. The third stage, 13th-14th centuries, is associated with the last great unrest and the peak of Silk Road activity (Trushaj, 2023). Nevertheless, this study does not address the fact that many caravan trade routes were actively developed during this period, linking diverse regions and along which unique cultural and economic monuments emerged. It is also worth noting that each of these phases contributed to the history and significance of the Silk Road, reflecting its dynamic development and impact on world history, hence the distinction between this study and the author's work.

As M.S. Alsubaie *et al*. (2024) note, the cells of the caravanserai of Tash Rabat are rooms of various sizes arranged in rows, sometimes creating a labyrinth-like structure, among them more than forty. Each keli has a domed light hole in the centre, reminiscent of a tunduk in a yurt. The kelis offer a variety of sizes to suit the different needs of travellers and traders. It is also worth noting that the cultural and architectural influences of the Tash Rabat caravanserai spread over a wide area, this included a variety of spaces ranging from small rooms for single travellers to large rooms for caravans and groups. This diversity provides convenience and meets the needs of different categories of travellers and traders, making the caravanserai a centre of vitality and cultural exchange across the many spaces of the journey.

CONCLUSIONS

The study reveals that management strategies gradually led to the fact that the route passing through the Kaghan's stakes in Semirechye became the main route of ambassadorial caravans. The study shows that caravanserais on the Silk Road vary in their architectural form and functionality, representing a wide range of structures from large stationary fortresses to temporary tents and mobile structures. Caravanserais served a variety of functions, including providing shelter for caravans, protection from attack and convenience for travellers, some also had trading areas, baths and places of prayer. The study analysed the changes in the architectural features of caravanserais which may have occurred following the evolution of time and location, for example, as trade increased and security improved, larger and more elaborate structures became necessary.

A detailed analysis of the operation of the caravanserai, a key element of the architectural landscape of medieval Asia, is produced. Special attention is paid to the analysis of technological processes, as well as to the identification of problems arising in the process of creating caravanserais. Implementation of effective tools contributes to the successful resolution of these issues and the prevention of mistakes in the future. Caravanserais were not only trade sources, but also centres of cultural and social exchange. They contributed to the rapprochement of different cultures and peoples and played an important role in the dissemination of ideas and art. This study has successfully achieved its objectives, including analysing the typology and architectural features of trade complexes located on historical routes, with a special focus on the caravanserais of the Great Silk Road. The process of creating fortresses (rabats) to ensure the safety of the roads has also been considered earlier. Some caravanserais may have been decorated with carvings, mosaics, frescoes or other decorative elements reflecting local traditions and art.

The studied typology and architectural features of trading complexes on historic trade routes will endeavour to meet modern requirements for the future prospective use of caravanserais. Planned research aims to develop and implement innovative methods of analysis, using the caravanserais of the Great Silk Road as a case study, to contribute to the development of the archaeological field.

ACKNOWLEDGEMENTS

None.

CONFLICT OF INTEREST

None.

REFERENCES

[1] Abedi, F., Amirkhiz, A.C., Niknami, K.A., & Khamseh, H. (2023). Typology of caravanserais on the Tehran-Anzali route in the Qajar period (based on archaeological documents and research). *Athar*, 43(4), 610-629. doi: 10.30699/athar.43.4.610.

[2] Adilkhodzhaeva, S. (2023). The ancient Fergana state of Davan in the origins of the development of national statehood of Uzbekistan. *Universum: Social Sciences*, 10(101).

[3] Almaganbetovna, T.A., Daniyarovna, T.A., Ogly, M.S.E., Papin, H.E., Nikolayevna, K.Y., & Alua, A. (2023). Development of the architecture of residential buildings from the beginning of XX to XXI century (by the example of Astana). *Civil Engineering and Architecture*, 11(3), 1220-1233. doi: 10.13189/cea.2023.110308.

[4] Alnaemy, R.W. (2024). Architectural characteristics of vaults and their uses in building in the city of Mosul – selected models. *Athar Alrafedain*, 9(1), 295-312. doi: 10.33899/AA.2024.181703.

[5] Alsubaie, M.S., Almutery, S.B., Almoufleh, A.A., Khalil, M.M.E., & Sallam, A. (2024). Architectural heritage conservation in the city of Qurh: Assessing and stabilizing Islamic era mud brick structures. *Mediterranean Archaeology and Archaeometry*, 24(1), 50-73. doi: 10.5281/zenodo.10559426.

[6] Andrews, M.M., & Bernard, S.G. (2020). Places of economic exchange. In *City of encounters, public spaces and social interaction in Ancient Rome* (pp. 69-112). Rome: Quasar.

[7] Berdiev, D.P. (2023). Administrative units of the Kashkadarya oasis (late XIX early XX century). *Central Asian Journal of Social Sciences and History*, 4(4), 195-199. doi: 10.17605/OSF.IO/FNQEJ.

[8] Darendeli, T., & Binan, C.Ş. (2021). Seljuks inherit to Anatolia; Caravanserais. *Athens Journal of Architecture*, 7, 137-172. doi: 10.30958/aja.7-0-2.

[9] Darmenov, R.T. (2023). Construction materials and constructive methods of folk architecture in the dwellings of South Kazakhstan. *Cultural Heritage*, 3(102), 68-79. doi: 10.47500/2023.v15.i3.05.

[10] Deljavan, N., & Çinar, K. (2023). Comparison of Anatolian and Persian caravanserais in the Seljuk period. *Journal of Karatay Social Research*, 11, 27-43. doi: 10.54557/karataysad.1333320.

[11] Ergashev, J. (2023). Caravanserais and their importance on caravan routes. *E3S Web of Conferences*, 458, article number 07002. doi: 10.1051/e3sconf/202345807002.
[12] Hafeez, S., Kabir, N., & Ahsan, A. (2024). Architectural legacy of Zīb Al-Nisā: Patron of first Mughal woman architect. *International Journal of Human and Society (IJHS)*, 4(1), 9-17.
[13] Hmood, K.F., & Goussous, J. (2022). The phenomenon of diversity and the effective response to the physical environment: The formation of old traditional markets (Suq). *Conservation Science in Cultural Heritage*, 22(1), 97-114. doi: 10.6092/issn.1973-9494/17305.
[14] Kana'an, R., & Shalem, A. (2024). An introduction to approaching architecture in the Muslim world: Novel paths of investigations. *Journal of Material Cultures in the Muslim World*, 4(2), 143-152. doi: 10.1163/26666286-12340043.
[15] Kemelbekova, E., Baidabekov, A., & Yeziyeva Nehir, M. (2023). Study of the basic geometric dimensions of the Mausoleum of Hodja Ahmed Yassawi in Central Asia. *Lecture Notes on Data Engineering and Communications Technologies*, 146, 986-993. doi: 10.1007/978-3-031-13588-0_86.
[16] Khabdulina, M.K., & Koshman, T.V. (2023). Historical and cultural landscape of the Terisakkan-Ishim region. *Bylye Gody*, 18(4), 1797-1808.
[17] Kostopoulou, S., Sofianou, P.K., & Tsiokanos, K. (2022). Silk Road architectural heritage and polycentric tourism development. In *Conservation of architectural heritage (CAH) embodiment of identity* (pp. 33-58). Cham: Springer. doi: 10.1007/978-3-030-95564-9_3.
[18] Latham-Sprinkle, J. (2023). Kate Franklin, everyday cosmopolitanisms: Living the Silk Road in medieval Armenia. *Journal of Near Eastern Studies*, 82(2), 372-375. doi: 10.1086/726208.
[19] Lin, R., Yang, F., Zhang, D., Zou, C., Zeng, Z., & Li, X. (2024). Landscape feature extraction and floristic division of traditional villages in the Minjiang river basin. *Journal of South Architecture*, 1(1), 1-9. doi: 10.33142/jsa.v1i1.10430.
[20] Mohimani, M., & Nabavi, F. (2022). Investigation of the formative-spatial structure of caravanserais along the Silk Road in Great Khorasan. *Journal of Great Khorasan*, 13(48), 113-134.
[21] Niknam Asl, S.A., Bazrafkan, K., & Alimohammadi, P. (2022). "Idea-Product" correlation in Iranian traditional architecture evolutionary construction (the architecture of Caravanserai). *Armanshahr Architecture & Urban Development*, 15(38), 151-167. doi: 10.22034/aaud.2021.277821.2451.
[22] Osni, H. (2024). Everyday migrant architecture and socio-spatial practices: Bawean Langkher in the Singapore Ponthuk. *International Journal of Islamic Architecture*, 13(1), 145-171. doi: 10.1386/ijia_00132_1.
[23] Salokhiddinova, D.Z., & Soliev, F.F. (2022). To the question of restoration of traditional background building of the Gur Emir Ensemble. In *Materials of the international scientific and practical conference "Architecture and urban planning of Tajikistan: Yesterday, today, tomorrow"* (pp. 129-133). Dushanbe: Tajik Technical University named after academician M.S. Osimi.
[24] Shonazarov, S. (2023). Roadside Sogdian inns on the route of the Great Silk Road (on archaeological materials of the Karshi oasis). *History and Culture of Central Asia*, 1(1), 157-162.
[25] Shumka, L., Peri, L., & Lato, E. (2020). The needs for determining degradation risks from temperature and relative humidity of post-byzantine church indoor environment. *Journal of Environmental Management and Tourism*, 11(3), 601-605. doi: 10.14505//jemt.11.3(43).13.
[26] Trushaj, A. (2023). Features of the foreign policy of the Republic of Kazakhstan. *Foreign Affairs*, 33(5), 45-51. doi: 10.46493/2663-2675.33(5).2023.45-51.

Ольга Воліченко
Доктор архітектури
Киргизький державний технічний університет ім. І. Раззакова
720044, просп. Ч. Айтматова, 66, м. Бішкек, Киргизька Республіка
https://orcid.org/0000-0002-1403-8021

СяоЮ Хуанг
Докторант
Киргизький державний технічний університет ім. І. Раззакова
720044, просп. Ч. Айтматова, 66, м. Бішкек, Киргизька Республіка
https://orcid.org/0009-0004-6813-6198

Вей Сьонг
Докторант
Киргизький державний технічний університет ім. І. Раззакова
720044, просп. Ч. Айтматова, 66, м. Бішкек, Киргизька Республіка
https://orcid.org/0009-0001-0991-1658

Фей Ву
Докторант
Киргизький державний технічний університет ім. І. Раззакова
720044, просп. Ч. Айтматова, 66, м. Бішкек, Киргизька Республіка
https://orcid.org/0009-0003-9597-3218

Азик Орозонова
Кандидат економічних наук, доцент
Киргизький національний університет ім. Жусупа Баласагина
720033, вул. Фрунзе, 547, м. Бішкек, Киргизька Республіка
Киргизький економічний університет ім. Муси Рискулбекова
720033, вул. Тоголок Молдо, 58, м. Бішкек, Киргизька Республіка
https://orcid.org/0000-0001-6877-7674

Типологія та архітектурні характеристики торговельних комплексів на історичних торговельних маршрутах: аналіз на прикладі караван-сараїв Великого Шовкового шляху

Анотація. Дослідження, присвячені типології та архітектурним особливостям торговельних комплексів, розташованих на історичних маршрутах, караван-сараїв Великого Шовкового шляху, залишаються актуальними в сучасному світі, оскільки ці структури не лише репрезентують історичну спадщину, а й володіють потенціалом для розуміння впливу торгівлі та культурного обміну на формування міського середовища. Мета дослідження полягає у виявленні типології та архітектурних особливостей торговельних комплексів, розташованих на історичних маршрутах, з поглибленим вивченням караван-сараїв Великого Шовкового шляху. Дослідження включає в себе застосування аналітичного підходу, методу класифікації, функціонального аналізу, статистичних методів, методу синтезу та інших методологічних підходів. У процесі дослідження було виявлено особливості та відмінності в типології та архітектурних характеристиках торговельних комплексів, розташованих на історичних маршрутах. Має важливе значення проведення аналізу змін на прикладі караванних торговельних шляхів, що простягалися через середньовічну Азію та Євразію, з метою оцінювання еволюції та ускладнення в ході їхнього розвитку. Розглянуто доцільність використання аналізу на прикладі караван-сараїв Великого Шовкового шляху, виявлено обмеження в ході процесу, проаналізовано вплив обмежень на результат. Виявлено, що під час архітектурних досліджень, які ґрунтуються на археологічних пошуках, була приділена увага розкопкам великих міських центрів, розташованих уздовж маршрутів. Практична значущість роботи полягає у застосуванні отриманих результатів для усунення помилок у покращенні типології та архітектурних характеристик торговельних комплексів на історичних маршрутах, також розглянуто надійність застосування аналізу на прикладі караван-сараїв Великого Шовкового шляху з урахуванням різноманітних чинників, що слугуватиме підґрунтям для надання рекомендацій щодо використання отриманих даних типології караван-сараїв

Ключові слова: археологічні дослідження; культурний обмін; аналіз міжкультурних взаємодій; рекомендації для розвитку та покращення; розкопки великих міських центрів

Architectural Studies
International Journal about Architecture

Volume 10, No. 1

UDC 72.01(091):725.1]:656.013(477.83-25)
DOI: 10.56318/as/1.2024.35

Yurii Dyba
Doctor of Architecture, Professor
Lviv Polytechnic National University
79013, 12 Stepan Bandera Str., Lviv, Ukraine
https://orcid.org/0000-0001-7783-2284

Youri Rotchniak*
Doctor of Architecture, Professor
Lviv Polytechnic National University
79013, 12 Stepan Bandera Str., Lviv, Ukraine
https://orcid.org/0000-0002-0344-7989

Evolution of the buildings layout of the Lviv Main Railway Station

Abstract. The architecture of railway stations is determined by social, economic, technical, military, historical, cultural, and other factors. Their actions occur constantly, but after certain periods, more radical changes take place through the reconstruction and development of the building substance of the stations. Understanding the value of historical structures must be consistent with the inevitable social and transport changes that occur everywhere and are reflected in the architecture of railway stations, in particular, through the planning structure. The purpose of the study was to identify the development of planning properties – based on horizontal projections of structures – of two historical buildings of the Lviv Main Railway Station in its further use. For this purpose, general scientific research methods were used in accordance with architectural studies. Based on archival materials, literature sources and field observations, it became possible to conduct the research and draw conclusions. Different levels of two buildings of the Lviv Railway Station were analysed and compared. Planning schemes, communication, and sequence of premises of these buildings, and their connections with the platform (tracks and landing platforms) and with the station forecourt were described. It was noted that already in the first building of the station, the features of functionalism were manifested as a concept of the primacy of processes in determining the layout and the whole construction shell of the structure; the second building continued this concept. Options for using an underground pedestrian connection between the platform of the existing second building of the Lviv Main Railway Station and the platform of the Suburban Railway, and their connection with the main street and one of the historical sites of Lviv separated by tracks, were considered. Underground pedestrian connections form a public space that has a large resource, including for temporary protection from air threats. These considerations are based on the evolution of historical railway stations in major European cities. The practical significance of the study was the established ways of further possible development of the architecture of the main railway station of Lviv in the historical concepts and schemes based on the directions and trajectories of pedestrians and transport

Keywords: railway; platform; station; tunnel; passenger

INTRODUCTION

The railway plays a huge role in passenger traffic. Its stations are a place of contact between the carrier and the public and the means of architecture in an urbanised space. There is a need to respond to user requests, technical and

Suggested Citation:
Dyba, Yu., & Rotchniak, Yo. (2024). Evolution of the buildings layout of the Lviv Main Railway Station. *Architectural Studies*, 10(1), 35-46. doi: 10.56318/as/1.2024.35.

Journal homepage: https://arch-studies.com.ua/en
Architectural Studies, 10(1), 35-46
Received: 26.02.2024 Revised: 02.05.2024 Accepted: 20.06.2024

*Corresponding author

technological innovations, social and artistic preferences, economic and political challenges, and the need to protect and care for the historical substance of existing historical railway stations. In Ukraine, the vast majority of railway stations are of historic origin, including the Lviv Main Railway Station. Achievements in architectural thought and construction activities require professional understanding and appropriate actions regarding the building of railway stations in the face of constant changes, which makes this study relevant.

The paper by M. Nazaruk & O. Misiura (2019) examined the spatial structure of railway station in Kovel, where, among other things, the multi-level layout of the building was analysed, which was based on characteristic features: symmetry, massiveness, wall division, etc. The paper by M. Nazaruk (2021) marked the architecture of Holoby and Kovel railway stations by architect O. Verbytskyi. It was noted that they contain similar planning schemes, where a large passenger hall and a waiting room acquire dominant importance in communication with other rooms, and influence on the overall structure layout. Given the two-level station building in Kovel, its planning is more complex, which to some extent brings it closer to the planning of the second building of the Lviv Main Station. These planning properties were typical of the new station buildings of major cities in the 1900s, allowing underground access to the platform.

Y. Rotchniak (2023) examined the layout of railway station buildings in Western Ukraine, noting changes in the design of railway stations from different historical periods of the country. At their core, they are closely related to the planning basics. A number of papers consider to the connection of railway station planning as part of railway station complexes with the urban planning context. In particular, I. Dreval (2019) investigated the actual problem of the existence of railway station complexes in Ukraine as important structural and functional elements of a modern city. Based on the analysis of world experience, significant features of the architectural and urban planning organisation of modern railway station complexes in functional, transport, compositional, economic, and ergonomic aspects are revealed.

V. Timokhin *et al*. (2023) noted that in the construction of underground spaces of transport and transfer hubs, efficient use of land resources is achieved to release the territories of pedestrian squares, delineation of transport and pedestrian flows, organisation of shortest routes to various types of transport and evacuation when used as a shelter, etc. Planning schemes of railway stations were discussed in the study by Y. Rotchniak (2021), where the researcher pointed to the connection and mutual subordination of these levels. Planning schemes, together with inter-level connections, form the general planning characteristics of railway stations, and are the basis of forming processes.

Philosophical and cultural foundations are provided in the monograph by R. Kellermann (2021), which deals with the phenomenon of "waiting" on the railways. The categories of "time", "waiting" and their feelings and experiences also unfold in railway station spaces. The historical development of railway station premises reflects the dynamics of these categories in the period 1830-1935. The acceleration of the processes of movement of modern times opens up a field of research, and in particular, this applies to the planning properties of station structures. Professional achievements are presented in publications about the most successful and well-known railway stations. In particular, J. Gympel (2020) demonstrated and commented on the most beautiful railway stations in Germany as a reflection of the architecture of different eras.

It is not only the architecture of the historic railway station buildings themselves that is important, but also their connection to the station squares and platforms. With the increase in the number and length of pedestrian connections of the station, it is moving to the level of urban planning studios. The aim of the study was to establish the features and patterns of changes in the planning of historical buildings of the Main Railway Station of Lviv and outline the directions of future development of its planning on functional, social and other grounds.

MATERIALS AND METHODS

The materials for the study were published scientific sources on the problems of research (articles, monographs), drawings and texts from the Central State Historical Archive in Lviv (Foundation No. 248); photo recording of the object of research, its analogues (own photos of the authors, postcards) and direct observations of real objects. The use of these sources has created a fairly broad basis for further study on this topic. The paper uses some of the general scientific research methods – empirical (observation, description) and theoretical (analysis, abstraction, generalisation, explanation), which were carried out in the field and desk conditions.

The analysis of historical data and observations was used to determine temporary changes in railway station buildings based on finding out the economic, political, military, and other background. The description of the elements and their connections allowed organising the system and concluded an understanding of the object under study. Comparison of drawings of building level plans and the territory of the railway station allowed tracing the emergence and development of functional and social concepts of the structure of station space. Communication with the urban planning environment has influenced and continues to affect the patterns of pedestrian and other transport movements (carriage, tram, car, bus, suburban lines) around railway station buildings. The comparison method made it possible to contrast drawings of railway station buildings and their urban planning and transport bases.

The use of a systematic approach identified the existence of functional connections of elements of the station building through a set of connections, abutments and penetration of architectural spaces (premises). At the same time, the model of social separation in relation to employees of the station (station), classes of passengers, and

customers was considered. This helped to establish schematic diagrams of combinations and delineation of these elements. They formed a stable structure, which was implemented by means of architecture and construction.

Direct observations of the latest objects, which are analogues (time, historical, geographical, typological) to those under study, confirm the assumption of the need to use extrapolation of pedestrian connections of the historical Lviv Main Railway Station with other public facilities in the urban planning background. The development of the station building and adjacent territories was considered in comparison with the analogues of planning railway stations in European cities.

Modelling of possible future pedestrian connections between the building and the platform of the Lviv Main Railway Station is performed graphically based on the latest photography of the area of the railway station in a fragment of the Western part of the city of Lviv. However, the established principal lines of ground and underground connections will require proofreading if other factors are involved and after additional research. It should be noted that railway stations are strategic objects, which implies certain restrictions in access to information about them. All data presented is based solely on available public sources and surveys based on the movement areas and places of permitted stay of citizens.

RESULTS AND DISCUSSION

Initially, the railway connection of Lviv was concluded in general directions to the West (Lviv-Przemysl-Kraków-Vienna, 1861), to the South-East (Lviv-Stanyslaviv-Chernivtsi-Suceava, 1866/1869) and to the East (Lviv-Krasne-Brody, 1869; Krasne-Ternopil-Pidvolochyska 1870/1871). In total, by 1910, the railway junction of Lviv was formed with nine directions of tracks along with branches. The railway station is located in the West of the city centre of Lviv, and in the Eastern part of the station there is a passage to Suburban railway (Hrankin *et al.*, 1996; Basarab, 2008).

The first building of the Lviv Railway Station of the Carl-Ludwig Bahn was constructed in 1860-1861 with the participation of the architect and railway manager Ludwik Wierzbicki (1834-1912), based on the motifs of a medieval castle and in the style of the then common round-arch architecture (Rundbogenstil) (Kotlobulatova, 2007). In 1860-1870, the same architectural design of typical buildings of different sizes created a single artistic image of the stations of a separate railway company from Lviv through Khodoriv, Halych, Stanyslaviv, Kolomyya, Chernivtsi to Suceava and to the cities of Roman and Botoşani in modern Romania (Hrankin *et al.*, 1996).

The layout of the first two-or four-storey building of the Lviv Railway Station is based on a longitudinal symmetrical ridge-shaped shape, 162.16 m long, which is based on a rectangular through corridor scheme with two service entrances at the ends. Communication with the landing platform for passengers existed through weakly defined transverse passages (entrance – on the left, exit – on the right), which simultaneously formed separate expressive symmetrical four-story blocks in the overall layout. The scheme of the main axes of movement along the corridors in the building body approached a complicated U-shape with a strong elongation of the horizontal link. In the layout of the departure lobby (entrance left, Southern wing), there is an attempt to add grandeur to the design of the main staircase along the entrance axis, and symmetrical double cash windows around the lobby. At the same time, the exit to the landing platform shifted from this axis, dividing into the movement of passengers themselves, and separately their luggage. There were also exits to the platform from other rooms. The arrival lobby (right, Northern wing) had a simple view of the passageway. With two entrances and exits to the station building, two symmetrical covered entrances for horse-drawn carriages were arranged in front of the risalits. The entrances had large terraces on the second floor, which generally gave the impression of a parade of this structure. On the upper floors of the station building there were office premises (Fig. 1-3).

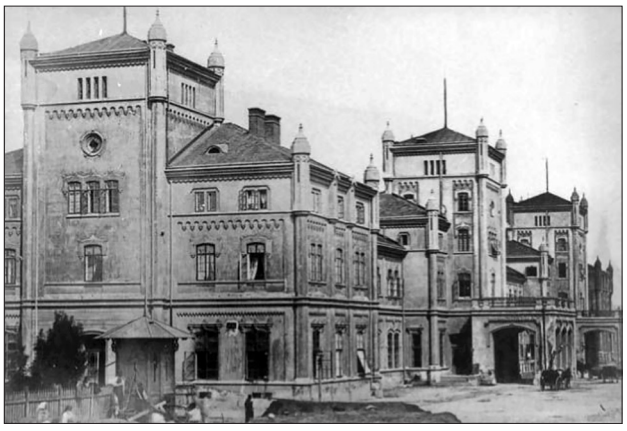


Figure 1. The first building of the Lviv Railway Station of the Carl-Ludwig Bahn
Source: J. Purchla (1997)

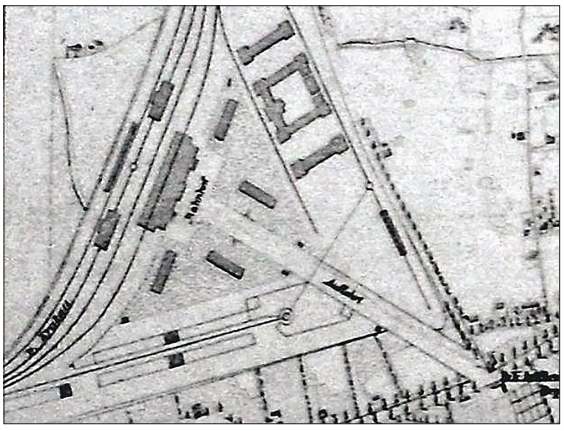


Figure 2. The first station of the Carl-Ludwig Bahn on the map of Lviv
Source: J. Purchla (1997)

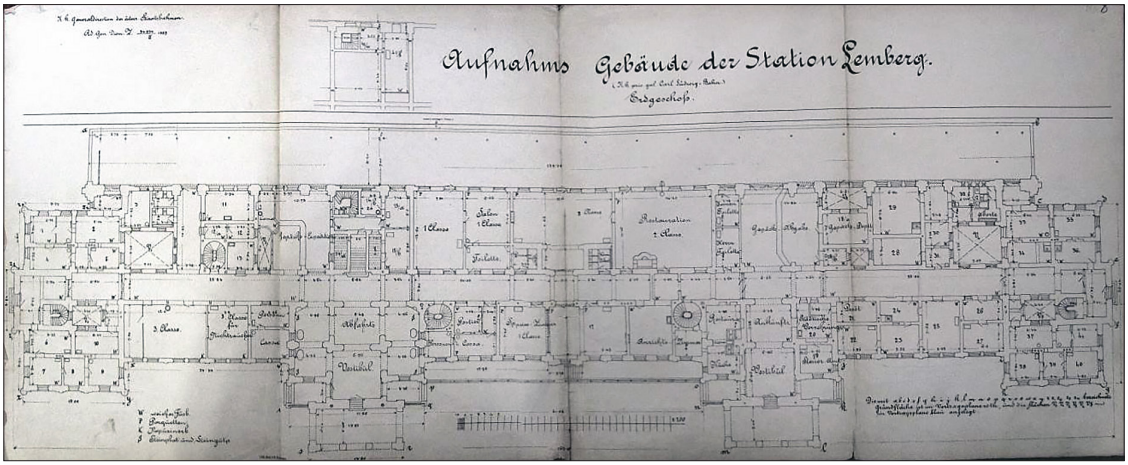


Figure 3. Plan of the entrance level of the first building of the Lviv Railway Station of the Carl-Ludwig Bahn
Source: Central State Historical Archive of Ukraine in Lviv (n.d.)

There was a regulation in the movement to and inside the station building, which was based on functional zoning of space and on the social division of passengers. In the project of the building, there was a list and interaction of the following components: 1) directions of movement to the platform and opposite to the station square (corridors); 2) distribution of movement of persons and their luggage separately (corridors); 3) division into passenger rooms and service rooms (halls, rooms); 4) division of passengers into 1st, 2nd, 3rd classes (ticket offices, waiting rooms, restaurants); 5) division into women's and men's rooms (toilets); 6) division into smokers and non-smokers (waiting rooms). The named users, processes, and spaces were ordered in a rectangular cell layout of the building and had logic in positioning, combination, and sequence. In its essence and in the layout of the first building of the Lviv Railway Station, the ideas of functionalism are manifested. These components fit into the regular layout scheme and into the forms of the usual round-arched manner of window and door openings with decorative elements of plastic facades of the era of historicism. The facade hides the processes and rooms enclosed inside.

The station building was connected to the first track through an adjacent (frontal) passenger platform with a length of 139.36 m. In fact, the platform was limited to three tracks and this landing platform with a sloping roof covering within the building. Such contact with trains, the layout of the station building met the needs in 1860-1890. The second building of the Lviv Railway Station (later – the Lviv Main Railway Station) was built in 1901-1904 in a palace character according to the project of Władysław Sadłowski (1869-1940) and other architects, artists and entrepreneurs (Biriulov *et al.*, 2008; Kubinszki, 2009).

On the site of the dismantled previous building, a new one was built (159 m×29.75 m), with central and two side symmetrical risalit blocks with domed finishes in artistic techniques of historicism and early art nouveau. The platform with a length of 218.45 m on 8 tracks with 4 passenger and 4 luggage platforms is raised to the level of the second floor of the building and covered with two arched floors with cylindrical metal-glass coverings of the platform (landing stage) with a width of 2×33.5 m (Fig. 4, 5). Since the end of the 19th century, the station area received two tram terminals along its edges on both sides of Chernivetska Street, the axis of which rests almost perpendicularly to the plane of the main facade at the entrance of the central risalit of the station building.

Figure 4. The second building of the Lviv Main Railway Station
Source: J. Purchla (1997)

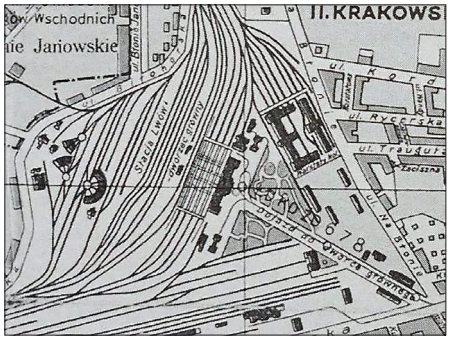


Figure 5. Main Railway Station on the map of Lviv, 1925
Source: J. Purchla (1997)

In the layout of the station building, the longitudinal shape of the initially one- or three-storey building along the tracks is based on a rectangular scheme with three front entrances on the main facade and additional service entrances at the ends of the building (Fig. 6, 7). The left (Southern) front entrance, as well as a whole two-story risalit block with an internal grand staircase, was intended for receiving and staying "for the Highest" ("für die Allerhöchsten"). Outside, not far from the building, an elevator was designed from the level of the square to the level of the first passenger platform. The main entrance is exactly along the axis of symmetry of the entire building through the lobby and a spacious cash register and continued with a direct tunnel for sending luggage (as of 2024, it is not valid). Passengers of 1st and 2nd classes moved through another tunnel despite 5 ticket windows on the left in the hall, and passengers of 3rd class – through a tunnel despite 5 ticket windows on the right. The right (North) front entrance to the building was located to the left of the extreme risalit block and continued through the lobby with two more tunnels: a tunnel for receiving incoming luggage (as of 2024, not valid) and a separate passenger tunnel. The right risalit block, unlike the other two risalit blocks, did not have a direct frontal entrance to itself. In this block, the premises of the railway, postal, medical, police and tax services were located on two floors in the corridor-enfilade planning scheme. The third level of two side risalit blocks contained service housing.

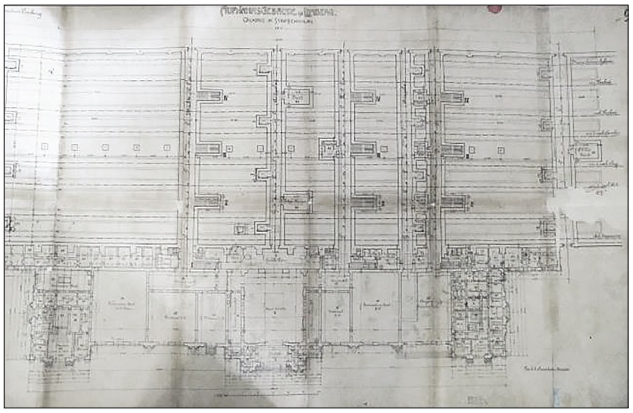


Figure 6. Fragment of the plan of the first (entrance) level of the main hall of the Lviv Railway Station
Source: Central State Historical Archive of Ukraine in Lviv (n.d.)

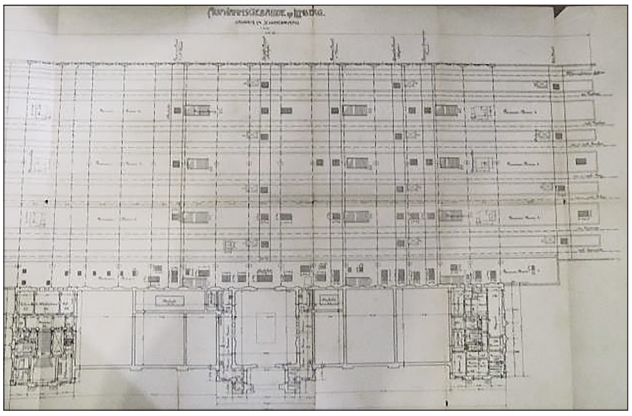


Figure 7. Fragment of the plan of the second (track) level of the main hall of the Lviv Railway Station
Source: Central State Historical Archive of Ukraine in Lviv (n.d.)

Thus, five tunnels from the level of the suburban area were connected through the building with a high platform, and two more tunnels outside the building had a direct connection between the square and the platform: the postal tunnel on the right and the Eilgut-Tunnel on the left. All of them were through, connecting from the East the station forecourt, the station building with the rest of the railway station in the West direction. It is noteworthy that all passenger landing platforms were connected to tunnels by stairs, and all baggage platforms were connected by elevators to baggage (service) platforms located through one of the passenger platforms. Consequently, there were no intersections of passenger and baggage lanes on the platform.

Regulation of processes and movements in the building and on the platform according to the project was coordinated with the movement of trains in their directions. The first track was intended for departure to Chernivtsi, the second – for the arrival of trains from Chernivtsi, the third – departure/arrival to/from Bełżec (Rava-Ruska direction), the fourth – departure/arrival to/from Stryi, the fifth – departure/arrival to/from Sambir, the sixth – to Kraków, the seventh – from Kraków, the eighth was a shunting track. It should be assumed that the composition of trains would have to be coordinated with the placement of train carriage classes with exits to the platforms to the tunnels of the respective classes.

In the second building of the station, the role of the platform has significantly increased – due to the separation of the platform and sub-track crossings in two levels of construction, a comprehensive approach has been implemented in the preparation, boarding/disembarking, loading/unloading of baggage and mail of passenger trains (Hofer *et al.*, 2010). This is more efficient than the first building and is well expressed in planning. The planning unit "room"/"hall", which was dominant in the first station building, is significantly supplemented by another planning unit – "passage"/"tunnel". The size of passenger rooms has significantly increased, service rooms have been moved to the upper levels; spatial ordering has increased. The ideas of a functional approach continue to develop, and in social terms, the "highest" category of passengers is added – In fact, there are four classes of passengers. At the same time, as in the previous building, there is no strict division according to the direction of passenger movement in the tunnels; functional and social regulation is preserved and expanded.

The Main Railway Station of Lviv, which was one of the most advanced in its time, was destroyed during the First World War, the Polish-Ukrainian War of 1918-1919, and the Second World War. It was rebuilt until 1930 and 1957, and the last restoration took place in 2003. The station has retained its original qualities and features, and the second floor has grown between the risalits, and the most remote fifth passenger platform has appeared under the cover of the platform (landing stage). Modern platforms are extended to about 600 m, from the first platform an external staircase is laid symmetrically on the sides of the building to the station forecourt. The main transport lines and passenger service functions laid down in the second building have been simplified at the same time. Three tunnels are used for passenger movement without dividing them into classes and directions of movement (Fig. 8, 9).

Figure 8. General view of the Lviv Main Railway Station, 2011
Source: M. Striltsiv (2011)

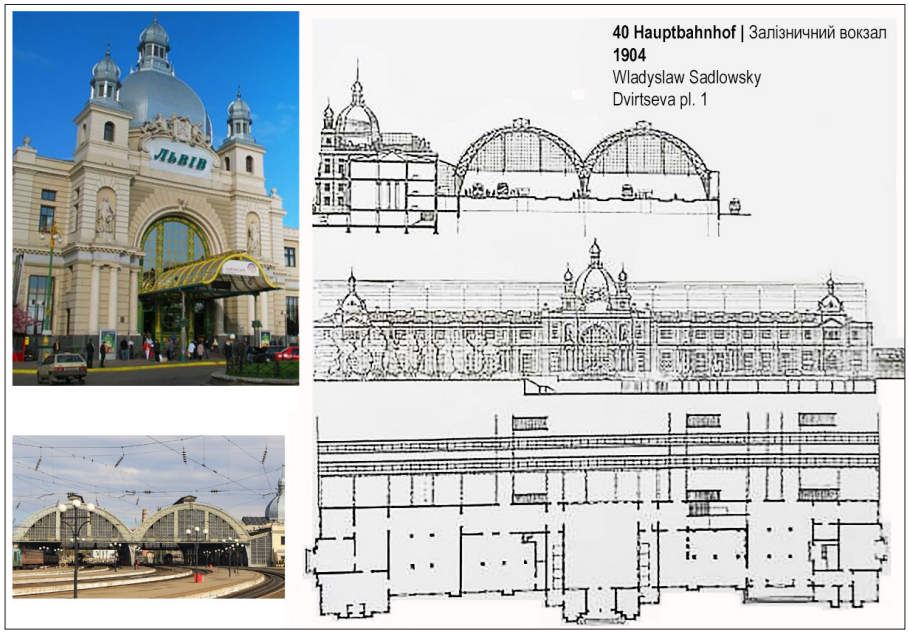


Figure 9. Modern view of the central risalit block and platform;
section, facade, and plan of the first (entrance) level of the Lviv Main Railway Station
Source: A. Hofer *et al*. (2010)

However, since the Soviet era, the division into ticket offices, information field and passenger zones of the station has been preserved in accordance with the so-called "passenger" and so-called "suburban" trains, which is a kind of radical division into types of passengers of conditionally long-distance and short-distance connections. In

addition, these "passenger ticket offices" in the main hall are also divided among themselves according to the time of purchase of tickets (daily departure ticket offices, presale ticket offices), into categories of passengers (general, preferential, service), ticket offices for domestic and foreign communication, refund ticket offices, etc. In the main passenger hall, information is distributed only about "passenger" trains, and in the hall of "suburban" ticket offices – only about "suburban" trains. Suburban ticket offices with their own information boards are located separately in the hall behind the entrance in the right (Northern) part of the building. The operation of paid and free waiting rooms confirms the hidden "class" approach. Such separation and organisation of ticket offices and premises makes it difficult for customers to navigate, forces them to stay at the train station for a longer time, slows down service, and, in general, does not contribute to facilitating travel, democratisation, or security.

From the above material, it is clear that nothing remains of the first building of the Main Railway Station of Lviv (the station of the former Galician Railway of Archduke Carl Ludwig). From its initial planning ideas, the ideas of directed and regulated communications and processes for passengers and staff in the building and in the entrance/access to/from the station forecourt developed. These ideas are more noticeable in the second existing building of the Lviv Main Railway Station (on the site of the old one) in the connection from the station forecourt through the new building to a completely new and large platform. The second building, together with the platform, is still functioning well in 2024, and has a great architectural and urban planning potential that needs to be developed. Pedestrian connectivity along the line "station square – station building – platform" is most commonly evolving by shortening distances and times between connecting nodes (transfer points, modal shift points, vertical connections, customer and service contact points), increasing the number and widening the number of lanes and aligning the directions of movement. In planning terms, this is expressed by communication through underground tunnels and passages. This is one of the ways of evolution of railway stations, which is the subject of the study by M. von Gerkan (1996) and S. Parissien (1997).

A good example of the development of the layout of the sub-track level of communication, vertical communications and passenger and service facilities is the reconstructed Salzburg Hbf in Austria. The passenger building of this station dates back to 1860 (F.R. Bayer, O. Thinemann). The development and semi-cylindrical metal-glass covering of the platform took place in 1906-1909. The last reconstruction with the extension of the platform to a length of about 500 m with the restored old and extended new covers, and with the sub-track space, was completed in 2014 (arch. K. Kada) (Fig. 10, 11).

Figure 10. Building of Salzburg Main Railway Station, 2018
Source: photo by Yo. Rotchniak

Figure 11. Sub-track passage from the lobby of the main hall of Salzburg Main Railway Station, 2015
Source: photo by Yo. Rotchniak

There was a cross-section connection of the Elisabeth-Vorstadt through a sub-track passage up to 200 m long and up to 20 m wide from the Station Square from the Northwest through the station building to the Southeast in the section of Schallmoos towards the city centre. This simplifies pedestrian traffic between two parts of the city that are separated by tracks. The platforms are connected to the passage by stairs, escalators and elevators, which significantly improves communication, service and creates a new construction of the space and a different aesthetic (Fig. 12, 13).

Figure 12. Platform with restored and expanded cover, sub-track passage of Salzburg Main Railway Station, 2015
Source: photo by Yo. Rotchniak

Figure 12. General view of the Salzburg Main Railway Station
Source: Central station... (2013)

Sub-track pedestrian communications are widely used in the reconstruction of historical railway stations and the construction of new ones. A pass-through pedestrian connection under the tracks has been introduced at Vienna Main Station. Long underground passages connect the continuous pedestrian strip of the South Tyrolean square (Südtiroler Platz) with the metro station (U1) and the Rapid City Railway Line (S-Bahn) with the new Vienna Main Railway Station building almost on the site of the demolished Vienna South Station (Fig. 14, 15).

Figure 14. Two levels of the entrance to the Vienna Main Railway Station, 2015
Source: photo by Yo. Rotchniak

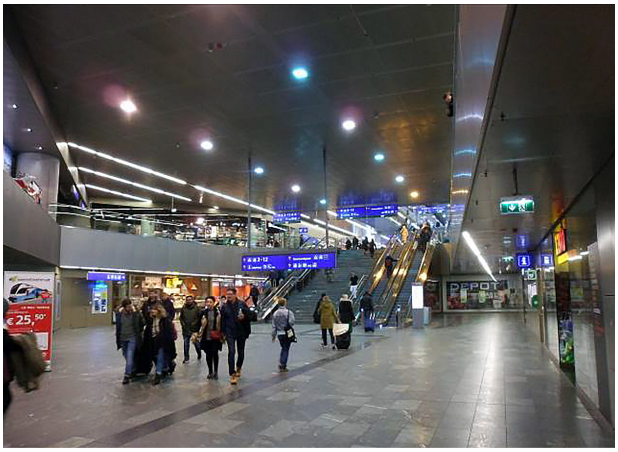


Figure 15. Crossings at the Vienna Main Railway Station, 2020
Source: photo by Yo. Rotchniak

A multi-level organisation of spaces exists at the renovated main railway stations in Berlin (Reuter, 2007; Preuß, 2007), Graz, Katowice, Kraków, and other cities. The extensive development of underground platforms, tunnels, and vertical connections is being carried out in coordination with the construction of new passenger rail and other track connections (metro, urban railways), which further transforms the station into an important urban planning factor. Such an example is the ongoing and controversial construction of Stuttgart's Main Railway Station (Roser, 2008; Preuß, 2010). The Munich Main Railway Station building (built in 1960) has been completely demolished as of 2024, and a completely new one will be created in its place while maintaining and expanding access to it (not implemented in 2024). Over time, train stations turn into "temples of consumers", which continue to develop. They become iconic objects, as reflected in the paer by J. Gympel (2020) on the example of 40 railway stations in Germany.

The key idea of modern railway stations in highly developed countries is fast and safe boarding/disembarking to/from the train in connection with the settlement. This idea is implemented through the possibility of approaching the station from different sides of the city, the presence of many entrances/exits to/from the station and several lanes of passenger movement, and shortening the time spent on the way and on the platform, etc. Due to various methods of purchasing travel documents – through ticket offices, ticket machines in different places of public space and outside the railway station, the possibility of paying in cars or remotely in advance via electronic network means – the time before the trip is shortened. This significantly reduces the need to equip a large number of ticket offices and spaces for long waiting periods. Unified visual and audio information at train stations, when approaching them, in other public spaces and in the media sphere accelerates orientation and promotes quick selection. In addition, the simplicity and clarity of repeated messages work together with the client's determination – to get to their car or back – to the right place in the settlement, leaving the car and station. Due to a sufficient number of trains and regular traffic, there is no need for a long wait, as it was a long time ago. Mail and baggage cars as part of passenger trains have been reduced or practically disappeared, which, in turn, simplifies and frees up the flow of correspondence, cargo and loading/unloading places. The service is being introduced in road trains – primarily in large cities with mainline connections. For this purpose, special car trips to railway stations are arranged, if possible, near railway stations. At the client's choice, there is still the possibility of a longer stay at railway stations with extended Information, various assistance, trade, service, respite, entertainment, etc. (halls, rooms, passages, other spaces). Such processes pass into the rank of additional relative to purely primary transport, and become the basis for the development of railway and station complexes. This is thoroughly investigated by I. Dreval (2019).

A large number of sub-track tunnels in the Lviv Main Railway Station have the potential for fast and convenient movement. It seems appropriate to update two long-standing baggage tunnels for the needs of passenger traffic. The same applies to two other side tunnels outside the station. Notably, with the current increased length of boarding platforms, it seems unfair that there are no scattered underpasses – the end cars of long trains are far removed from the existing exits and tunnels. The installation of an additional one on each side of the edges of the platform cover (with stairs, escalators and elevators to each platform), in addition to speeding up communication, would also increase the level of overall security at the station. Passenger (reception) buildings and platforms (tracks with platforms), which are connected by underground tunnels, play an important role in protecting against airborne hazards, similar to underground metro stations. Dispersing people, regulating, directing their flows, and creating opportunities for informing, staying, and monitoring – these and other processes should be considered when optimising station planning.

In the context of Lviv's urban development, it is possible to envisage a pedestrian connection through the tunnel from the station square from the North under the platform of the Main Railway Station to the Northwest of the tracks to Estonska Street in the Levandivka urban district, considering the needs of the rest of the railway station. Another area of the underground pedestrian tunnel-passage could run from the platform of the main station to the South, connecting the underground and the platform of the Suburban (former Chernivtsi) station and Horodotska Street. Thus, the platforms of the two railway stations would be connected underground. In these two tunnels, passengers could get to the desired platform by the shortest route, bypassing the station buildings, and also have the closest connection to tram and bus services along Horodotska Street with a number of trade and service facilities (Skrynya shopping centre, station market, etc.). More radical would be an underground car passage near the building and under the platform of the main station, close to the axis of Chernivetska and Shyroka Streets, connecting Horodotska Street and Levandivka. The possibility of arranging such passages and driveways will require more in-depth research and substantiation (Fig. 16).

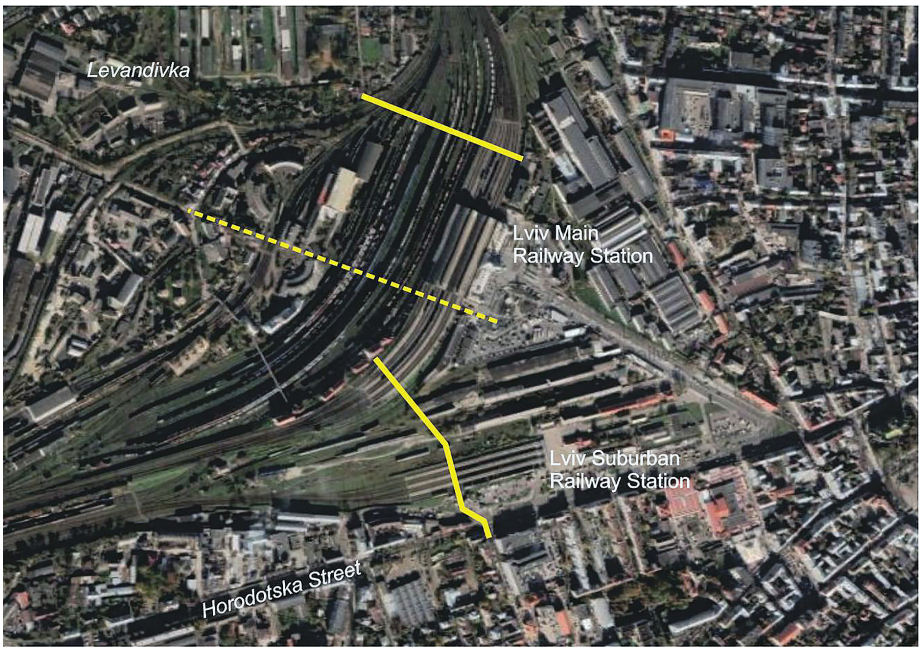


Figure 16. The proposed tunnels connecting the platforms of the Main and Urban Railway Stations in Lviv between Horodotska Street (South) and Levandivka (North-West)
Notes: upper line – from the Station Square to Estonska Street; lower polyline – from the station, the platform of the Main Station to Horodotska Street; dashed line – from Chernivetska and Horodotska Streets to Levandivka
Source: compiled by the authors based on the Google imagery

The development of new railway stations is largely based on the organisation of travel and stay spaces, based on existing planning properties in the urban context and the buildings themselves. At the same time, the historical construction substance is integrated into broader architectural ideas, losing its original significance in some places.

CONCLUSIONS

The evolution of the layout of buildings of the Lviv Main Railway Station took place by replacing the dominant corridor-cell scheme in the first building with a mixed corridor, hall, and enfilade scheme of the second station building. In the second building, movements and processes were regulated when the platform was raised to the second level of the building with eight tracks, four boarding, and four luggage platforms. Seven tunnels connected the platform to the building and the station forecourt using stairs for passengers and elevators for luggage. The station platform has acquired a separate method of planning in comparison with the platform of the first station building. This was a new phenomenon in the architecture of railway stations at the end of the 19th-beginning of the 20th century, revealing the ideas of functionalism.

In the second building of the Lviv Main Railway Station, the lines of train traffic and the lines of movement of pedestrians-passengers, their luggage are divided in two levels, which in a horizontal projection forms a rectangular grid of these lines. On the platform, at the intersections of the movement axes, nodes appear that correspond to the location points in the horizontal projection of stairs and elevators. Such a scheme of arrangement of movement lines goes beyond the station building and is the basis for the organisation of platforms of large railway stations of the 20th century.

The symmetrical composition of the facades of the first and second buildings of the Lviv Main Railway Station partially corresponds to the internal layout; approximate lines of passenger movement in buildings with the axes of entrances in risalit blocks. In general, the exterior of buildings is an artistic framework beyond which the functional and social diversity of the interior space does not extend. The order and style of the facades form an independent and expressive composition, which generally corresponds to the then general ideas about the architecture of public buildings.

The planning scheme of the existing Lviv Main Railway Station is naturally developed by expanding the horizontal grid of movement axes: the addition of former baggage tunnels for pedestrians, the construction of new tunnels symmetrically and remotely from the existing platform covers, the installation of elevators, escalators to each platform. The existing pedestrian connections between the station and the city should be considered. The evolution of the layout of the historical station building goes beyond the building and concerns primarily the arrangement of station forecourts, platforms, and connections between them. Such an underground pedestrian "expansion" is familiar to the newest and adapted historical railway stations.

The proposed underground pedestrian passages-tunnels are an alternative to the "usual" underground pedestrian lanes and connect the main station platform, the suburban station platform and Horodotska Street, and the Levandivka urban district. In addition to the convenience of comprehension and the absence of intersections with other modes of transport, underground spaces are formed for staying and protecting against air hazards. These crosswalks can partially serve as shopping passages, which contributes to comfort. Pedestrian passageways-tunnels become an integral part of the latest railway stations, have a significant length and take over part of the maintenance and maintenance processes before and after the trip.

The construction of pedestrian underground passages and spaces near the building of the Lviv Main Railway Station is seen as one of the possible ways to develop the latest architecture, urban planning relations with the preservation of the spirit of this place. This approach looks more humane, more sensitive to the environment and more expedient in comparison with the ideas of a large-scale construction of the "new international railway station" in Lviv next to the existing main one, or a "transport hub" at Sknyliv station in a remote area from the station under study.

Understanding the history and actual state of architecture of the Lviv Main Railway Station and its planning opens the way for research of other similar stations. The twin goals of conservation and development are the guiding principles.

ACKNOWLEDGEMENTS

The authors are grateful to the staff of the Central State Historical Archives of Ukraine in Lviv, and in particular to its director, Ms O. Stefanyk, for her friendly support in working with archival materials. The authors also express their gratitude for the opportunity to discuss the architecture of railway stations with Prof. Dr. Habil. E. Lehner and for the communication with Prof. Dr. Habil. C. Jäger-Klein from the Technical University of Vienna. In addition, the opportunity to access information in the libraries of the TU Vienna and to collect field information on the architecture of railway stations in Austria and other countries with the support of the Austrian Academic Exchange Service (OEAD) was used.

CONFLICT OF INTEREST

None.

REFERENCES

[1] Basarab, A. (2008). Railway transport. In A. Kozytskyi (Ed.), *Encyclopedia of Lviv* (pp. 372-380). Lviv: Litopys.
[2] Biriulov, Yu., Cherkes, B., Bevz, M., & Rudnytskyi, A. (2008). *Architecture of Lviv. Time and styles. 13th-21st centuries*. Lviv: Centre of Europe.
[3] Central State Historical Archive of Ukraine in Lviv. (n.d.). *Main Building, Débarcadère, Details. Lviv. Fund No. 248, Description No. 2, Case No. 2688, Case No. 2690*. Retrieved from https://tsdial.archives.gov.ua/.
[4] Central station: Salzburg becomes a hub for the Austrian train timetable. (2013). Retrieved from https://www.salzburg24.at/news/salzburg/stadt/hauptbahnhof-salzburg-wird-zum-taktknoten-fuer-den-oesterreichischen-zugfahrplan-43975495.
[5] Dreval, I. (2019). Featers of architectural and town-planning forming of railway stations complexes. *SWorldJournal*, 2(2), 86-92.
[6] Gympel, J. (2020). *The most beautiful railway stations in Germany*. Berlin: Eisengold.
[7] Hofer, A., Leitner, E., & Cherkes, B. (2010). *Lviv. A guide to the city and architecture*. Leobersdorf: Digitaldruck.
[8] Hrankin, P., Lazechko, P., Siomochkin, I., & Shramko, H. (1996). *Lviv railroad. History and modernity*. Lviv: Centre of Europe.
[9] Kellermann, R. (2021). *In the interstice of accelerated modernity: A construction and cultural history of waiting for railways, 1830-1935*. Bielefeld: transcript Verlag. doi: 10.1515/9783839455890.
[10] Kotlobulatova, I. (2008). Railway stations. In A. Kozytskyi (Ed.), *Encyclopedia of Lviv* (pp. 380-383). Lviv: Litopys.
[11] Kubinszki, M. (2009). *Railway stations in Old Austria*. Wien: Verlag Slezak KEG.
[12] Nazaruk, M. (2021). Architecture of the railway stations Holoby and Kovel in the work of O.M. Verbytskyi. *Current Problems of Architecture and Urban Planning*, 59, 80-88. doi: 10.32347/2077-3455.2021.59.80-88.

[13] Nazaruk, M., & Misiura, O. (2019). Architecture of the railway station in Kovel. *Student Bulletin of the National University of Water Management and Nature Management*, 1(11), 6-8.
[14] Parissien, S. (1997). *Railway stations of the world: A history of architecture and art*. München: Knesebeck.
[15] Preuß, E. (2007). *Berlin central station.* Stuttgart: Trans Press Verlag.
[16] Preuß, E. (2010). *100 legendary railway stations*. Stuttgart: Trans Press Verlag.
[17] Purchla, J. (1997). *Architecture of Lviv of the 19th century*. Krakow: Wydawnictwo Antykwa.
[18] Reuter, O. (2007). *Berlin central station 1994-2006. Lehrter station.* Berlin: Luftbildverlag.
[19] Roser, M. (2008). *Stuttgart central station.* Stuttgart: Schmetterlig Verlag.
[20] Rotchniak, Y. (2021). *Theoretical bases of formation of railway stations architecture*. (Doctoral dissertation, Lviv Polytechnic National University, Lviv, Ukraine).
[21] Rotchniak, Y. (2023). Architecture of railway station buildings of the railway Ivano-Frankivsk-Voronenka. *Urban Development and Spatial Planning*, 84, 294-308. doi: 10.32347/2076-815x.2023.84.294-308.
[22] Striltsiv, M. (2011). *Railway station, XX Century*. Lviv: Aerial Photography of the LUFA Agency.
[23] Timokhin, V., Harbar, M., & Shchurova, V. (2023). Conceptuality and rationality in underground spaces transport interchange hub organization. *Current Problems of Architecture and Urban Planning*, 67, 382-393. doi: 10.32347/2077-3455.2023.67.382-393.
[24] Von Gerkan, M. (1996). Renaissance of railway stations as the nucleus of urban development. In *Renaissance of the railway stations* (pp. 17-63). Berlin: Vieweg+Teubner Verlag. doi: 10.1007/978-3-322-85042-3_2.

Юрій Диба

Доктор архітектури, професор
Національний університет «Львівська політехніка»
79013, вул. Степана Бандери, 12, м. Львів, Україна
https://orcid.org/0000-0001-7783-2284

Юрій Рочняк

Доктор архітектури, професор
Національний університет «Львівська політехніка»
79013, вул. Степана Бандери, 12, м. Львів, Україна
https://orcid.org/0000-0002-0344-7989

Еволюція розпланування будівель головного залізничного вокзалу Львова

Анотація. Архітектуру залізничних вокзалів визначають суспільні, економічні, технічні, військові, історичні, культурні та інші чинники. Їхні дії відбуваються постійно, але через певні періоди стаються більш радикальні зміни шляхом перебудов і розбудов будівельної субстанції вокзалів. Розуміння цінності історичних споруд повинно узгоджуватись із неминучими соціальними і транспортними змінами, що відбуваються повсюдно та відображаються в архітектурі вокзалів, зокрема через планувальну структуру. Метою дослідження було виявити розвиток розпланувальних властивостей – на базі горизонтальних проєкцій споруд – двох історичних будівель Головного залізничного вокзалу Львова у подальшому його використанні. Для цього застосовувалися загальнонаукові методи дослідження та використання їх у відповідності до архітектурних студій. На основі архівних матеріалів, літературних джерел та польових спостережень уможливилось проведення власного дослідження та отримання висновків. Було проаналізовано різні рівні двох будівель залізничного вокзалу Львова та проведено їхнє порівняння. Описано розпланувальні схеми, сполучення і послідовність приміщень цих будівель, а також їхні зв'язки з пероном (коліями та посадковими платформами) і з привокзальною площею. Зазначено, що вже у першій будівлі вокзалу проявляються риси функціоналізму як концепції первинності процесів у визначенні розпланування та цілої будівельної оболонки споруди; друга будівля продовжує цю концепцію. Було розглянуто варіанти застосування підземного пішохідного сполучення перону існуючої другої будівлі Головного залізничного вокзалу Львова з пероном Приміського вокзалу Львова, а також сполучення їх з магістральною вулицею та відділеною коліями однієї з історичних дільниць Львова. Підземні пішохідні сполучення утворюють громадський простір, що має великий ресурс, у тому числі й для тимчасового захисту від повітряних загроз. Ці міркування опираються на еволюцію історичних вокзалів залізничних станцій великих міст Європи. Практичною цінністю роботи є встановлені шляхи подальшого можливого розвитку архітектури Головного залізничного вокзалу Львова у закладених історичних концепціях та схемах на базі напрямків і траєкторій руху пішоходів і транспорту

Ключові слова: залізниця; платформа; перон; тунель; пасажир

Architectural Studies
International Journal about Architecture

Volume 10, No. 1

UDC 711:338.2
DOI: 10.56318/as/1.2024.47

Sabina Bollano
PhD in Social Sciences and Behaviour, Lecturer
European University of Tirana
1000, Xhanfize Keko Str., Tirana, Albania
https://orcid.org/0000-0003-0201-8442

The study of "Cities of the Future" urban planning and development decision-making experience

Abstract. Given the rapid technological and global development, "Cities of the Future" are becoming important centres of innovation, where cultural, economic, and technological influences intertwine. The research relevance of such studies is determined by the impact of innovations on the development of the urban environment, which contribute to sustainable development and improve the quality of life of residents. The study aims to analyse planning practices and urban development solutions in "Cities of the Future" in Albania, focusing on the interaction of social, economic, and environmental aspects. The following methods were used: generalisation, induction and deduction, analysis, and synthesis. The study examined data on urbanisation in Albania, the gross domestic product of the country and in the cities of Tirana, Diber, Durres, Vlora and Korca per capita, as well as the main aspects of planning and economic sustainability in general. The study of the architectural and infrastructural development of Albanian cities revealed key trends and innovations, including the implementation of modern residential complexes, interactive applications, the use of energy-efficient technologies, the restoration of historical sites and the creation of eco-parks. This demonstrates the importance of balanced development that incorporates both modern technologies and the preservation of cultural heritage. Stable economic conditions point to opportunities for sustainable development and investment in cities. The positive trend in gross domestic product creates favourable conditions for attracting new businesses, technological innovations, and the development of sustainable lifestyles. In addition, the analysis of innovations in transport, aesthetic approaches and economic sustainability of Albanian cities determines the prospects for their global competitiveness. The results of the study can be useful for the development and planning of future urban development in Albania, as well as used as a basis for decision-making in the fields of economics, technology, and urbanisation

Keywords: infrastructure; energy-efficient technologies; restoration; eco-parks; innovations; smart systems

INTRODUCTION

In the context of rapid technological and global development, cities in today's world act as laboratories of innovation, combining the influence of culture, economics, and technology. Growing pressure on urban resources and rapid population growth makes it necessary to consider new strategies for planning and developing urban spaces to ensure the sustainability and efficiency of future megacities. Insufficient exploration of new urban design strategies threatens inefficient resource management, environmental problems, and socio-economic imbalances, which can threaten sustainable development and quality of life in cities.

The rapid pace of urbanisation requires rethinking approaches to urban planning. "Cities of the Future" focuses on the harmonisation of technological advances, environ-

Suggested Citation:
Bollano, S. (2024). The study of "Cities of the Future" urban planning and development decision-making experience. *Architectural Studies*, 10(1), 47-57. doi: 10.56318/as/1.2024.47.

Journal homepage: https://arch-studies.com.ua/en#
Architectural Studies, 10(1), 47-57
Received: 28.01.2024 Revised: 06.05.2024 Accepted: 20.06.2024

*Corresponding author

mental sustainability, and human well-being. In this context, much attention is paid to cities that integrate the latest technologies, sustainable development, and improved quality of life (Săraru, 2023). M. Kaššaj & T. Peráček (2024) note that smart cities use advanced technologies to improve infrastructure efficiency. Intelligent transport systems and energy-efficient buildings, as well as data from waste management collection and analysis systems and the introduction of smart technologies, simplify urban operations and improve the overall quality of life. In the context of rapid technological and social development, cities should be prepared for changes and challenges, such as climate change, population growth, technological innovation and global economic shifts (Myalkovsky *et al.*, 2023). It is especially important to study the interaction between urban development and urban tourism, as tourism can be an important factor for economic development.

A. Afezolli (2022) emphasises that from 2000s, Albania has been marked by the most dynamic economic, urban, and industrial transformation in its history. The growing economic opportunities of cities are driving large-scale migration from rural areas to large centres. In the past, Albania's transport system consisted of bicycles, mass transit and walking, but the current trend towards more private cars and sparse development is rapidly turning Albanian society into a car-dependent one. In a growing economy, the improving quality of life, increasing housing space and car dependency are creating serious environmental, public health and safety issues.

E. Aliaj & E. Tiri (2023) note that Albania, being at the crossroads of cultural and historical influences, is becoming an interesting object for architectural research on the planning and development of urban areas. The country's history of transformation and change, as well as its geographical location, make it a unique context for studying and applying innovative approaches to urban development. In addition, the studies of Albanian scholars, in particular A. Hysa *et al*. (2021), highlight the importance of Albania's unique cultural and historical heritage, which poses several challenges and opportunities for the country in the field of urban development. The emphasis is placed on the fact that the integration of innovative technologies and global approaches can help ensure the sustainability and competitiveness of Albanian cities in the modern world. The results also highlight the need for a balanced development that considers the quality of life of citizens, environmental issues, and the need for economic growth.

Albania, with its unique natural and cultural diversity, is facing challenges from intensive urbanisation and infrastructure projects. For instance, according to A. Hysa *et al*. (2021), the turbulent development of Tirana, the capital of Albania, after the post-socialist era, is generating discussions about preserving the city's identity, as disproportionate development causes a hybrid identity. Despite the municipality's attempts to clean up the mess, the new master plan is questionable due to insufficient consideration of the historical heritage and the living city. It is important to improve the development strategies, considering the adaptability of the city and preserving its unique identity, as well as considering the participation of citizens in the decision-making process. Despite the existing potential, there are gaps in research on urban planning and development in Albania. This aspect requires attention to the identification of key challenges facing the country's cities, such as environmental issues, infrastructure development and social inclusion. Therefore, it is important to focus on filling these gaps and to propose concrete strategies that can contribute to the development of future urban spaces in Albania, combining innovation and cultural heritage preservation.

The study aimed to examine the experience of planning and urban development solutions in the "Cities of the Future" in the context of Albania, considering social, economic, and environmental development. The current state of urban spaces is analysed, and the problems and opportunities facing Albanian cities are identified. The objectives of the study encompass analysing the current state of cities to evaluate their social and economic development and their role in the national economy, examining innovative urban planning solutions to promote sustainable development and enhance residents' quality of life, and assessing the environmental sustainability of urban areas by analysing natural resource utilization and conducting impact assessments.

MATERIALS AND METHODS

The theoretical segment of the study includes works by researchers in the field of "Cities of the Future" and Smart Cities planning. In addition, the sustainable development goals, and statistics of Ministry of Tourism and Environment of Republic of Albania (2019), the World Bank in Albania (2023), and the United Nations (2024), as well as monographic and periodical literature was used as an information component of the study.

A set of general scientific groups of methods was used in the study. In particular, the systematisation and generalisation methods were used to structure information on urban transformation projects in different cities of Albania. The induction method was used to move from specific examples of urban development to the formulation of general principles, and the deduction method was used to derive recommendations for individual cities. Grouping was used to combine related data into logical categories to facilitate understanding and analysis. This included grouping projects into thematic areas such as innovative technologies and environmental sustainability. A thorough analysis of the collected information was used to formulate conclusions and recommendations for further urban development and the impact of urban planning decisions on environmental sustainability. Statistical methods were used to quantify and analyse the data, in particular, to assess the effectiveness of the implemented projects using development indicators. The synthesis method was used to combine individual components and knowledge into a single whole, to create a holistic picture of urban development in

the context of "Cities of the Future". Comparative analysis was used to identify differences and similarities between different cities in Albania.

To analyse the development of cities in Albania, study the impact of urban strategies on the quality of life, and social integration, assess the impact of urban development on the country's economic potential, and evaluate environmental pollution in cities, the economic, environmental and social situation was studied using data from the Institute of Statistics of Albania (n.d.) and the Ministry of Urban Development (n.d.). In addition, the following indicators were analysed: Albania's urbanisation data, population, and gross domestic product (GDP) per capita in the following cities: Tirana, Diber, Durres and Korca, as well as the gross domestic product in Albania for the period 2000-2023. The rationale for selecting the cities is based on their role in the economy, location, and ability to represent different aspects of urbanisation and development in different regions of Albania.

The research involves a detailed description, analysis, and interpretation of urban phenomena in the cities of Tirana, Diber, Durres, Vlora and Korca. The main emphasis is on studying how these cities implement plans and projects, incorporating relevant practices and strategies for sustainable and technological development. This descriptive approach was used to study and compare the cities' development, identifying their strengths and weaknesses, as well as opportunities for further sustainable development.

The obtained research results were processed for reliability by applying the multivariate method of MANOVA analysis of variance using Microsoft Excel software and the Statistica 10 software package. Differences in the results obtained are possible at a significance level of $P \leq 0.05$ according to the Student's criterion.

RESULTS

Urbanisation and urban development in Albania are deeply interconnected and influence each other in various ways. Increased urbanisation can stimulate economic development in cities by increasing production and services, developing infrastructure, and attracting investment. The growing level of urbanisation increases the demand for various municipal services, such as water, sewerage, electricity, transport infrastructure. Urban development is a response to this demand. Urbanisation can cause changes in the social and cultural spheres of life. Urban development helps expand educational opportunities, cultural life, access to healthcare and other social benefits. Cities are often centres of economic activity where new jobs are created. This can attract migrants from rural areas and increase urbanisation. Growing urbanisation can put the natural environment and ecosystems at risk. Therefore, urban development requires careful planning to preserve natural resources and reduce emissions. The analysis of urbanisation shows a gradual increase in Albania from 43% in 2000 to 64.2% in 2023. The level of urbanisation increased with particular intensity in the period from 2012 to 2018 when it rose from 54.33 to 60.32%. The data obtained indicate a trend towards increasing urbanisation in the country, which may be the result of economic development and changes in social structures (Fig. 1).

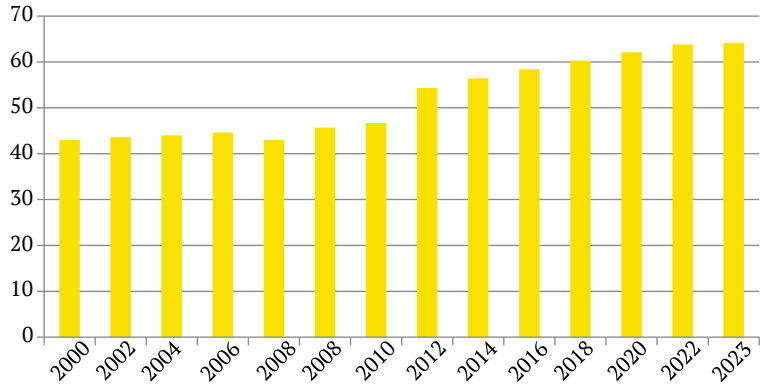


Figure 1. Urbanisation in Albania from 2000 to 2023, %
Source: Institute of Statistics of Albania (n.d.)

Considering urbanisation in the context of the selected cities, it is worth noting that Tirana's population grew by more than 50% between 2000 and 2023, indicating a steady level of growth. Potential growth drivers may include economic development, infrastructure projects, job opportunities, political stability, and the attractiveness of the city to new residents. In contrast, the population of Diber, from 2000 to 2023, decreased by 47.37%, from 190,000 to 100,000 people. Population decline can be caused by a variety of factors, such as the outflow of people in search of work, the lack of jobs, demographic trends, or a lack of economic activity in the city. On a positive note, the city of Durres has a steady positive population growth, even if this growth is rather moderate and has been within 25% for 23 years. Analysing the population data of the city of Korca, it is possible to note that the growth rate is decreasing from 2000 to 2023.

The population of the city of Vlora is also expected to increase, reaching about 187 thousand people in 2024. The population decline occurred consistently during this period.

The most significant decrease in population occurred from 2010 to 2023, when the growth rate was negative 11.36% (Fig. 2). According to the data obtained, Albanian cities show different urbanisation dynamics during the period under consideration. Such differences may be the result of various factors, such as economic development, job availability, infrastructure projects, and socio-cultural factors. Analysis of these data can identify the reasons for the different rates of urbanisation in different cities, contributing to an understanding of the dynamics and identifying possible vectors for further development. Additional research on the economic, socio-cultural, and infrastructural situation of each city could provide a deeper understanding of these differences in urbanisation levels.

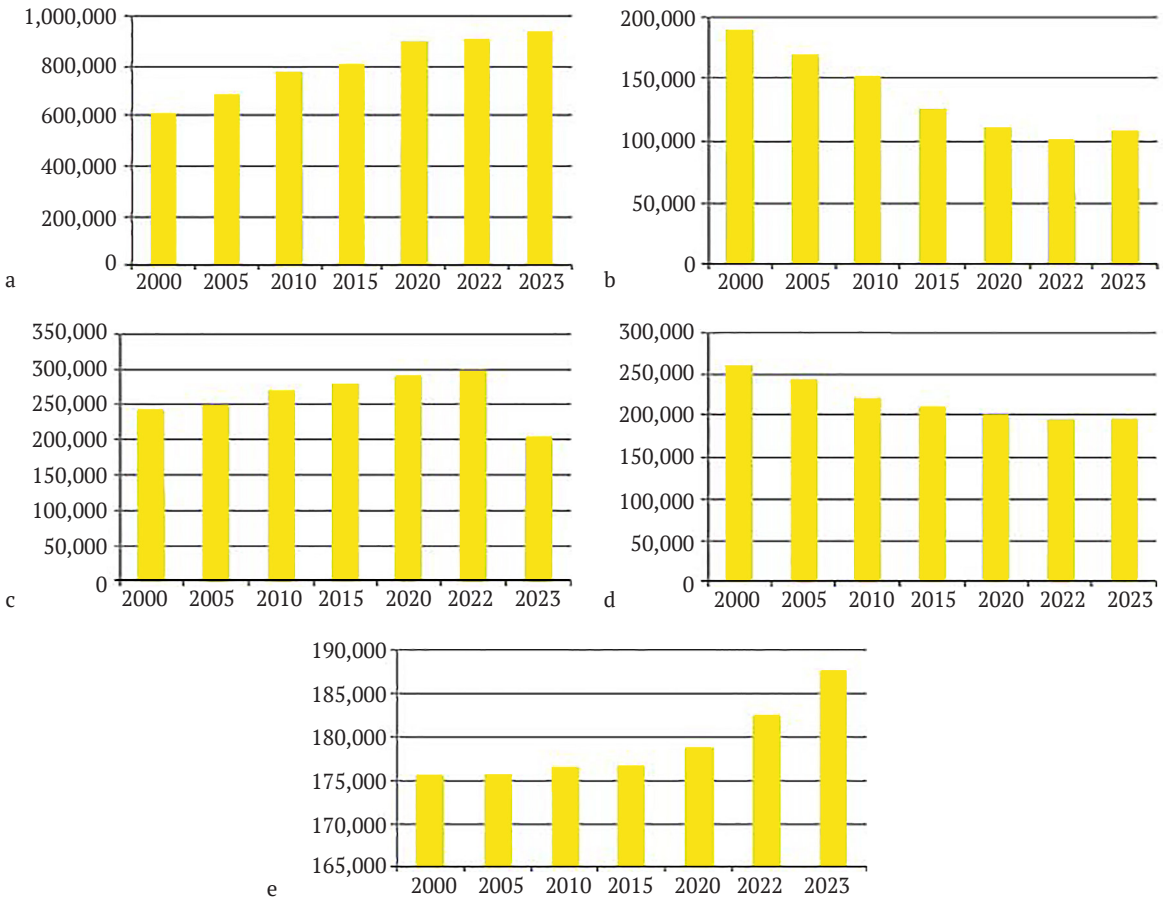


Figure 2. Population of Tirana (a), Diber (b), Durres (c), Korca (d), Vlora (e)
Source: Institute of Statistics of Albania (n.d.)

Tirana, as the capital and economic heart of Albania, is experiencing significant development and challenges related to overpopulation, air pollution and environmental issues. In particular, the growth of the car fleet and the use of fuels with high sulphur and lead content contributed to the air quality deterioration. In response to these challenges, Tirana is implementing initiatives to improve environmental quality and develop a city of the future. In 2015, the city joined numerous cities around the world in organising its first vehicle-free day. This initiative aimed to combat air pollution problems in the city and helped unite worldwide efforts to reduce the negative impact of transport on the environment. As of 1 January 2019, the government introduced a ban on imports of used cars manufactured before 2005 to limit environmental pollution, encourage the purchase of new cars from certified Albanian dealers and improve overall road safety. It is important to note that airborne particulate matter PM10 and PM2.5, as well as NO_2 and CO_2 gases, are additional sources of air pollution. They are caused by the rapid growth of new building construction and the expansion of road infrastructure (Mele & Muka, 2022). Furthermore, the government is actively developing green spaces and parks, such as Grand Park, which are becoming not only recreational areas but also important components of the city's environmental plan. Initiatives to restrict construction in green areas help preserve natural reserves and create environmentally friendly areas. With the expansion of its road infrastructure and the construction of new facilities, Tirana is adapting to the challenges of a modern city of the future, trying to balance development with the preservation of natural resources. This demonstrates the city's commitment to creating an environmentally friendly and sustainable environment for its residents. The authorities' efforts to develop

infrastructure, limit construction in green areas and create new recreational areas demonstrate their desire to realise the concept of a city that effectively uses its potential to improve the quality of life of its citizens while preserving the environment.

Tirana actively engages citizens and uses open data to develop projects in five priority areas: mobility, society, lifestyle, economy, and agriculture. It's worth noting that the administrative-territorial reform has significantly increased the size of Tirana municipality. In the context of financing various projects, the city is considering innovative schemes such as crowdfunding. The city also considers reward-based crowdfunding models that allow citizens to contribute to specific projects involving private service providers. For example, by paying electricity bills, citizens may have the opportunity to contribute to a social project that meets Tirana's smart city goals. Importantly, the #Crowdfunding4Children initiative, using social media, crowdfunding platforms, and human rights initiatives, aims to raise USD 20,000 to build the country's first comprehensive playground for children with special needs. It is also worth noting that Tirana is introducing electric buses and creating charging zones for electric vehicles, helping to reduce gas emissions, and developing online platforms for public participation in city management, with the possibility of submitting applications for repairs, cleaning. As for architectural innovations, modern residential complexes are being built, focused on sustainable and comfortable living, using energy-efficient technologies, and considering aesthetic aspects. In addition, restoration works are being carried out using restoration technologies to preserve and highlight the architectural heritage.

Even at the early development stage, various projects already demonstrate great potential for interaction with citizens. The city also plans to engage in civic participation through a new mobile application, Tirana Ime. The app not only provides real-time information about bus stations, taxis and traffic but also allows citizens to report any problems in their neighbourhood, receiving quick responses from the municipality. The implementation of such projects and inventive financial schemes allows Tirana to move towards becoming an independent "smart city", which other localities in the country can easily follow in the future.

Nestled among the Deshat Korab and Lure Selishte mountain ranges, Albania's Diber, although naturally rich in 21 glacial lakes, two national parks and thermal baths, faces challenges in tourism development due to deficiencies in infrastructure and road network. Private sector involvement is needed for effective development, as the lack of infrastructure amenities is currently hampering the growth of tourism in this charming region. Diber, despite its challenges, remains somewhat more developed than the neighbouring districts of Elbasan and Kukes. It is important to work actively to attract investment and develop effective infrastructure so that the region can tap into its development potential and become attractive to tourists, as well as improve the quality of life for the local population. Despite some stagnation, the city is implementing programmes to preserve nature and green areas, including the creation of eco-parks and the development of ecological routes, the launch of virtual tourist expositions and the use of augmented reality technologies to attract tourists. Architectural solutions are based on the development of environmentally friendly residential projects using materials with the lowest environmental impact. Art spaces are also created, and modern art objects are installed to enrich the city's cultural environment. However, according to the local population, the city lacks sports and recreational facilities, both indoor and outdoor. There are not enough public parks and playgrounds, nor are there enough centres where children and young people can engage in drawing, singing or other activities. Schools lack laboratories. This not only hinders the learning process but often leads to demotivation. Institutions and organisations should create conditions and equal opportunities for young people (Caso & Giordano, 2022).

The city of Durres is strategically located on the shores of the Adriatic Sea, which makes it a key connection for the sea routes connecting Albania with the Balkan, Mediterranean and European spaces. Throughout history, this geopolitical and strategic position has attracted the attention of major powers, which has influenced the development of the city and its socio-economic life. The city of Durres has become a key urban centre in the Eastern Adriatic due to its important position, which determined its role in regional geopolitical developments. This resulted in a rich cultural environment and the development of trade and cultural ties. In light of this, the importance of Durres in the context of the city's future development is emphasised, as its strategic geopolitical position, rich cultural heritage and history contribute to the creation of a unique environment. Ensuring a high quality of life for residents, creating sustainable infrastructure, and attracting investment plays an important role in maintaining and strengthening the city's position in the region, as well as in its future development. However, rapid development and urbanisation affected the city's environment, and since 2000, various measures and policies have been introduced to improve environmental quality and protect it. These measures are aimed at reducing the significant pollution caused by urbanisation, increasing population density and concentration of industrial, commercial, telecommunications and other activities.

In this context, measures to develop road infrastructure, and improve utilities and sanitation systems were taken, especially in problematic areas of Durres such as Shkozet, Keneta and Porto Romano. There has also been a focus on increasing green space, not only in residential areas but especially along the coast, which has suffered significant losses due to the expansion of development after the 1990s (Aliaj & Tiri, 2023). It is worth noting that Durres is famous for its sports infrastructure, including stadiums, swimming pools, football pitches and other sports facilities. The city is implementing smart port management

systems that optimise cargo handling and improve maritime safety. Interactive online maps of the city for tourists and residents are being developed, which contain information about the city's infrastructure and events. Innovative marine facilities are being developed that combine modern design and functionality with environmental sustainability. A light-emitting diode (LED) technologies are also used to create atmospheric lighting for architectural objects along the coastline.

Korca is identified as a key player in the development of the "Cities of the Future" in eastern Albania. In particular, the city is experiencing significant cultural and economic growth, becoming an important cultural and industrial centre in the region. Its museums reflect the city's centuries-old cultural heritage, creating a foundation for tourism development and drawing attention to the city's uniqueness. Given the migration outflow, Korca has a Regional Development Agency (S.M.E.), which is tasked with implementing various projects aimed at supporting and developing the region, cooperating with donors, authorities, and central government bodies to ensure the sustainable development of the region. The provision of advisory services to support the private sector creates an environment conducive to improved business performance. Through surveys and feasibility studies, informed decision-making by public institutions and local entrepreneurs is facilitated to develop private businesses and improve public services. In addition, it actively engages in cross-border cooperation (Burda, 2019).

The city's efforts to introduce online learning in schools and universities, develop virtual classrooms and learning platforms, and create online services for paying taxes, submitting documents, and receiving other municipal services are important. Modern art installations and objects have been installed that interact with viewers and create unique experiences. In addition, historic neighbourhoods are being restored using innovative methods of reconstruction and adaptation to modern needs. It is worth noting that in 2020, Albania launched the Smart Cities/Smart Villages programme, which is an energy-efficient and green investment initiative to implement integrated strategies and effective use of information and communication technologies (ICT) to improve basic infrastructure in the areas of transport, energy, lighting, and environmental protection.

In Albania, cities such as Durres and Korca have been selected as pilot projects for this programme. The overall goal is to develop these cities to provide basic infrastructure services through the implementation of smart solutions, thereby improving the quality of life and preserving a clean and sustainable environment. According to gross domestic product per capita, the cities under study are showing positive dynamics. The years 2018 and 2022 look like periods of significant economic development (Table 1). An overall analysis of the dynamics of Albania's GDP may indicate promising prospects for the "Cities of the Future". The period from 2000 to 2008 shows successful economic development, which may indicate that cities will have stable economic conditions for development. The slight downturn after 2008, likely related to the global financial crisis, can serve as a lesson for cities to develop sustainable and balanced economic strategies. The impressive economic growth in 2020 and 2023 may point to new opportunities for cities to attract investment and develop modern infrastructure solutions (Fig. 3).

Table 1. The impact of emotional intelligence on professionalism GDP per capita by city, EUR

City	2000	2004	2008	2010	2014	2018	2020	2022	2023
Tirana	4,610	4,752	4,911	4,741	4,600	6,140	3,203	6,675	6,452
Diber	1,302	1,450	1,658	1,798	2,370	3,374	3,564	3,657	3,754
Durres	2,840	2,960	3,196	3,508	3,330	4,412	4,560	4,670	4,691
Korca	1,830	1,950	2,065	2,097	2,587	3,284	3,350	3,462	3,574
Vlora	2,678	2,840	2,998	2,867	3,265	3,837	3,850	3,921	3,984

Source: Institute of Statistics of Albania (n.d.)

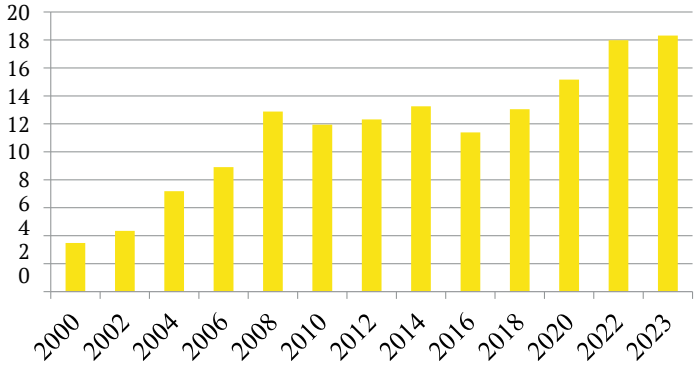


Figure 3. GDP in Albania, USD billion

Source: Institute of Statistics of Albania (n.d.)

This positive trend can create favourable conditions for attracting new businesses, technological innovation and sustainable living in the "Cities of the Future". Successful economic development may also reflect the high standard of living and social well-being in these cities. In summary, the positive dynamics of gross domestic product in the Albanian cities under study indicate successful economic development, promising prospects for future cities and the potential to attract investment, develop infrastructure and improve the quality of life of residents.

DISCUSSION

With the rapid development of modern cities and their importance as centres of economic, social, and cultural life, the analysis of architectural and infrastructural innovations is becoming a key element in understanding and planning the future development of urban spaces. The diversity of approaches to urban planning and construction in different countries and regions of the world creates variations in the achievements of cities in the context of sustainable development. An analysis of the experience of different countries not only identifies common trends but also unique solutions that reflect the characteristics of each city and its response to modern challenges. In modern smart cities and "Cities of the Future", there is an active development of social initiatives. This includes creating inclusive spaces, promoting equality, and tackling social challenges. This may include developing social programmes, improving housing conditions, and ensuring access to education and healthcare services for all segments of the population.

Environmental development is aimed at preserving natural resources and reducing negative environmental impact. Smart cities use technology to use energy and water efficiently and reduce air emissions (Bieliatynskyi *et al.*, 2023). Green technologies and clean energy sources are becoming an integral part of urban development. Architectural projects in such cities focus on the efficient use of space, creating aesthetically appealing and functional buildings (Dzyba & Saveliev, 2023). Architects use innovative materials and concepts to ensure sustainable construction and create comfortable conditions for residents. In addition, the "Cities of the Future" are implementing technologies to optimise transport, energy management, water supply and waste management. The use of sensors, artificial intelligence systems and the Internet of Things allows cities to effectively manage resources and ensure the safety of citizens (Baidrakhmanova *et al.*, 2023).

D. Nováčková & J. Wefersová (2021) note that "Cities of the Future" are becoming centres of innovation and technological development. The integration of smart technologies, sustainable construction, and social initiatives allows for the creation of environmentally friendly, comfortable, and safe environments for residents. Such cities are aimed at ensuring the quality of life and creating conditions for sustainable development, which is also demonstrated in the current study, which correlates with the findings of G. Maia *et al.* (2023), who emphasised that cities that intensively use their cultural heritage to develop tourism and cultural events have a positive impact on the economy. This approach contributes to both the preservation and restoration of historical sites, which is important in the context of sustainable urban development. The successful use of cultural heritage not only contributes to economic growth but also maintains and enriches the socio-cultural landscape, rendering it more attractive to residents and visitors (Barseghyan *et al.*, 2023). Such harmonious development can serve as a model for other cities seeking to balance economic growth with the preservation of their unique cultural heritage.

A similar opinion is also expressed by I. Butoracová Šindleryová & A. Čajková (2023), who emphasise that cities that implement modern architectural concepts and create creative urban spaces attract innovative enterprises and promote technological development. This also corresponds to the results of the study, which confirms the positive impact of using modern concepts in urban planning on business and technology development. The provision of innovative and creative spaces can be a key factor in stimulating economic growth and creating a favourable environment for the development of modern technologies in the "Cities of the Future". In addition, according to Z. Zou *et al.* (2020), cities where the business community, community and government actively cooperate have great potential for sustainable development. The creation of such partnerships contributes to the formation of a favourable environment for economic growth, which ensures sustainability and moves cities forward in the context of their development.

According to R. Matheus *et al.* (2020), the study is consistent with the view of scientists that cities that actively implement green technologies and energy-efficient solutions in architecture contribute to reducing their carbon footprint and creating a favourable environment for residents. This indicates the importance of green technologies in shaping a sustainable and environmentally balanced urban environment. The study by W. Li *et al.* (2020) on active public participation in urban development emphasises that open and interactive relations between the community and the authorities determine the effectiveness and sustainability of urban development. This approach not only increases the level of support and acceptance of development strategies but also ensures that the real needs and opinions of residents are considered, which is a key aspect of creating a more sustainable and adaptable urban environment. Such interaction contributes to the efficient use of urban resources, support for innovative initiatives, and a sense of shared responsibility and partnership to achieve common goals in urban development.

This study and the views expressed by scholars such as S. Mirzabeigi & M. Razkenari (2022) further illustrate the importance of the interaction between economic prosperity, cultural diversity, and innovation in architecture as key factors for achieving sustainable urban development. This approach not only contributes to the creation of attractive and resilient communities but also identifies new avenues

for further research and strategies in urban planning and development. The results indicate that the integration of these components forms the basis for effective urban governance, promoting sustainable development, improving the quality of life and interaction between different socio-cultural groups. Thus, the importance of a balanced approach to urban planning and development is becoming known through the prism of the studies and recommendations in the relevant scientific works. However, S. Matúšová & P. Nováček (2022) express different views on the relationship between economic success, urban culture, and architecture. The authors argue that the economic success of a city is closely linked to the rational use of urban spaces and high-quality infrastructure. Their approach emphasises the need for effective management of urban resources and the creation of conditions for entrepreneurship. At the same time, when referring to architecture and cultural aspects, they point out the importance of preserving and restoring historical sites as part of the city's identity.

This study is similar to the point of view of H. Silvennoinen *et al*. (2023), who emphasised the importance of developing creative and cultural industries to stimulate economic growth in cities. The authors emphasised that investment in culture and the arts can play a key role in creating new jobs, attracting innovative businesses, and improving the overall economic situation. This agreement highlights the importance of further research into the development of creative and cultural industries for the sustainable economic success of cities. These diverse perspectives emphasise that the relationship between economic success, urban culture and architecture is complex and determined by a wide range of factors. To ensure sustainable urban development, it is important to consider the diversity of approaches and to find a balance between different aspects of development, while adhering to the principles of a sustainable economy, social justice, and environmental sustainability (Zotsenko & Vinnikov, 2016).

The findings of this study are also reflected in the statements of I. Mutambik *et al*. (2023), also emphasised the importance of an integrated approach to analysing urban development. According to the authors, understanding the interaction between the economic, socio-cultural, and architectural aspects of the city is critical to achieving efficiency and sustainability in the urban environment. The authors identified that dynamic urban development requires a deep understanding of contemporary challenges, including population growth, economic changes, and deepening environmental problems. The scientists confirm that the relationship between different areas of urban life, including economy, culture, and architecture, determines the overall success of a city's development. Albania, as a country that has undergone a significant transformation after decades of socialist rule, sees its cities as key factors in achieving sustainable development and improving the quality of life of its population. The country, located at the intersection of different cultural and historical influences, demonstrates its readiness to adapt to modern challenges by seeking effective ways to develop its cities (Saaty & De Paola, 2017; Razavi, 2021).

The high gross domestic product in Albanian cities indicates stable economic conditions, which can be used as a basis for developing urban planning strategies. Studying how successful economic trends affect the structure and planning of cities can help to develop optimal solutions for future projects. The positive trend in the economy in 2020 and 2023 creates favourable conditions for innovation and sustainable development in cities. A study of which cities are using this economic growth to implement innovative solutions in urban planning can serve as an important input for architectural research. Some innovative solutions that can be used by the cities of Tirana, Diber, Durres, Korca and Vlora in urban planning include:

- sustainability and sustainable development: the principle of sustainability takes into account not only the current needs of the city, but also the needs of future generations. This can mean integrating sustainable development into city planning, such as the use of renewable energy sources, preservation of green areas, and other environmentally friendly initiatives;
- smart technologies: implementation of innovative technologies to improve the quality of life of residents, such as smart lighting, air quality monitoring, waste management systems;
- smart transport: development of infrastructure to support sustainable movement, such as bicycle paths, public transport based on electric vehicles, and integration of smart transport technologies;
- urban green building: the creation of green and ecological zones in the city, including vertical gardens, roof gardens, parks, and other urban green spaces that contribute to the ecological balance and health of residents;
- community participation: involvement of local residents in the decision-making process regarding the development of the city, using innovative methods such as public consultations, mapping, and support for public initiatives.

These innovative approaches can help to improve urban development in a liveable and workable environment.

Thus, the confirmation of the study is reflected in the statements of recognised experts who emphasise the importance of a deep understanding of the interaction between different aspects of the urban environment to create sustainable and effective strategies for the development of "Cities of the Future". Research on innovative approaches to urban planning and analysis of their impact on the quality of life of residents indicate the need to implement sustainable development in urban planning. In particular, consideration of environmental aspects and rational use of resources are becoming key factors in achieving environmentally sustainable urban development. Thus, to summarise, the results of the study indicate the importance of an in-depth analysis of the economic, socio-cultural, and architectural dimensions of urban planning in the context of Albania. The analysis of the current state of cities and their interaction with economic and environmental

development provides valuable insights into the challenges and opportunities facing these cities.

CONCLUSIONS

Analysing the modern architectural and infrastructural landscape of the selected Albanian cities of Tirana, Diber, Durres, Vlora and Korca, various innovations can be identified that reflect their rapid development. In the context of architectural solutions, there is an active implementation of modern residential complexes, the use of energy-efficient technologies and the restoration of historical sites.

An important aspect of sustainable development is the environmental dimension, which is implemented through the creation of eco-parks, the use of environmentally friendly materials in construction, and support for ecotourism. Another important aspect of sustainable development is the use of innovative technologies in solving transport and logistics problems, including the introduction of electric transport and smart city management systems. Architectural innovations also include the creation of art spaces, the use of naval architecture and interactive architectural objects. These measures are designed not only to ensure the functionality and sustainability of cities but also to enhance the aesthetic level and create an attractive urban environment. An analysis of GDP dynamics shows promising prospects for the "Cities of the Future". Stable economic conditions from 2000 to 2008 can serve as a basis for the likelihood of sustainable development and promotion of cities. The resilience and growth of the economy in 2020 and 2023 also point to new opportunities for such cities in terms of investment attractiveness and the development of modern infrastructure solutions. A positive trend can create favourable conditions for attracting new businesses, technological innovations, and sustainable lifestyles in the "Cities of the Future", which reflect a willingness to implement innovative solutions and adapt to challenges.

Further study should explore aspects of global urban competitiveness, develop innovative solutions to transnational challenges, and build more sustainable and efficient urban systems in light of rapidly changing technologies and societal needs.

ACKNOWLEDGEMENTS

None.

CONFLICT OF INTEREST

None.

REFERENCES

[1] Afezolli, A. (2022). Some smart solutions towards rapid urbanization in Albanian cities. *Smart Cities and Regional Development (SCRD) Journal*, 6(1), 27-34.

[2] Aliaj, E., & Tiri, E. (2023). E-commerce regulation in Albania. *Juridical Tribune*, 13(3), 441-455. doi: 10.24818/TBJ/2023/13/3.07.

[3] Baidrakhmanova, M., Mamedov, S., & Karabayev, G. (2023). Modern classification of mixed-use residential complexes. *Civil Engineering and Architecture*, 11(5), 2533-2542. doi: 10.13189/cea.2023.110521.

[4] Barseghyan, A., Serafin, S., Kostyakova, A., Naamo, Gh.S., & Qinbr, M.I. (2023). Financial and analytical assessment of the costs of maintaining large urban park spaces in the Mediterranean on the example of Barcelona. *Scientific Horizons*, 26(4), 108-118. doi: 10.48077/scihor4.2023.108.

[5] Bieliatynskyi, A., Yang, S., Pershakov, V., Shao, M., & Ta, M. (2022). The use of fiber made from fly ash from power plants in China in road and airfield construction. *Construction and Building Materials*, 323, article number 126537. doi: 10.1016/j.conbuildmat.2022.126537.

[6] Burda, A. (2019). Evolution of central square of Korça: The impact of three different political systems. In F. Nepravishta & A. Maliqari (Eds.), *Cities in transitions* (pp. 337-342). Tirana: Polytechnic University of Tirana.

[7] Butoracová Šindleryová, I., & Čajková, A. (2023). Implementation of smart city solutions from the perspective of the population in Slovakia. *Administrative in Management Public*, 40, 113-131. doi: 10.24818/amp/2023.40-07.

[8] Caso, A., & Giordano, S. (2022). Cross-border territorial development through geographical indications: Gargano (Italy) and Dibër (Albania). *Encyclopedia*, 2(4), 1845-1858. doi: 10.3390/encyclopedia2040127.

[9] Dzyba, A., & Saveliev, K. (2023). The importance and the effectiveness of cultural ecosystem services provided by parks in the city of Kyiv during the war in Ukraine. *Ukrainian Journal of Forest and Wood Science*, 14(2), 38-52. doi: 10.31548/forest/2.2023.38.

[10] Hysa, A., Manahasa, O.D., Naselli, F., Manahasa, E., Yunitsyna, A., & Dervishi, S. (2021). Introducing the architectural, urban, and landscape challenges of Albania. In A. Yunitsyna, A. Hysa, E. Manahasa, F. Naselli, O.D. Manahasa & S. Dervishi (Eds.), *Current challenges in architecture and urbanism in Albania* (pp. 1-15). Cham: Springer. doi: 10.1007/978-3-030-81919-4_1.

[11] Institute of Statistics of Albania. (n.d.). *Demography and social indicators*. Retrieved from https://www.instat.gov.al/en/themes/demography-and-social-indicators/.

[12] Kaššaj, M., & Peráček, T. (2024). Sustainable connectivity – integration of mobile roaming, WiFi4EU and smart city concept in the European Union. *Sustainability*, 16(2), article number 788. doi: 10.3390/su16020788.

[13] Li, W., Batty, M., & Goodchild, M.F. (2020). Real-time GIS for smart cities. *International Journal of Geographical Information Science*, 34(2), 311-324. doi: 10.1080/13658816.2019.1673397.

[14] Maia, G., Ponte, C., Caminha, C., Furtado, L.S., Melo, H.P.M., & Furtado, V. (2023). A global empirical study on how street networks facilitate driving longer distances. *Scientific Reports*, 13, article number 18154. doi: 10.1038/s41598-023-45236-7.
[15] Matheus, R., Janssen, M., & Maheshwari, D. (2020). Data science empowering the public: Data-driven dashboards for transparent and accountable decision-making in smart cities. *Government Information Quarterly*, 37(3), article number 101284. doi: 10.1016/j.giq.2018.01.006.
[16] Matúšová, S., & Nováček, P. (2022). New generation of investment agreements in the regime of the European Union. *Juridical Tribune*, 12(1), 21-34. doi: 10.24818/TBJ/2022/12/1.02.
[17] Mele, M., & Muka, M. (2022). Uneven peripheral developments in Central and Eastern Europe: A case study of the Tirana city region, Albania. *Quaestiones Geographicae*, 41(2), 37-47. doi: 10.2478/quageo-2022-0018.
[18] Ministry of Tourism and Environment of Republic of Albania. (2019). *National strategy for sustainable tourism development 2019-2023*. Retrieved from https://turizmi.gov.al/wp-content/uploads/2019/12/National-Tourism-Strategy-2019-2023-EN.pdf.
[19] Ministry of Urban Development. (n.d.). *General national plan*. Retrieved from https://planifikimi.gov.al/index.php?id=ppk_shqiperia&L=2.
[20] Mirzabeigi, S., & Razkenari, M. (2022). Design optimization of urban typologies: A framework for evaluating building energy performance and outdoor thermal comfort. *Sustainable Cities and Society*, 76, article number 103515. doi: 10.1016/j.scs.2021.103515.
[21] Mutambik, I., Lee, J., Almuqrin, A., & Zhang, J.Z. (2023). Transitioning to smart cities in gulf cooperation council countries: The role of leadership and organisational culture. *Sustainability*, 15(13), article number 10490. doi: 10.3390/su151310490.
[22] Myalkovsky, R., Plahtiy, D., Bezvikonnyi, P., Horodyska, O., & Nebaba, K. (2023). Urban parks as an important component of environmental infrastructure: Biodiversity conservation and recreational opportunities. *Ukrainian Journal of Forest and Wood Science*, 14(4), 57-72. doi: 10.31548/forest/4.2023.57.
[23] Nováčková, D., & Wefersová, J. (2021). Use of digital technologies in business in Slovakia. In N. Kryvinska & A. Poniszewska-Marańda (Eds.), *Developments in information & knowledge management for business applications* (pp. 335-355). Cham: Springer. doi: 10.1007/978-3-030-76632-0_12.
[24] Razavi, S. (2021). Deep learning, explained: Fundamentals, explainability, and bridgeability to process-based modelling. *Environmental Modelling & Software*, 144, article number 105159. doi: 10.1016/j.envsoft.2021.105159.
[25] Saaty, T.L., & De Paola, P. (2017). Rethinking design and urban planning for the cities of the future. *Buildings*, 7(3), article number 76. doi: 10.3390/buildings7030076.
[26] Săraru, C.-S. (2023). Regulation of public services in the Administrative Code of Romania: Challenges and limitations. *Access to Justice in Eastern Europe*, 1(18), 69-83. doi: 10.33327/AJEE-18-6.1-a000110.
[27] Silvennoinen, H., *et al*. (2023). A semantic web approach to land use regulations in urban planning: The OntoZoning ontology of zones, land uses and programmes for Singapore. *Journal of Urban Management*, 12(2), 151-167. doi: 10.1016/j.jum.2023.02.002.
[28] United Nations. (2024). *Albania progress report 2023*. Retrieved from https://albania.un.org/en/266091-albania-progress-report-2023.
[29] World Bank in Albania. (2023). Retrieved from https://www.worldbank.org/en/country/albania/overview.
[30] Zotsenko, N., & Vinnikov, Y. (2016). Long-term settlement of buildings erected on driven cast-in-situ piles in loess soil. *Soil Mechanics and Foundation Engineering*, 53(3), 189-195. doi: 10.1007/s11204-016-9384-6.
[31] Zou, Z., Cai, T., & Cao, K. (2020). An urban big data-based air quality index prediction: A case study of routes planning for outdoor activities in Beijing. *Environment and Planning B: Urban Analytics and City Science*, 47(6), 948-963. doi: 10.1177/2399808319862292.

Сабіна Боллано
Кандидат соціальних наук та поведінки, викладач
Європейський університет Тирани
1000, вул. Ханфизе Кеко, м. Тирана, Албанія
https://orcid.org/0000-0003-0201-8442

Вивчення досвіду містобудування та прийняття рішень щодо розвитку «Міст майбутнього»

Анотація. Враховуючи стрімкий технологічний та глобальний розвиток, «Міста майбутнього» стають важливими центрами інновацій, де переплітаються культурні, економічні та технологічні впливи. Наукова актуальність таких досліджень визначається впливом інновацій на розвиток міського середовища, які сприяють сталому розвитку та покращують якість життя мешканців. Дослідження спрямоване на аналіз практик планування та рішень міського розвитку в «Містах майбутнього» в Албанії, зосереджуючись на взаємодії соціальних, економічних та екологічних аспектів. Використовувалися такі методи: узагальнення, індукції та дедукції, аналізу та синтезу. Дослідження вивчало дані про урбанізацію в Албанії, валовий внутрішній продукт країни та в містах Тирана, Дібер, Дуррес, Влера та Корча на душу населення, а також основні аспекти планування та економічної стійкості в цілому. Дослідження архітектурного та інфраструктурного розвитку албанських міст дозволило виявити ключові тенденції та інновації, серед яких впровадження сучасних житлових комплексів, інтерактивних додатків, використання енергоефективних технологій, реставрація історичних місць та створення екопарків. Це свідчить про важливість збалансованого розвитку, який включає як сучасні технології, так і збереження культурної спадщини. Стабільні економічні умови вказують на можливості сталого розвитку та інвестицій у містах. Позитивна динаміка валового внутрішнього продукту створює сприятливі умови для залучення нових підприємств, технологічних інновацій та розвитку сталого способу життя. Крім того, аналіз інновацій у транспорті, естетичних підходах та економічній стійкості албанських міст визначає перспективи їх глобальної конкурентоспроможності. Результати дослідження можуть бути корисними для розробки та планування майбутнього міського розвитку в Албанії, а також використовуватися як основа для прийняття рішень у сферах економіки, технологій та урбанізації

Ключові слова: інфраструктура; енергоефективні технології; реставрація; екопарки; інновації; розумні системи

Architectural Studies
International Journal about Architecture

Volume 10, No. 1

UDC 726
DOI: 10.56318/as/1.2024.58

Bohdan Cherkes
Doctor of Architecture, Professor
Lviv Polytechnic National University
79000, 12 Stepan Bandera Str., Lviv, Ukraine
https://orcid.org/0000-0001-6809-956X
Oksana Diachok*
Doctor of Architecture, Professor
West Ukrainian National University
46009, 11 Lvivska Str., Ternopil, Ukraine
https://orcid.org/0000-0002-5808-6826
Józef Hernik
Doctor Habilitatus, Professor
University of Agriculture in Krakow
31-120, 21 Adam Mickiewicz Alley, Krakow, Poland
https://orcid.org/0000-0001-7335-1600

Theoretical studies of identity in the sacral architecture of Ukraine

Abstract. Modern reconstruction of central districts in cities and villages with a historical environment raises discussions on the protection of cultural heritage. Architectural monuments are a reflection of changes in ideological and political transformations in society, and the attitude to them is a reflection of the culture of the nation. The need to protect the ancient Ukrainian holy places as the genetic memory of the nation, and to build modern churches that will have the features of the new Ukrainian church, became even more important in the times of the Russian invasion of Ukraine. The relevance of the study is conditioned by the aggravation of socio-political and national-cultural problems and insufficient coverage in studies of the process of creating and reflecting identity in Ukrainian churches. The purpose of the study was to investigate the process of shaping national identity and its visualisation by architectural means in the creation of Ukrainian churches. To achieve the goal, the following research methods were used: empirical (search for literary and archival sources, observation, comparison and description), theoretical (comparative and compositional analysis, classification and generalisation), and special research methods (full-scale survey of temples, their photo recording, identification of characteristic features and features, research of retrospective development). All this allowed investigating the process of development of the architecture of Ukrainian authentic churches in chronological order, to show the process of creating a new Ukrainian sacred style, which became the prototype of the creative search of modern architects. The researchers focused on the role of the artistic and creative elite in the creation of national identity; showed the problems of creating Ukrainian identity related to the historical past; analysed the influence of social and political factors on Ukrainian sacral architecture and the possibility of visualising the image of the national church through architecture; noted the importance of the image of Ukrainian sacral architecture for confirming national identity. The research demonstrates the importance of preserving ancient Ukrainian churches, which carry the genetic memory of the nation, supplement data on the development of sacral architecture, and open the way for further research. The practical significance of the study lies

Suggested Citation:
Cherkes, B., Diachok, O., & Hernik, J. (2024). Theoretical studies of identity in the sacral architecture of Ukraine. *Architectural Studies*, 10(1), 58-68. doi: 10.56318/as/1.2024.58.

Journal homepage: https://arch-studies.com.ua/en#
Architectural Studies, 10(1), 58-68
Received: 03.01.2024 Revised: 25.04.2024 Accepted: 20.06.2024

*Corresponding author

in the fact that the results obtained can be used by architects in the design of modern Ukrainian churches, will be useful in museum work and in educational activities for training architecture and design specialists

Keywords: authenticity; Ukrainian churches; spatial composition; cultural heritage; Ukrainian nation

INTRODUCTION

The current state of research on sacral architecture shows that until today (2024), theoretical aspects of the development of national identity in the architecture of the church have not been defined. However, the threat of loss of statehood, the revival of national culture, the importance of preserving monuments that have significant historical and cultural value makes the study relevant.

The problems of preserving architectural heritage and historical identity in a globalised world have been considered by researchers from many countries. The issues of nationalism and national identity were considered by N. Miščević (2022). The researcher asks the question: is national identity important in modern society? Modern challenges in politics, real events in different countries of the world and the importance of critically assessing the situation in national states are highlighted by P. O'Neil *et al*. (2020). At the same time, the critical review by S. Pandya (2020) analyses scientific problems related to "architectural nationalism". The researchers suggest future areas for research on this issue.

The process of forming a national identity is necessary for the development of a nation. State governments use a variety of tools to link civil society with the state. One of these "nationalist tools" or "cultural means" is the construction of national monuments. M.H. Rahmat & A.S. Ismail (2022) concluded that personalising architecture that is consistent with national identity can "ignite the spirit of patriotism" and can strengthen multicultural relations in the country. Researchers review the architectural works of different countries and argue that national identity can be expressed in different socio-political conditions and it is necessary to create an ideology of national identity in architecture.

Identity is studied by Ukrainian specialists in various scientific fields: philosophy, history, psychology, sociology, cultural studies, art history, and architecture. The importance of national identity in the regional security of the state was formulated in the paper by V. Miroshnichenko (2022). L. Prybeha (2023) in the analysis of sacred buildings, points out the phenomenon of ancient Ukrainian wooden churches, which are an expression of national identity and notes their role in the development of modern Ukrainian architecture. The researcher identified the signs of national identity, summarising the results of field studies and proves that despite their regional diversity, all authentic wooden temples have common architectural forms that indicate the all-Ukrainian traditions of their creation.

H. Shevtsova & H. Ponomarenko (2020) analysed the modern achievements of Ukrainian architects who turned to wooden church construction. In particular, the researchers considered the work of the Ukrainian architect Oleh Sleptsov, his romantic ideas, a combination of world and national ideas of shaping in sacral architecture. B. Cherkes & O. Diachok (2019), considering the importance of sacred complexes in the architectural and planning structure of Galician cities, pointed out the importance of their preservation and inclusion in the cultural heritage sites of the temples of architect Vasyl Nahirnyi. The question of identity in sacral architecture was raised by S. Linda *et al*. (2022). However, the analysis of research on the expression and visualisation of identity in the architecture of Ukrainian sacral architecture shows that the search for national style in the church architecture of Modern Ukraine is not completed, which determines the relevance of the study.

The purpose of the study was to determine the features of the creation of Ukrainian national identity and its expression in the architecture of churches. To achieve this goal, it is necessary: to reveal the concept of "national identity" and show the problems of creating Ukrainian identity related to the historical past; to conduct an art history analysis of three-dimensional compositions of sacral buildings of different periods of development of Ukrainian architecture; to show the influence of socio-political factors on Ukrainian sacral architecture.

The research methodology was determined by the multidimensional nature of this study and provided for a review of scientific literature in the following areas: history, philosophy, history and theory of architecture. The research was conducted based on archival sources, the materials of nature reserves, scientific institutions, and publications of leading scientists. The source base and the object of research was the sacral architecture of Ukraine, represented by wooden and stone temples. The following research methods were applied: general scientific (empirical and theoretical), and special ones. By the method of field surveys, the analysis of sacred complexes was carried out, sketches, photo recording and measurement drawings were made. In particular, the best wooden and stone churches on the territory of Ukraine were visually examined, photographed and described. Empirical research methods were used to define the concept of "national identity" and investigate the complex process of creating a national Ukrainian identity. Historical, comparative, and art history analyses revealed structural and decorative elements that are characteristic of national churches in chronological order. Theoretical methods (structural analysis, comparison, identification, abstraction) identified the characteristic features of the development of sacred complexes at different historical stages.

DEFINITION OF THE CONCEPT AND MARKERS OF NATIONAL IDENTITY

The issues of national and cultural identity have been addressed by A.D. Smith (1994) and O. Marquard & K. Stierle (1979), who defined the communities that form them. Their research was continued by S.P. Huntington (1997; 2005). C.P. Lee (2015) proved that the differences between peoples lie primarily in the cultural plane and indicate the important cultural and educational role of studying the history of a nation.

Among modern researchers, the issue of national identity was highlighted by P. O'Neil *et al*. (2020). The researchers note that the concept of national identity is inextricably linked with the concept of historical tradition. S. Pandya (2020) proved that national identity creates a sense of belonging, and to reflect the values and priorities of a nation's identity, symbols are usually used – the colours of the national flag, the words of the national anthem, promises of loyalty, etc. The researcher shows how national identity affects modern politics. That is why events that, although not personally happened to specific people, are important, but a strong national identity based on impersonal and distant connections helps to understand what others have experienced and make people influence political behaviour.

N. Miščević (2022), in his study on national identity, examined the development of nations and states, and argued that the modern notion of nationality differs from the ancient notions of cultural differences between peoples by its emphasis on collective self-determination. The researcher asks questions: "…is national identity important for people's identity?" and proves that "…a stable nation generates stable personalities" and the value of freedom and the development of one's identity is important. O. Dahbour (2002) shows that two concepts of national identity are common in modern political philosophy: ethnic and free – based on the principle of national self-determination. The researcher analysed both forms, argued for the choice in favour of "strict" – ethnic identity. Many researchers consider regional problems related to national identity. Thus, Q. Liu & D. Turner (2018) in the history of international student mobility from China to other countries explored how individuals' goals respond to national policies and predict the implications for future development in a globalised context.

The importance of architecture for the development of a nation's identity was pointed out by H. Skotte (2010), analysing the theory of Norwegian architecture theorist Christian Norberg-Schultz, who defined architecture as a form of "PlaceArt". However, the researcher also points out a fundamental problem of a globalised world "…where more and more people are moving around and constantly need to reconnect with the environment", so, in his opinion, this idea of a "place" that can be a source of identity should be revised. E. Sistac (2022) examined the tools that the state uses to strengthen the collective identity of the nation, including cultural means – the creation of national monuments, buildings, specific styles of architecture, and the protection of historical and cultural heritage. J. Walsh (n.d.), exploring the expression in architecture of national identity cites the example of Wellington Futuna Chapel in New Zealand as a key component of architectural identity. However, according to the author, the National difference of New Zealand is a clean and green environment. The researcher analysed how National countries were represented at the Venice Architecture Biennale, and how they coped with the challenge of showing a modern impact on the architectural identity of each country.

J. Latief (2018) argued that architecture shapes national identity and helps to understand history, and how "buildings shape people". G. Delanty & P.R. Jones (2002) discussed issues of "European post-national identity", beyond the nation-state, and its expression in residential space architecture. The researchers show that architecture can express contradictory and ambiguous national identities, which are illustrated by post-communist European societies.

National representation through visual form and the phenomenon of national style in architecture was studied by Ukrainian researchers S. Linda *et al*. (2022), who found a relationship between the development of a national idea in society and architectural form. Architecture researcher M. Habrel (2003) studied church construction after 1990 in Ukrainian cities, and emphasised the importance of this factor in the revival of the nation, the development of a new national identity, and the revival of multicultural identity.

A published interview of V. Belogolovsky (2022) with architect Oleh Drozdov considered the issue of rebuilding Ukraine's national identity, the struggle for collective freedom and the personal freedom of every Ukrainian. Oleh is convinced that the post-war world will be more cautious in seeking cooperation with authoritarian and dictatorial regimes, and the role of preserved Ukrainian architectural heritage in rebuilt cities is great.

Signs of national identity in wooden traditional churches of different ethnic regions of Ukraine are analysed by H. Shevtsova (2019) and L. Prybeha (2023). The importance and preservation of cultural heritage for the development of national identity was determined by R. Hnidets (2004). O. Diachok (2018) investigated the problems of forming the architecture of sacred complexes under the influence of socio-political processes and pointed out the importance of finding a national style in the modern architecture of the church.

As the literature review shows, researchers cover the philosophical concept of national identity quite widely. Its construction is connected with the idea of unity of the country, similarity in traditions, cultural kinship. Some aspects of national identity and its expression in architecture are also outlined, but the search for a modern national style in temple construction is not completed.

Markers of national identity are own historical territory, economy, responsibilities and legal rights of people, culture, language, common myths and the pantheon of

heroes, etc. (Marquard & Stierle, 1979; Smith, 1994). The studies also define the concept of "cultural identity". Thus, S.P. Huntington (1997) notes: "...the most important differences between peoples are no longer ideological, political, or economic. They are on the cultural plane". The elite of a nation has the ability to construct a national identity; changing the elite, its priorities and aspirations can lead to radical transformations in the development of national identity, which sometimes negates the former (Anderson, 1991). This happens when the political system changes, revolution or war; the construction of identity is based on the revision of history, the restoration, partial or complete falsification of the historical past – in a light favourable to a particular political regime. Thus, a new layer of collective memory is created, a new mythology, a set of symbols and values, a "new" cultural heritage and cultural kinship are formed. If the process of changing national identity takes place in an evolutionary way, it is accompanied by a gradual process of development of society and the formation of its new symbols and values. The other way is "imposed" by an act of will of a new political power as a result of a revolution or annexation of one country by another (Hnatenko & Pavlenko, 1999). As history shows, when the political elite changes or weakens, the identity "imposed", not rooted in the historical traditions of the people, disintegrates. The role of the artistic and creative elite, including architects, in the process of forming national identity is outstanding, because it is architecture that is inseparable from the social order, serves the national and political elite, and thus helps to assert national identity.

Ukrainian scientists S. Linda (2003) and V. Pasichnyk (2019) claim that at the end of the 18th century, at the time of the emergence and development of nationalism, artists turned to "spiritual historicism", reconstructed the "Golden Age", its images and heroes by means of art. This was a testament to the continuity of the nation, its noble heritage, glorious past and future. In architecture, along with the revival of historical styles, the search for their own "national" styles began, which was Tudor Gothic in England, French Neo – Renaissance in France, German Renaissance in Germany, and at the turn of the 19th and 20th centuries – an appeal to the national construction of "Ukrainian Art Nouveau".

According to Professor B. Cherkes (2008), after the establishment of a new political power in architecture, the search for means of expressing change, transformation and visualisation of identity by architectural means immediately begins according to the following scheme:

- the need to find a new paradigm for the development of society and a new national identity through the coming to power of a new political regime;
- development of a new paradigm of national identity, creation of a new mythology, revision of history, development of a new layer of historical memory;
- search for urban planning and architectural tools to read (often through competitions organised at the state level) the visual transformation of new myths;
- creation of works of architecture that visualise new myths and thereby assert a new identity.

The process of forming a national identity by architectural means is most pronounced in the development of architecture in the central public spaces of cities. These structures remain in existence even when political regimes change and transmit visual verbal and spatial myths to subsequent generations (Cherkes, 2008). An important component of the development of an environment that has a powerful symbolic and figurative potential, a means of asserting national identity is the image of sacral architecture.

THE PROCESS OF CREATING UKRAINIAN IDENTITY AND ITS EXPRESSION IN THE ARCHITECTURE OF CHURCHES

The Ukrainian nation is one of the oldest in Europe with its own language, culture, church, architecture, and art. Since the middle of the 14th century, the country with a thousand-year history was under the rule of different states, for a long time its territory was divided and was part of different empires. Discontinuity and inconsistency of Ukrainian statehood led to the problems of creating a single nation. Nevertheless, the Ukrainian elite managed not to fully assimilate, but to maintain a connection with its own historical past (Hnatenko & Pavlenko, 1999).

The catalyst for national identity in Western Ukraine was the intensification of cultural and religious pressure (since the Union of Lublin in 1569), and the unwillingness to renounce the mother tongue and parental faith (Serhiichuk, 2001; Novak, 2004). Latin Catholicism caused a "sense of resentment" among the Rusyns, an anti-Polish reaction arose on religious grounds, developed into recognition of the Rusyns' own history, which was based on the glorification of Kievan Rus (Stotskyi, 2008; Kalach, 2011). In contrast to Catholicism, Ukrainians adopted the Greek Catholic faith, which since the end of the 18th century has represented a Western Ukrainian identity. However, it was only at the end of the 19th century that a national awakening took place in Galicia and, as a result, political separatism and awareness of own national identity developed (Sukhyi, 1999; Sladky, 2008).

The identity of the Left-Bank part of Ukraine was developed under the influence of the Cossacks, their freedoms, figures and heroes sung by Taras Shevchenko. In the 19th century, for the first time, the differences between Ukraine and Russia were noted, which consisted both in the political and cultural plane. The development of Ukrainian historiography and national identity was greatly influenced by M. Hrushevskyi, who argued that Ukrainian culture is much older than Russian; Ukrainian identity should be based not on the myth of the Cossacks, but on the existence of the Kievan Rus, which has existed since the end of the 9th century. Russia – Muscovy, which emerged much later, has no relation to it. Freed from Moscow's influence, Ukraine is part of Europe, not part of the "Asian Rus". Thus, "Europeanism" became the opposite of Russification (Novak, 2004).

The Ukrainian nation, although divided, emerged due to interaction and expansion of contacts between Ukrainians and the development of the literary Ukrainian language. Ukrainians have not lost their own national culture and have preserved their uniqueness, but the two parts of Ukraine had different models of national identity. Within the Russian Empire, a Little Russian regional identity was formed, and local nationalism developed in Galicia. In the Naddnipranshchyna Ukraine, a concept was formed that could be implemented in the context of the reforms of the Russian Empire (Sukhyi, 1999).

The short-term existence of the Ukrainian people's Republic in the Naddnipranshchyna Ukraine and the West Ukrainian People's Republic in Galicia ended with an even greater enslavement of Ukrainians by the Second Polish Republic and the Soviet Union – different ideologically and with different concepts of statehood. The post-war unification of the two parts of Ukraine required the creation of a common identity. Since 1957, a new Ukrainian historiography began to be created, which rejected Hrushevskyi's theory of the origin of Ukraine, but was based on the idea of "three peoples-brothers", on the "common origin", on the "eternal dream of the Ukrainian people to reunite with Russia", on the "partnership of Ukraine and a sovereign state within the USSR". However, M. Khrushchev developed the doctrine of "merging" nations into a single Soviet people, which led to important changes in language policy and a new wave of Russification, a new wave of anti-religious campaign (Merkatun, 1991). The policy of L. Brezhnev continued political arrests and repressions in the 1970s (Sukhyi, 1999).

The underground movement of the Greek Catholic Church actively opposed totalitarianism and contributed to the national revival (Perevezii, 1998; Serhiichuk, 2001). The rapid democratisation of political life in Russia in 1991 led to the collapse of the Soviet Union and the independence of Ukraine. However, the Ukrainian nation was not yet formed, and its two parts – the Eastern one with the centre in Donetsk and the Western one with the centre in Lviv – represented two identities, which was a sign of a transition period. According to S.P. Huntington (2005), this duality was the result of belonging to different cultural civilisations. They come from different historical experiences and different collective memories. Societies such as the Soviet Union, Yugoslavia, and Bosnia were either falling apart or undergoing severe upheavals. The peaceful transformation of the colonies into an independent state prevented the creation of important national myths, which are important for nation-building in general, a single pantheon of heroes, or even a single language in communication. A strong shock awaited the Ukrainian people in 2013 during the revolution of dignity, which began as a peaceful action, and resulted in the shooting of Ukrainian patriots, called the "Heavenly Hundred". No less dramatic events continued – the annexation of Crimea, the war in Eastern Ukraine with the participation of Russia, the full-scale invasion of Russian troops on the territory of Ukraine. The tragic events that continue can consolidate Ukrainians, unite them into a politically mature nation, and give an impetus to the creation of a single national identity.

The visual image of the Ukrainian church is an important component in the development of national identity. A large number of churches that are built according to certain national canons and their own construction equipment are unique examples of Ukrainian architecture. Especially authentic are the wooden churches, the uniqueness of which was confirmed by the inclusion of 16 of them in the UNESCO World Heritage List (Prokaieva, 2011). In contrast, there are churches built or rebuilt on the territory of Zakarpattia, which was under the rule of the Austrian Empire, or on the lands of Naddnipranshchyna, which were captured by the Russian Empire: the so-called Teresian churches and those built according to diocesan projects and had pronounced features of Russian architecture, which contrasted sharply with Ukrainian churches in terms of their spatial and volumetric design and decoration (Slobodian, 1996). The spread of Imperial strategies was manifested in sacral architecture through the "marking" of the occupied territories with images that changed the authentic architecture to a foreign one (Taras, 2018). The sacred image of a large part of Ukraine is shaped by imposed architectural forms. Examples of churches of the Theresian type include the church in Liubyntsi, the church in Staryi Sambir, in Khust, in the villages of Yasynia and Poroshkovo, in the village of Ruska Dolyna, and in other towns and villages of Galicia and Carpathian Ukraine. In most cases, the ancient three-story temples were rebuilt according to the scheme developed by Austrian architects (Fig. 1).

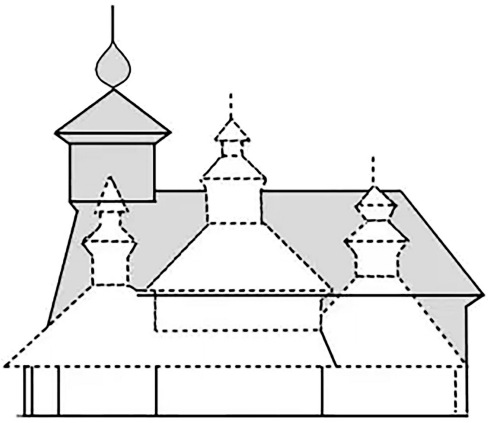


Figure 1. Reconstruction of the Ukrainian church in the village of Vyshniy Hrabovets
Source: Ya. Taras (2018)

In the territory controlled by the Russian Empire, after the National Liberation uprising (1863-1864) was suppressed, mass construction of churches of the Orthodox Church of the Moscow Patriarchate, which were popularly called "Muravyovka", took place. The newly built and rebuilt stone and wooden churches had pronounced Orthodox-Russian features: onion-shaped domes, hipped roofs,

kokoshniks, decorative ornaments, etc., and their architecture reflected Russian identity. These include the Church of St. Andrew the First-Called in Khmelnytskyi, the wooden churches of the Exaltation of the Holy Cross in Kremenets and the Holy Trinity Cathedral in Vyshnivka, St. Volodymyr's Cathedral in Kyiv, and many others (Fig. 2).

Figure 2. Church of the Intercession of the Blessed Virgin Mary in the village of Zalistsi and the Church of the Holy Trinity in the village of Rakovets
Source: I. Punda (2007)

Russification also befell small and large monasteries. In 1831, the Russian autocrat Nicholas I transferred the monastery of the Pochaev Lavra to the Department of the Russian Orthodox Church. In 1833, the architect B. Mikhalovsky was sent to the monastery from St. Petersburg to begin the reconstruction of the complex. The most spectacular building of the monastery, which causes discussions between architects and art historians, was built according to the project of architect O. Shchusev – the Trinity Cathedral (1906-1912) (Fig. 3). A modern cube-shaped church with a helmet-shaped dome, decorated in the style of Novgorod-Pskov architecture, destroyed the integrity of the architectural ensemble that had been created over the centuries.

Figure 3. Trinity Cathedral of the Pochaiv Lavra
Source: photo by the authors

In the final decade of the 19th and early 20th centuries, historical processes took place on the territory of Western Ukraine, which led to a sharp increase in the national consciousness of the population. This period was defined by significant events, such as the search for national identity in the Austro-Hungarian Empire, which led to intensive temple construction and attempts to create their own national style. After the spring of the peoples, free rural and urban communities could finance the construction of their churches, and the intensification of the pace of church construction led to the need to create such architectural forms that would have the unique features of the Ukrainian church. One of the first architects who started a new stage of the revival of national church architecture in Western Ukraine was Sylvester Gavrishkevich (1834-1911), who worked as a senior adviser to the Department of the Galician governorate. The Transfiguration Church in Lviv, rebuilt according to his design, turned from a three-nave basilica into one of the best examples of single-domed cruciform Ukrainian churches.

Vasyl Nahirnyi (1848-1921), an architect and public figure, continued to explore new forms in sacred construction. Focusing on the preservation of Byzantine traditions in the church rite, the architect took the cross-domed construction of the church as a basis. Its churches were characterised by simplicity and economy, but were significantly different from Catholic churches (Duda & Pindus, 2005). A striking example of such construction is the church in the village of Zavaliv, Ternopil Region, built in 1887, which has Eastern Byzantine forms. The building has a cross-shaped plan and an eight-sided nave. The temple is crowned by a large helmet-shaped dome with a crown placed on a high light drum. The main entrance is located in the Western part and is distinguished by the presence of a portal with a balcony. One-domed church designed by V. Nahirnyi was also built in the village of Dmytre, Pustomytivskyi district, in 1892. The temple is cruciform in plan with eight cornerstone pylons covered with small domes. The nave of the

building is topped by a dome with an openwork lantern, which stands on a luminous octagonal drum with arched windows. The roofs are gabled, and the walls are decorated with plasterwork, lobes, and an arch frieze. The main entrance is highlighted using a portal with arched decor and a rosette window (Fig. 4).

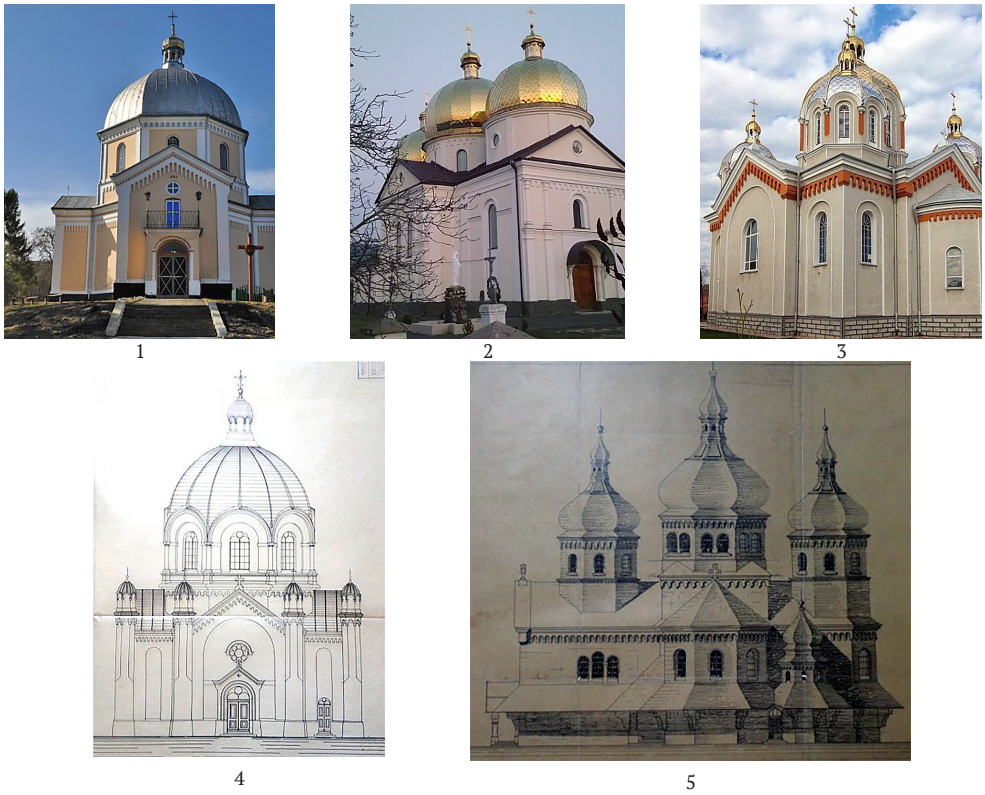


Figure 4. Churches by architect Vasyl Nahirnyi
Notes: 1 – Church of St. Michael the Archangel in Zavaliv village; 2 – Church in Chervone village; 3 – Church of St. Nicholas in Kopychenka; 4 – church project in Dmytre village; 5 – wooden church project in Bystre village
Source: 1-3 – photo by the authors; 4-5 – archives of Borys Voznytsky Lviv National Art Gallery (n.d.)

Churches that resemble authentic Ukrainian wooden churches in their three-dimensional design were built according to the project of V. Nahirnyi in the villages of Chervone, Utishkiv, and Mykolaiv. Their three-tiered structure is emphasised by the three domes, which are located above the babinets, the central nave, and the altar (Taranushenko, 2017). The author is also responsible for the appearance of five-domed churches in Galicia, which are a feature of Ukrainian cities and large villages (Fig. 4). The archives of the National Museum of Lviv contain drawings of such churches for Kalush, Kopychenets, Skhidnytsia, Yavoriv, Hlynsko, etc. The analysis of Vasyl Nahirnyi's churches shows that, even though they are similar in their layout, each building has its own unique stylistic features. This is expressed in the plan, in the decoration, in the shapes of the domes and lanterns, in the different shapes and heights of the drums. The architect often used arcaded decoration, pilasters, lobes, and porticos, but despite all the variety, the image of Vasyl Nahirnyi's churches points to their original Ukrainian character and Byzantine church rite.

Vasyl Nahirnyi's son Yevhen also devoted his work to the search for a national modern style in church architecture. He was the author of more than 200 wooden and stone temples (Fig. 5). Historical events in Galicia developed in such a way that most of the designed shrines remained undeveloped, but archival materials indicate a variety of stylistic trends in his work. The architect used the cross-bath type of the church in his design solutions, and Cossack Baroque architecture had a great influence on his work (Hrytsiuk, 2004; Cherkes & Diachok, 2019). The architect Yakov Rudnitskyi introduced elements of Byzantine architecture in temple construction (Fig. 6). He presented his creative works at competitions of projects of Greek Catholic churches and exhibitions (Slobodian, 2005). An analysis of the work of Western Ukrainian architects shows that the authors reinterpreted and combined the traditions of Byzantine and local centuries-old experience and considered the latest trends in European construction (Cherkes & Diachok, 2019). The growth of the national consciousness of the people led to the search for a modern Ukrainian artistic style, which in temple construction was expressed by stylisation of folk art as a key principle of its development. After the annexation of Western Ukraine by the USSR, architectural experiments and the construction of churches in general were stopped. Only after gaining Ukrainian independence did a new stage

of church construction begin. A significant number of modern architects are directly involved in the design and construction of new churches, and in the restoration of existing ones. The image of authentic sacral architecture and the ideas of architects who created in the early 20th century became key for their creative implementation of their projects. Bolder experiments in church architecture began after 2000 (Diachok, 2018).

Figure 5. Creative works by architect Yevhen Nahirnyi
Notes: 1 – church project in Mokryany Velyki; 2 – church in Busk; 3-4 – church project in Dunkovychi; 5 – sketch for the church in Manayiv; 6 – sketch for the church in Didyliv
Source: archives of Borys Voznytsky Lviv National Art Gallery (n.d.)

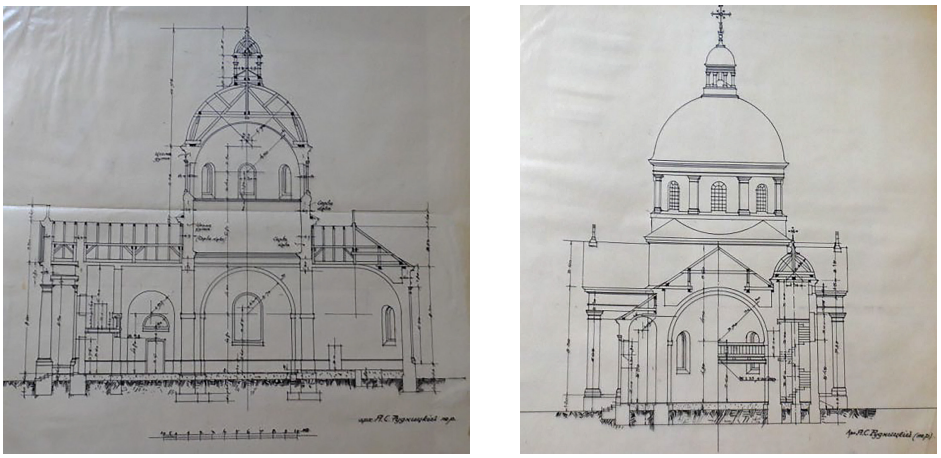


Figure 6. Church in Yuskovychi
Notes: architect – Y. Rudnytskyi
Source: archives of Borys Voznytsky Lviv National Art Gallery (n.d.)

Thus, a comparison of the results of the study with the data of other researchers shows that they focus on socio-political processes that influenced the development and expression of identity in the architecture of Ukrainian churches. Special attention was paid to Ukrainian architects, who at the beginning of the 20th century were actively looking for a visual image of the Ukrainian church that could form the identity of the Ukrainian people. Many researchers point out that the search for a national style in the architecture of the church is not complete and continues.

CONCLUSIONS

The study reveals the concept of "national identity"; shows the process of creation and problems of Ukrainian identity related to the historical past. The role of the artistic and creative elite of the nation, including architects, in the process of forming national identity is determined; the reasons for changes, transformation and visualisation of identity by architectural means are shown. The importance of the image of Ukrainian sacral architecture for establishing national identity was determined. The influence of socio-political factors on Ukrainian sacral architecture was shown. This art history analysis of three-dimensional compositions of sacred buildings from different periods of development of Ukrainian architecture. The process of creating a national style in the church architecture of modern Ukraine was considered.

The conducted research shows the importance of reflecting national identity in architecture, the importance of its expression in the architecture of the church, preservation of Ukrainian churches as a genetic memory of the nation. A prospect for further research is the scientific search for a new modern visual image for the Ukrainian church, which is formed under the influence of such socio-political processes as: the receipt of the Tomos of Autocephaly of the Orthodox Church of Ukraine, ecumenical trends and the war for independence, and the identity of the Ukrainian nation. Architects should get rid of other people's architectural forms both in the East and in the West of the state. The struggle for a united, independent Ukraine requires that architecture have those markers that will indicate its national character. Modern architects and researchers of sacral architecture face a difficult task that builders did not have time to solve at the beginning of the 20th century, which they did not consider necessary to solve throughout the entire period of independence – to find architectural forms that will reflect and form the identity of the united, conciliar Ukraine.

ACKNOWLEDGEMENTS

The authors express their gratitude to the researchers of the State Archives of the Ternopil Region (Ternopil), the staff of the Archives of the Department of Culture and Tourism of the Ternopil Region Military Administration (Ternopil), and the researchers of the Archives of Borys Voznytsky Lviv National Art Gallery (Lviv) for providing archival materials that made the research possible.

CONFLICT OF INTEREST

None.

REFERENCES

[1] Anderson, B. (1991). *Imagined communities: Reflections on the origin and spread of nationalism*. London, New York: Verso.
[2] Belogolovsky, V. (2022). *Ukrainian architect Oleg Drozdov talks about building at the time of war*. Retrieved from https://www.stirworld.com/think-columns-ukrainian-architect-oleg-drozdov-talks-about-building-at-the-time-of-war.
[3] Borys Voznytsky Lviv National Art Gallery. (n.d.). Retrieved from https://lvivgallery.org.ua/.
[4] Cherkes, B. (2008). *National identity in the architecture of the city*. Lviv: Lviv Polytechnic National University.
[5] Cherkes, B., & Diachok, O. (2019). Problems of maintenance of sacral buildings on an example in small cities and villages of Western Podillya. *Space & Form*, 37, 9-16. doi: 10.21005/pif.2019.37.B-01.
[6] Dahbour, O. (2002). National identity: An argument for the strict definition. *Public Affairs Quarterly*, 16(1), 17-37.
[7] Delanty, G., & Jones, P.R. (2002). European identity and architecture. *European Journal of Social Theory*, 5(4), 453-466. doi: 10.1177/136843102760514009.
[8] Diachok, O. (2018). Ternopil architects in the process of revival of sacral construction of Ukraine. *Modern Problems of Architecture and Urban Planning*, 51, 26-34.
[9] Duda, I., & Pindus, B. (2005). Vasyl Stepanovych Nahirnyy. In *Ternopil encyclopedic dictionary*. Ternopil: Zbruch.
[10] Habrel, M. (2003). The philosophical and ideological component in the architectural and spatial organization of regional systems. *Bulletin of Lviv Polytechnic National University*, 486, 292-301.
[11] Hnatenko, P., & Pavlenko, V. (1999). *Identity: Philosophical and psychological analysis*. Kyiv: Art-Press.
[12] Hnidets, R. (2004). Tradition of sacral architecture as a factor in the establishment of spirituality and faith. *Bulletin of LSAU. Architecture and Agricultural Construction*, 5, 199-208.
[13] Hrytsiuk, L. (2004). *Creative legacy of Evhen Nahirnyy and its importance for the development of Ukrainian architecture*. (Doctoral dissertation, Lviv Polytechnic National University, Lviv, Ukraine).
[14] Huntington, S.P. (1997). *The clash of civilizations and the remaking of world order*. Gurugram: Penguin Books India.
[15] Huntington, S.P. (2005). *Who are we? America's great debate*. New York: Free Press.
[16] Kalach, V. (2011). Religious identity of Ukrainian citizens and sociocultural transformations. *Bulletin of Taras Shevchenko National University of Kyiv*, 15, 37-39.
[17] Latief, J. (2018). *How architecture shapes national identity and helps us understand history*. Retrieved from https://www.designindaba.com/articles/creative-work/how-architecture-shapes-national-identity-and-helps-us-understand-history.
[18] Lee, C.P. (2015). *Training the party: Party adaptation and elite training in reform-era China*. Cambridge, UK: Cambridge University Press.

[19] Linda, S. (2003). The presence of history in the architecture of Soviet and Post-Soviet Ukraine. *Bulletin of Lviv Polytechnic National University*, 486, 147-158.
[20] Linda, S., Milchevych, S., Motyl, R., Boiko, K., & Berezovetska, I. (2022). National representation through visual form: The phenomenon of national style in architecture. *AIP Conference Proceedings*, 2574, article number 140003. doi: 10.1063/5.0105610.
[21] Liu, Q., & Turner, D. (2018) Identity and national identity. *Educational Philosophy and Theory*, 50(12), 1080-1088. doi: 10.1080/00131857.2018.1434076.
[22] Marquard, O., & Stierle, K. (1979). *Identity*. Munich: Fink Verlag.
[23] Merkatun, I. (1991). Anti-religious campaign of the 1950s and 1960s in Ukraine. *Ukrainian Historical Journal*, 10, 70-76.
[24] Miroshnichenko, V. (2022). Development of the Ukrainian identity of border guards in the context of national security of the state. In *Innovative scientific research in the field of pedagogy and psychology: Materials of the international scientific and practical conference* (pp. 120-123). Zaporizhzhia: Classical Private University.
[25] Miščević, N. (2022). Is national identity essential for the identity of persons? In *Nationalism and beyond: Introducing moral debate about values* (pp. 217-238). Budapest: Central European University Press. doi: 10.1515/9789633865286-015.
[26] Novak, O. (2004). Church life in Western Ukraine and on the Right Bank in the second half of the 17th-18th centuries. *History of Ukraine*, 17, 13-15.
[27] O'Neil, P.H., Fields, K., & Share, D. (2020). *Cases and concepts in comparative politics*. New York: W. W. Norton & Company.
[28] Pandya, S. (2020). Architecture in national identities: A critical review. *National Identities*, 22(4), 381-393. doi: 10.1080/14608944.2020.1812825.
[29] Pasichnyk, V. (2019). The national idea as a factor in the formation of the national identity of Ukraine. *Efficiency of Public Administration*, 60, 52-68. doi: 10.33990/2070-4011.60.2019.186745.
[30] Perevezii, V. (1998). *Educational activities of the Ukrainian Greek Catholic Church in the 20-30s of the 20th century*. (Doctoral dissertation, National Pedagogical Dragomanov University, Kyiv, Ukraine).
[31] Prokaieva, V. (2011). UNESCO's role in preserving the cultural heritage of humanity. *Scientific Bulletin of the Diplomatic Academy of Ukraine*, 17, 82-88.
[32] Prybeha, L. (2023). Historic residential building of the centre of Kyiv second half 19th-early 20th centuries in the monument preservation dimension. *Collection of Scholarly Works "Ukrainian Academy of Art"*, 33, 50-59. doi: 10.32782/2411-3034-2023-33-6.
[33] Punda, I. (2017). *Wooden Churches of Western Ukraine*. Retrieved from http://decerkva.org.ua/ter/pidhaitsi.html.
[34] Rahmat, M.H., & Ismail, A.S. (2022). Review on national identity in architecture through the understanding of its roles, typologies and themes. *International Journal of Law, Government and Communication*, 7(27), 1-12. doi: 10.35631/IJLGC.727001.
[35] Serhiichuk, V. (2001). *The unconquered church: The heroism of the Greek Catholics of Ukraine in the struggle for faith and state*. Kyiv: Dnipro.
[36] Shevtsova, H. (2019). *The genesis of the Ukrainian wooden church: World context and uniqueness*. Kharkiv, Kyiv: Publisher Oleksandr Savchuk.
[37] Shevtsova, H., & Ponomarenko, H. (2020). Romantic works of wooden sacred architecture of architect Oleg Sleptsov: world and national ideas of form creation. *KNUBA Architectural Bulletin*, 20-21, 73-104. doi: 10.32347/2519-8661.2019.20.73-106.
[38] Sistac, E. (2022). *Photo essay: National identity expressed in architecture*. Retrieved from https://identityhunters.org/2022/02/04/photo-essay-national-identity-expressed-in-architecture/.
[39] Skotte, H. (2010). *The state of identity in contemporary architecture*. Retrieved from https://www.architecturenorway.no/questions/identity/skotte-identity/.
[40] Sladky, D. (2008). National identity as a factor of national and international security. *Political Management*, 2(29), 110-119.
[41] Slobodian, V. (1996). Catalog of existing wooden churches of Ukraine and Ukrainian ethnic lands. *Bulletin of the Institute "Ukrzakhidproekrestavratsiya"*, 4, 74-159.
[42] Slobodian, V. (2005). Architect Lev Levinsky. *Bulletin of the Institute "Ukrzakhidproektrestavratsiya"*, 15, 12-21.
[43] Smith, A.D. (1994). The problem of national identity: Ancient, medieval and modern? *Ethnic and Racial Studies*, 17(3), 375-399. doi: 10.1080/01419870.1994.9993832.
[44] Stotskyi, Ya. (2008). *State and religions in the Western regions of Ukraine: Confessional transformations in the context of state policy 1944-1964*. Kyiv: FADA, LTD.
[45] Sukhyi, O. (1999). *Galicia: Between East and West*. Lviv: Lviv National University named after I. Franko.
[46] Taranushenko, S. (2017). *Wooden monumental architecture of the Left Bank of Ukraine*. Kharkiv: Publisher Oleksandr Savchuk.
[47] Taras, Ya. (2018). *The architecture of wooden temples of Ukrainian Carpathians: Cultural and traditional aspect*. Kharkiv: Folio.

[48] Walsh, J. (n.d.). *Architecture and national identity*. Retrieved from https://www.nzia.co.nz/explore/articles-and-essays/architecture-and-national-identity/.

Богдан Черкес
Доктор архітектури, професор
Національний університет «Львівська політехніка»
79000, вул. Степана Бандери, 12, м. Львів, Україна
https://orcid.org/0000-0001-6809-956X
Оксана Дячок
Доктор архітектури, професор
Західноукраїнський національний університет
46009, вул. Львівська, 11, м. Тернопіль, Україна
https://orcid.org/0000-0002-5808-6826
Юзеф Гернік
Доктор габілітований, професор
Аграрний університет в Кракові
31-120, алея Адама Міцкевича, 21, м. Краків, Польща
https://orcid.org/0000-0001-7335-1600

Теоретичні дослідження ідентичності в сакральній архітектурі України

Анотація. Сучасна реконструкція центральних районів у містах та селах з історичним довкіллям викликає дискусії щодо питань охорони культурної спадщини. Пам'ятки архітектури є відображенням зміни ідейно-політичних трансформацій в суспільстві, а відношення до них є віддзеркаленням культури нації. Необхідність бережного ставлення до старовинних українських святинь як генетичної пам'яті нації, будівництво сучасних храмів, які матимуть риси нової української церкви стали ще більш значимими у часи російського вторгнення в Україну. Актуальність дослідження зумовлена загостренням суспільно-політичних і національно-культурних проблем та недостатнім висвітленням у наукових працях процесу творення та відображення ідентичності в українських храмах. Метою статті є дослідження процесу формування національної ідентичності та її візуалізації архітектурними засобами при створенні українських храмів. Для досягнення мети були використані такі методи дослідження: емпіричні (пошук літературних та архівних джерел, спостереження, порівняння та опис), теоретичні (порівняльний та композиційний аналіз, класифікація та узагальнення) та спеціальні методи дослідження (натурне обстеження храмів, їх фотофіксація, виявлення характерних особливостей та ознак, дослідження ретроспективного розвитку). Усе це дало змогу дослідити процес становлення та розвитку архітектури українських автентичних церков у хронологічній послідовності, показати процес створення нового українського сакрального стилю, який став прообразом творчих пошуків сучасних архітекторів. Автори зосередили увагу на ролі художньої та творчої еліти у створенні національної ідентичності; показали проблеми творення української ідентичності, пов'язаної з історичним минулим; проаналізували вплив соціальних та політичних факторів на українську сакральну архітектуру та можливість візуалізації за допомогою архітектури образу національної церкви; відзначили важливість образу української сакральної архітектури для підтвердження національної ідентичності. Проведені дослідження переконують у важливості збереження давніх українських храмів, які несуть генетичну пам'ять нації, доповнюють дані про формування сакральної архітектури, відкривають шлях для подальших наукових пошуків. Практична цінність наукової роботи полягає в тому, що отримані результати можуть бути використані архітекторами при проектуванні сучасних українських храмів, будуть корисні в музейній праці та в навчальній діяльності з підготовки фахівців архітектури та дизайну

Ключові слова: автентичність; українські храми; об'ємно-просторова композиція; культурна спадщина; українська нація

Architectural Studies
International Journal about Architecture

Volume 10, No. 1

UDC 721.021:330.131.5
DOI: 10.56318/as/1.2024.69

Gentjana Rexhaj*
Master of Engineering
Mendel University in Brno
613 00, 1665/1 Zemědělská Str., Brno, Czechia
https://orcid.org/0009-0003-1709-4736

The role of building information modelling in the implementation of sustainable, environmentally friendly, and social infrastructure projects

Abstract. The realities of the 21st century in the context of overpopulation, political changes and economic challenges require the development and implementation of infrastructure projects that ensure the sustainability of resource use and have a minimal negative impact on the surrounding natural ecosystems. The purpose of this study is to substantiate and evaluate the main aspects of Building Information Modelling its possibilities and its advantages in the construction of sustainable infrastructure in the context of energy efficiency, balanced use of resources, implementation of environmentally friendly technologies, improvement of the principles of landscaping and improvement of people's quality of life. A number of general theoretical research methods were used, in particular: the methods of analysis and synthesis, the method of interviewing, the method of deduction and induction. The analysis of scientific articles showed an insufficient number of publications that reveal the features of the use of modern information modelling technologies in the design of environmentally safe, sustainable and socially responsible infrastructure. The study described the overall impact of Building Information Modelling on the environmental aspect of infrastructure activities. The peculiarities of the application of Building Information Modelling technology in environmental impact assessment were substantiated. The social aspect of information modelling of infrastructure projects was also analysed. The importance of building modelling using integrated approaches for safety assessment and management decision-making was emphasized. The problems in the processing of Building Information Modelling model information, which mostly concern socio-technical aspects, were revealed. The structure of the methodology of information modelling of buildings was substantiated in the context of a significant reduction of harmful emissions, energy saving, the use of environmentally friendly technologies and materials. The practical significance of the study lies in the integration of information modelling into the processes of construction, planning, monitoring and risk management in the long term, which allows to ensure the effective implementation of projects and the avoidance of environmental, technical and social problems in the future

Keywords: integrated technologies; ecological monitoring and assessment; energy efficiency; digital innovation; risk and security

INTRODUCTION

With the enlargement of the European Union to include new member states, a wide range of infrastructure network planning has emerged, encompassing areas such as road, sewer, civil engineering, and pipeline construction. These developments are in line with global efforts to make infrastructure projects more sustainable, environmentally

Suggested Citation:
Rexhaj, G. (2024). The role of Building Information Modelling in the implementation of sustainable, environmentally friendly, and social infrastructure projects. *Architectural Studies*, 10(1), 69-78. doi: 10.56318/as/1.2024.69.

Journal homepage: https://arch-studies.com.ua/en#
Architectural Studies, 10(1), 69-78
Received: 11.01.2024 Revised: 23.04.2024 Accepted: 20.06.2024

*Corresponding author

friendly, and socially responsible. In this context, Building Information Modelling (BIM) plays a crucial role by forming the core of the planning and construction process and enabling comprehensive monitoring of the construction project at all stages. The relevance of this research is driven by the need to educate engineering firms and other stakeholders on the potential benefits, challenges and wider implications of implementing BIM in infrastructure development. Promoting a comprehensive understanding of the synergistic relationships between BIM and Environmental, Social, and Governance (ESG) criteria is extremely important for sustainable infrastructure development.

Digitalization has also become increasingly important in the construction industry since 2010s. As digitalization has progressed, BIM has established itself as a methodology that goes far beyond a simple software program (Prokopenko & Povolotskyi, 2022). Unlike traditional 2D planning, BIM offers the integration of time (4D), cost (5D), sustainability aspects (6D) or facility management information (7D) outside the 3D model, enabling more efficient management construction projects and provides transparency of documentation for decades, as noted by R. Charef *et al*. (2018).

The methodological basis of BIM in the context of a complex process includes the creation and management of digital models of buildings or infrastructure measures according to the rationale of S. Theißen *et al*. (2020). BIM models contain more detailed information such as soil layers, planned pipe layouts, or even specific product sheets for specific components.

Infrastructure planning encompasses a variety of aspects, from the design of large transportation networks to the planning of utility systems, according to data analysis by A. Sharafat *et al*. (2021). These projects are often highly complex and involve a large number of interfaces with other trades, some of which cannot be easily integrated into a BIM model. For example, there is still a lack of options for integrating information on the ground conditions into the BIM model, as soil experts, for example, deliver their results as written reports and not as a visual BIM model.

Old existing underground pipelines are often unreliable and, in some cases, only available as old paper plans. Especially for large linear structures, many BIM software tools are not yet (as of 2024) designed to accurately display global coordinate systems such as Universal Transverse Mercator. Therefore, the integration of BIM methodology into these processes is a complex task that requires adaptation of existing BIM tools and practices according to the research of M.Q. Huang *et al*. (2020). This adaptation should take into account both the specific requirements of infrastructure projects and the existing working methods of the involved stakeholders.

A key aspect of using BIM in infrastructure planning, according to the statements A.M.I. Raouf & S.G. Al-Ghamdi (2018), is the consideration of the long-term perspective. Infrastructure projects often have a very long-life cycle, and decisions made during the planning phase have long-term consequences. Therefore, the ability of BIM to cover and model the entire project life cycle is extremely important. This includes consideration of aspects of sustainability, long-term maintenance and operation costs, and adaptability to future needs and technologies.

Thus, BIM plays a key role in the implementation of sustainable, environmentally friendly infrastructure projects. However, there are aspects that require more attention and further research, in particular: integration of energy efficiency in modern engineering and planning solutions, ensuring the principles of inclusiveness in projects, environmental assessment and rational choice of building materials, social responsibility of infrastructure projects. The purpose of the study was to substantiate the BIM and ESG criteria in the context of a balanced partnership and to promote a sustainable, holistic approach to the implementation of infrastructure measures, taking into account the principles of resource conservation, management efficiency, the use of renewable energy sources, improving safety, working conditions and social responsibility.

MATERIALS AND METHODS

A literature review and qualitative expert interviews, which were analysed using the structuring of scientific content, were two main methods in this article. The combination of these methods enables a comprehensive analysis that provides both theoretical knowledge and practical insights into the application of BIM about ESG issues. The research questions guiding this study are:

1. RQ1: How can BIM help to improve the environmental sustainability of infrastructure projects?
2. RQ2: How can BIM be used to promote social aspects such as occupational safety in infrastructure projects?
3. RQ3: How does BIM influence transparency and communication between stakeholders in construction projects?

The qualitative literature analysis followed a systematic approach proposed by A. Fink (2019) and is divided into six steps:

1. Defining the research questions.
2. Selection of suitable databases.
3. Definition of the search terms.
4. Definition of the research period.
5. Definition of selection criteria.
6. Conducting the analysis.

Scopus, Web of Science, Google Scholar, and IEEE Xplore databases were used during the study to create a comprehensive database for deductive qualitative content analysis. The search terms included key concepts such as “BIM”, “infrastructure”, “ESG”, “environmental sustainability”, “occupational safety”, and “transparency” and were used in various combinations to identify the relevant literature (Fig. 1). Particular attention was paid to linking these terms with BIM. In addition, care was taken to ensure that the literature also dealt with the consideration of infrastructure measures.

Keywords 1	Keywords 2	Databases
• Environmental sustainability, environmental impact, green building • Workplace safety, social responsibility • Governance, transparency, stakeholder communication	• BIM and/or infrastructure	• Web of Science • Scopus • Google Scholar • IEEE Xplore

Figure 1. Search string and databases

Source: compiled by the author

The time period for the study was set from 2007 to December 2023 in order to capture the developments and applications of BIM since its introduction in Europe. The sources analysed included primarily scientific articles and project presentations that contained at least one of the ESG keywords. The use of different search strategies – from keyword and free text searches to targeted searches in titles and abstracts – made it possible to capture a broader range of information. This method made it possible to gain deep insights into existing research and to identify patterns and gaps in the current literature, which is essential for answering the research questions.

Qualitative expert interviews were conducted to further deepen and validate the insights gained from the literature analysis. These interviews served to capture current, practice-based knowledge and experiences that may not yet be fully reflected in the academic literature. This approach is particularly valuable in gaining a deeper understanding of the practical application and challenges of BIM in relation to ESG issues in infrastructure planning. The selection of experts focused on experience in infrastructure planning using the BIM method. This included experts from different hierarchical levels in engineering firms – from management level to project engineers – as well as experts from cooperating companies, such as consulting firms and software vendors. Limiting the sample to the areas of transport infrastructure and water supply and disposal enabled a focused and in-depth analysis with regard to infrastructure planning (Huang *et al.*, 2022; von Soest, 2022).

During the interview, the main principles and provisions of the code of ethics were applied. In particular, the diversity of the respondents, mutual respect, the opportunity to express themselves in the language that is most convenient to master, the protection and confidentiality of information in accordance with local and international ethical standards, the avoidance of any forms of discrimination based on gender, race, age, disability or other factors were taken into account factors (Global Code of Ethics, 2021). The interviews were conducted to the point of theoretical saturation, with a total of 19 expert interviews conducted. The interviews were based on a carefully developed interview guide containing ten open-ended main questions in four thematic blocks. These questions served as conversation starters and were supplemented by specific follow-up questions to deepen the discussion and obtain more detailed information. The interviews were recorded and then transcribed to ensure a precise and comprehensive analysis. The interviews were analysed using MAXQDA software (Kuckartz & Rädiker, 2019), which enables efficient and systematic analysis of both the qualitative and quantitative elements of the interviews. While the qualitative analysis focused on summarizing and interpreting the content, MAXQDA also supported the quantitative frequency analysis by making the frequency of certain themes and opinions visible. This combined method of analysis helped to present a more complete picture of the different perspectives and experiences.

The results were presented descriptively and then critically examined to highlight both the potentials and challenges of BIM in the context of ESG in infrastructure planning. The use of MAXQDA ensured a high level of transparency and traceability in data processing and evaluation, which is essential for the credibility and reliability of the study results.

RESULTS

The overall results of the literature research on the influence of BIM on ESG in infrastructure measures are shown in Figure 2. After removing duplicates and a subsequent examination of the abstract and full text, 20 publications were found and thoroughly analysed. The deductive keywords were not discussed directly in the articles found, which is why an inductive categorization was carried out first, in which categories were derived from the texts. The inductive categories were then assigned to the superordinate categories (Table 1).

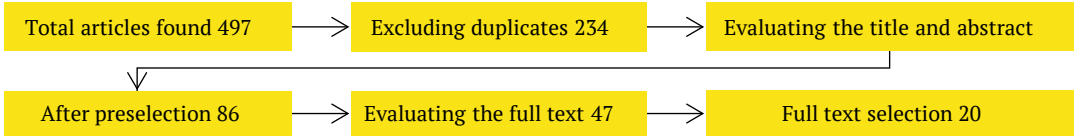


Figure 2. Systematic literature search

Source: compiled by the author

Table 1. Deductive and inductive categorization

Deductive	Inductive
Environmental sustainability, environmental impact, green building	Sustainability in infrastructure projects
	BIM in the context of sustainable buildings
	BIM in environmental assessment
	Digital twin in sustainability assessment
	BIM for energy-efficient construction
	Road design through shadow analysis
	CO_2 savings through sustainable building approaches
	Integration of environmental assessment into the design process
	Material selection and CO_2 footprint
Workplace safety, social responsibility	Factors that influence social collaboration in BIM projects
	Safety in educational institutions
	Prevention of accidents at work
	BIM for safety assessments
	Use of technology for safety in the workplace
	Humanistic approach to infrastructure management
Governance, transparency, stakeholder communication	Data Governance Act
	Adapting to future requirements and uncertainties
	Challenges in the processing of BIM model information
	Communication efficiency through BIM
	Implementation of BIM in communication networks

Source: compiled by the author according to J.Á. Aranda *et al*. (2021), M. McPherson *et al*. (2022), G.T.N. Veerendra *et al*. (2022), A. Laali *et al*. (2022), C.X. Hui *et al*. (2023), Z. Yang *et al*. (2023), N.F. Arenas & M. Shafique (2023)

The results of the literature analysis showed an unexpected distribution of the thematic focus of the articles with regard to infrastructure measures. Although the primary aim of the analysis was to identify literature explicitly dealing with infrastructure measures, the study revealed a lack of articles directly focused on this area. Specifically, the analysis revealed that only 35% of the articles analysed dealt explicitly with infrastructure measures. Interestingly, although 25% of the articles contained the keyword "infrastructure", they referred to infrastructure-related building construction, such as hospital buildings. While these articles provided relevant insights, they did not focus primarily on infrastructure in the narrower sense. In addition, 40% of the articles were classified as thematically neutral. These articles covered topics that are relevant to both infrastructure measures and other areas in a broader context. This category of articles therefore offers potential starting points for the application of BIM in different contexts of infrastructure planning and development.

A graphical representation of this distribution is shown in Figure 3. These results illustrate the thematic focus of the articles found in the literature and highlight the need to intensify research in specific areas of infrastructure interventions in order to better understand the application and impact of BIM in this sector.

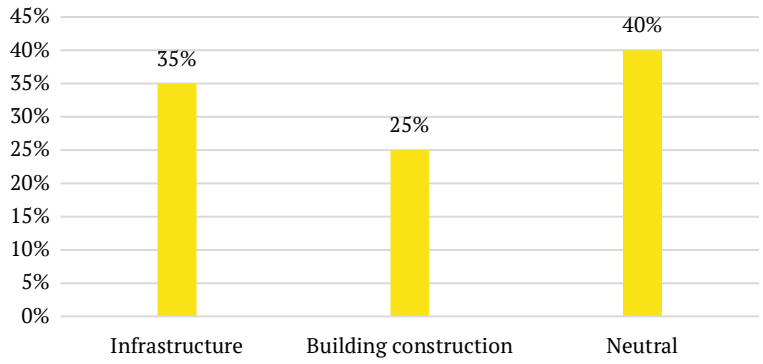


Figure 3. Thematic focus of the literature examined

Source: compiled by the author

Given the thematic limitations identified within the existing literature with regard to specific infrastructure measures, there is a need to broaden the perspective and tap into additional sources of information. That is why qualitative interviews of respondents play a key role in the results of this study. These interviews offer the opportunity to gain practical and detailed insights into the impact of the BIM method on ESG issues in the context of infrastructure projects.

Influence of BIM on the environmental aspect of infrastructure measures. BIM enables significant progress in the context of sustainable buildings. By integrating BIM into the design and construction process, more environmentally friendly materials can be selected and used more efficiently, contributing to a significant reduction in carbon emissions. This is reinforced by the integration of Life Cycle Assessments (LCA) and energy efficiency analysis into BIM processes, leading to a reduction in carbon emissions (Wang, 2022).

BIM has a substantial influence on the environmental aspect of infrastructure measures. The adoption of BIM in infrastructure projects can lead to several environmental benefits and improvements (Fig. 4).

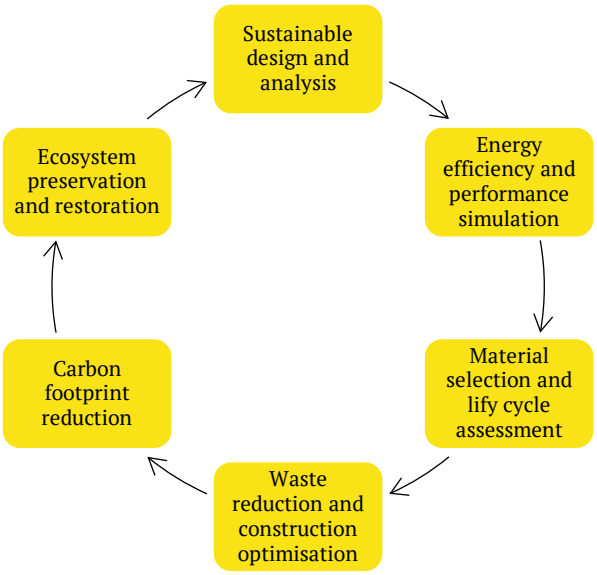


Figure 4. The main aspects of the impact of BIM on the environmental aspect of infrastructure measures
Source: compiled by the author according to Y. Yang *et al*. (2021), A. Rodríguez-Amigo *et al*. (2022), A.R. Nasab *et al*. (2023)

BIM enables the evaluation of materials and components based on environmental criteria LCA tools integrated into BIM software help assess the environmental impact of materials throughout their life cycle, aiding in the selection of more sustainable options (Chen *et al*., 2023; Kalajian *et al*., 2023). The adoption of BIM in infrastructure measures contributes significantly to addressing environmental challenges by promoting sustainable design, optimizing construction processes, and facilitating ongoing environmental monitoring and management. This results in infrastructure projects that are not only efficient and cost-effective but also environmentally responsible and resilient. By using BIM technologies in environmental impact assessment, it becomes possible to enable or optimize the energy-efficient integration of construction measures and materials, which leads to a further reduction in overall energy consumption (Shalbolova *et al*., 2021). BIM thus offers an opportunity for an in-depth assessment of the sustainability and environmental impact of measures, which contributes to the environmentally conscious implementation of infrastructure projects. Also related to BIM is the so-called digital twin, which enables realistic simulation and analysis, providing precise insights into environmental impacts and life cycle costs. This technology not only supports a comprehensive assessment of the environmental impact of projects, but also enables agile adaptation to changing environmental conditions and resource availability (Borjigin *et al*., 2022).

BIM, in combined with a geographic information system, can make environmental impact assessments more efficient, as environmental data and information on existing animal and plant species can be used to optimize the consideration of structure in the environment and assessment options. also, more efficient. For example, when building a new road, one might study how the road should be built to avoid the need to relocate animal species. It may also be possible to study how the integration of a new road will affect the environment in the long term, in which areas compensation measures for animals are needed, or whether compensation measures for plants need to be created (Noor *et al*., 2022; Moudgil *et al*., 2023). By integrating BIM into the design and construction process, energy consumption and CO_2 emissions can be significantly reduced, leading to a more efficient use of resources and a reduction in environmental impact. This methodology supports the development of smart cities by providing intelligent solutions for energy management and resource optimization.

The social impact of BIM in infrastructure projects. As a result of interviewed respondents, in particular engineers, designers, planners, it was established that BIM has a significant social impact on infrastructure projects, affecting various stakeholders and aspects of project development. However, the use of information modelling technologies has both advantages and disadvantages from the point of view of social perception. The social impact in BIM projects is influenced by factors such as management commitment, guidelines, work process manuals and individual willingness to adapt to digital practices. Effective collaboration is promoted through the integration of BIM execution plans.

The respondents describe that it is necessary to create an awareness of BIM, especially at senior management level. The respondents describe that the switch from conventional planning to BIM results in additional work, particularly in the earlier service phases, which also increases the working time of employees in these initial phases. The modelling of the buildings requires more time at the beginning, which must be taken into account by the managers. It is important to make certain internal determinations and to allow more time for the initial planning phases in particular and to communicate this information to all employees and clients. It is also necessary to consider the higher costs of training and software and to be prepared to invest in staff training.

The respondents emphasize the importance of BIM, particularly in relation to safety assessments and decision making. The focus is on using BIM for visualization, understanding and transparency in construction projects, as well as combining it with multi-criteria decision-making methods to incorporate environmental metrics and social factors into the decision-making process. The implementation of BIM-based systems helps to minimize fall hazards and accidents in the construction industry. Early identification of hazards and alternative design recommendations are key elements to increase occupational safety. BIM supports safety assessment and decision-making through visualization and transparency. This includes the integration of LCA and multi-criteria decision methods to systematically incorporate safety aspects into the planning process. In this way, BIM can be used to identify and manage safety risks in construction projects with many interfaces.

The respondents also describe that with the BIM methodology, the number of workers required on the construction site can be determined more efficiently, and the exact knowledge of the areas and masses required on the construction site can also be used to more accurately check how many workers are required on the construction site. The timeline of the construction project can also be tracked in the long term and potential safety gaps and problems can be identified so that problems can be addressed at an early stage and, for example, additional employees can be provided so that the project does not have to be overloaded or postponed.

In one of the case studies, the use of virtual fences to prevent accidents at work using Bluetooth Low-Energy is being used. To prevent accidents, the areas on the construction site are evaluated according to the safety aspect and it is determined which areas may not be entered during certain construction phases. Such system can be integrated cost-effectively and easily into the BIM method (del Carmen Rey-Merchán *et al*., 2021). In addition, C.M. Chang *et al*. (2023) emphasize the humanistic approach in infrastructure management. This approach expands the focus of BIM beyond technical and environmental aspects to also consider social factors in the planning and execution of infrastructure measures. BIM supports efficient coordination and communication between the various employees, promotes transparency and enables the participatory design of projects that are both environmentally friendly and socially responsible.

3D modelling makes it easier for employees to read the plan. It is no longer necessary to display three different plans from three different perspectives. In infrastructure planning in particular, it is becoming increasingly common for employees to find it difficult to understand longitudinal plans in particular, because collisions are not always immediately recognizable in conventional 2D plans. In addition to improving understanding, BIM modelling also provides greater transparency, as all employees can access the same model and can highlight any problems or errors directly in the plan.

DISCUSSION

This study examines the role of BIM in the implementation of infrastructure measures, with a focus on the integration of ESG criteria. The results show that BIM plays a key role in promoting sustainability, which is confirmed by the articles analysed. Thus, BIM can help to achieve ESG goals in infrastructure development. It not only promotes environmentally friendly and social construction practices, but also strengthens governance structures in construction projects. The integration of BIM into construction and planning processes can make a significant contribution to achieving sustainable goals. When examining the impact of BIM on governance, particularly in the area of data governance, the integration of BIM has a significant impact on the management and regulation of data in construction projects. The article by B. Weber *et al*. (2023) provides insights into the evolving legal framework for data sharing in BIM processes. At the same time, the impact of the European Data Management Act on common data environments is important, which requires a reassessment of existing data exchange models in the construction industry. In addition to the role of BIM in data governance, as described by the authors, BIM plays an essential role in adapting to future requirements and uncertainties.

According to these research results, it is followed the view that small and medium-sized engineering companies can find it difficult to manage large amounts of data. However, there is a downside to managing large volumes of data for large infrastructure projects, as they typically require much more storage space than smaller buildings. In infrastructure planning, projects are often 40 km long, whereas in building construction, buildings are often limited to much smaller areas. Data protection is also a major concern for information modelling professionals; guidelines and specifications are needed to define how data should be shared with other parties involved in the project. In addition, it is necessary to clearly regulate the procedure for transferring data if planning is transferred to another office or the performing construction company at a later stage in the provision of services. The challenges in processing BIM model information relate in particular to the socio-technical aspects, as highlighted by P.N. Gade & K. Svidt (2021). Their research shows that lack of flexibility and transparency in BIM systems can lead to difficulties in practice. This highlights the importance of developing BIM systems that are not only technically advanced but also adaptable in terms of user needs and ever-changing project requirements. This also makes it clear that governance in the BIM context must include not only data management, but also the consideration of socio-technical dynamics.

The present research results highlight the importance of the statement of S. Gaur & A. Tawalare (2021) and also describe the need for adaptability when applying the BIM method. They describe that not every BIM tool can be used for every infrastructure measure. For example, software that is also used in building construction can be used for smaller projects, such as Revit software for transforming

bus stops. On the other hand, other measures, such as retrofitting longer highways, require different software systems. Therefore, it is necessary to be flexible, especially when planning infrastructure, and not just use closed BIM. In addition, the transformation of infrastructure measures involves working together with cities, municipalities and many other municipal institutions, as well as with utility companies that are responsible for various lines (Sidliarenko, 2023). These stakeholders often do not have access to all software systems. Engineering firms must be willing to be transparent and communicate so that all stakeholders can access this information. Also, if these requirements are met, BIM can bring greater added value to the infrastructure, since the experience shows that there is a more frequent and intensive exchange of information, which leads to a faster reduction in the number of errors (Sakr & Sadhu, 2023).

The use of BIM in infrastructure projects has a significant impact on environmental sustainability. By integrating BIM, the planning, construction and maintenance of infrastructure projects can be made more efficient and environmentally friendly. The BIM method enables detailed monitoring and assessment of environmental impacts throughout the lifecycle of a project (Schults *et al.*, 2016). This includes the selection of sustainable paving surfaces and associated materials as well as resource optimization. BIM thus not only promotes environmentally conscious project design, but also contributes to the long-term reduction of environmental impacts and increased economic efficiency. The role of BIM in the early phase of project design is particularly noteworthy, where simulation-based analyses can be used to identify and implement environmentally friendly solutions. This makes BIM an indispensable tool for the realization of sustainable and environmentally friendly infrastructure measures (Oreto *et al.*, 2023).

The results of this study indicate that BIM in infrastructure has a positive effect on the accurate determination of mass. This gives a great advantage in the field of movement of the earth's mass, and also allows not only to accurately calculate the cost, but also to effectively plan the necessary masses on the construction site (Kutia *et al.*, 2023). This leads to a better optimization of resources, as material deliveries can be coordinated with the required quantities. But optimized for more than just cobblestone or gravel surfaces, precise materials can be determined early on, such as the exact size of sewer pipes to avoid collisions. However, some scientific reports contain concepts that characterize the BIM method, which has not yet progressed to the point where the exact position of existing routes can be traced, which is still a problem when it comes to determining the optimal quantities and laying of pipes (Correa & Santos, 2021).

S.H. Khahro *et al.* (2021) describe that a significant reduction in energy consumption and CO_2 emissions can be achieved by using BIM in conjunction with sustainable construction. Especially in the planning and construction of healthcare facilities, BIM supports efficient use of resources and promotes the implementation of energy-efficient solutions, which leads to a significant reduction in negative environmental impacts and costs. The integration of environmental assessment into the planning process using BIM can therefore improve sustainability. It turns out that BIM offers a structured method for assessing the environmental impact of infrastructure projects as early as the design phase. This makes it possible to systematically record environmental impacts and incorporate them into the planning and decision-making process at an early stage, leading to a more effective and environmentally friendly design of infrastructure projects (van Eldik *et al.*, 2020). In 2020, the construction sector was responsible for 36% of global energy consumption and 37% of energy-related CO_2 emissions (Energy-related emissions..., 2024). BIM can assist in the selection of materials to actively contribute to the reduction of the carbon footprint in construction projects. This leads to more sustainable construction decisions and a reduction in overall CO_2 emissions from construction activities, which is particularly important in the development of sustainable infrastructure.

The results of this work present characteristics of how BIM can be used to check which equipment can be used on a construction site. In traditional planning, it often happens that certain equipment is ordered to a construction site, and then it is discovered that it is too large and does not meet the existing conditions for use on the construction site. In such cases, additional work is required, resources are used unnecessarily and CO_2 emissions increase, which can be avoided by using the BIM methodology. BIM allows you to check the position and movement of certain equipment on a construction site using a 3D model for position and height. This is often particularly useful when expanding infrastructure activities, as infrastructure is often built within existing buildings and surrounding structures need to be taken into account during construction work.

CONCLUSIONS

BIM plays an extraordinary role in increasing environmental sustainability in infrastructure projects. By significantly increasing design accuracy and effectively optimizing resources, BIM makes a significant contribution to minimizing the environmental impact of construction projects. It actively promotes the implementation of green building practices and supports the use of sustainable materials.

In the field of social stability, BIM contributes to strengthening work safety. By providing improved risk reduction tools, BIM significantly contributes to safety on construction sites. In terms of governance aspects, BIM plays a key role in promoting transparency and effective communication between stakeholders. By providing real-time information, BIM supports clear and informed decision-making and facilitates intensive data sharing. In summary, it can be seen that BIM not only increases technical efficiency, but also makes a significant contribution to the achievement of ESG goals. Integrating these principles into the BIM process is a crucial step towards more sustainable, responsible infrastructure development.

The results of this study showed that there is a lack of specific scientific articles on the use of BIM in infrastructure planning with a particular focus on ESG issues. This indicates a research gap that should be addressed in the future to provide a deeper understanding of the complex demands of modern infrastructure development. In particular, during the implementation of this study, the transformational role of BIM in infrastructure planning was substantiated, not only increasing the efficiency and economic efficiency of projects, but also making a positive contribution to the environment and society. Thus, the integration of ESG principles into the BIM process is a crucial step towards more sustainable and socially responsible infrastructure development.

Based on the understanding that BIM has a significant impact on the sustainability, environmental and social aspects of infrastructure projects, it is worth forming new models and optimization systems that will meet the modern requirements and needs of consumers. Areas of further research in this context may include integration with modern technologies, improvement of environmental aspects, social interaction and public participation, standardization and improvement of BIM standards, ensuring interoperability with the legal and regulatory framework, effective land use management and assessment of the impact of technology on climate change. These areas of research can contribute to the further development of BIM in the context of sustainable, green and social infrastructure projects, providing more comprehensive and balanced project management for the benefit of society and the environment.

ACKNOWLEDGEMENTS

None.

CONFLICT OF INTEREST

None.

REFERENCES

[1] Aranda, J.Á., Santonja, M.M., Saurí, M.G., & Peris-Fajarnés, G. (2021). Minimizing shadow area in mountain roads for improving the sustainability of infrastructures. *Sustainability*, 13(10), article number 5392. doi: 10.3390/su13105392.

[2] Arenas, N.F., & Shafique, M. (2023). Recent progress on BIM-based sustainable buildings: State of the art review. *Developments in the Built Environment*, 15, article number 100176. doi: 10.1016/j.dibe.2023.100176.

[3] Borjigin, A.O., Sresakoolchai, J., Kaewunruen, S., & Hammond, J. (2022). Digital twin aided sustainability assessment of modern light rail infrastructures. *Frontiers in Built Environment*, 8, article number 796388. doi: 10.3389/fbuil.2022.796388.

[4] Chang, C.M., Salinas, G.T., Gamero, T.S., Schroeder, S., Vélez Canchanya, M.A., & Mahnaz, S.L. (2023). An infrastructure management humanistic approach for smart cities development evolution and sustainability. *Infrastructures*, 8(9), article number 127. doi: 10.3390/infrastructures8090127.

[5] Charef, R., Alaka, H., & Emmitt, S. (2018). Beyond the third dimension of BIM: A systematic review of literature and assessment of professional views. *Journal of Building Engineering*, 19, 242-257. doi: 10.1016/j.jobe.2018.04.028.

[6] Chen, S., Zeng, Y., Majdi, A., Salameh, A.A., Alkhalifah, T., Alturise, F., & Ali, H.E. (2023). Potential features of Building Information Modelling for application of project management knowledge areas as advances modeling tools. *Advances in Engineering Software*, 176, article number 103372. doi: 10.1016/j.advengsoft.2022.103372.

[7] Correa, S.L.M., & Santos, E.T. (2021). BIM support in the tendering phase of infrastructure projects. In E.T. Santos & S. Scheer (Eds.), *Proceedings of the 18th international conference on computing in civil and building engineering* (pp. 365-379). Cham: Springer. doi: 10.1007/978-3-030-51295-8_27.

[8] del Carmen Rey-Merchán, M., Gómez-de-Gabriel, J.M., López-Arquillos, A., & Fernández-Madrigal, J.A. (2021). Virtual fence system based on IoT paradigm to prevent occupational accidents in the construction sector. *International Journal of Environmental Research and Public Health*, 18(13), article number 6839. doi: 10.3390/ijerph18136839.

[9] Energy-related emissions of greenhouse gases and air pollutants. (2024). Retrieved from https://www.umweltbundesamt.de/daten/energie/energiebedingte-emissionen#entwicklung-der-energiebedingten-treibhausgas-emissionen.

[10] Fink, A. (2019). *Conducting research literature reviews: From the Internet to paper*. Thousand Oaks: Sage Publications.

[11] Gade, P.N., & Svidt, K. (2021). Exploration of practitioner experiences of flexibility and transparency to improve BIM-based model checking systems. *Journal of Information Technology in Construction*, 26, 1041-1060. doi: 10.36680/j.itcon.2021.055.

[12] Gaur, S., & Tawalare, A. (2021). Investigating the role of BIM in stakeholder management: Evidence from a metro-rail project. *Journal of Management in Engineering*, 38(1). doi: 10.1061/(ASCE)ME.1943-5479.0000979.

[13] Global Code of Ethics. (2021). Retrieved from https://emccuk.org/Public/Public/Accreditation/Global_Code_of_Ethics.aspx.

[14] Huang, M.Q., Ninić, J., & Zhang, Q.B. (2020). BIM, machine learning and computer vision techniques in underground construction: Current status and future perspectives. *Tunnelling and Underground Space Technology*, 108, article number 103677. doi: 10.1016/j.tust.2020.103677.

[15] Huang, Y., Wu, L., Chen, J., Lu, H., & Xiang, J. (2022). Impacts of Building Information Modelling (BIM) on communication network of the construction project: A social capital perspective. *PLoS ONE*, 17(10), article number e0275833. doi: 10.1371/journal.pone.0275833.
[16] Hui, C.X., Dan, G., Alamri, S., & Toghraie, D. (2023). Greening smart cities: An investigation of the integration of urban natural resources and smart city technologies for promoting environmental sustainability. *Sustainable Cities and Society*, 99, article number 104985. doi: 10.1016/j.scs.2023.104985.
[17] Kalajian, K., Ahmed, S., & Youssef, W.M.A. (2023). BIM in infrastructure projects. *International Journal of BIM & Engineering Science*, 6(2), 74-87. doi: 10.54216/ijbes.060205.
[18] Khahro, S.H., Kumar, D., Siddiqui, F.H., Ali, T.H., Raza, M.S., & Khoso, A.R. (2021). Optimizing energy use, cost and carbon emission through Building Information Modelling and a sustainability approach: A case-study of a hospital building. *Sustainability*, 13(7), article number 3675. doi: 10.3390/su13073675.
[19] Kuckartz, U., & Rädiker, S. (2019). Documenting and archiving the research process. In *Analyzing qualitative data with MAXQDA* (pp. 283-290). Cham: Springer. doi: 10.1007/978-3-030-15671-8_20.
[20] Kutia, M., Li, J., Sarkissian, A., & Pagella, T. (2023). Land cover classification and urbanization monitoring using Landsat data: A case study in Changsha city, Hunan province, China. *Ukrainian Journal of Forest and Wood Science*, 14(1), 72-91. doi: 10.31548/forest/1.2023.72.
[21] Laali, A., Nourzad, S.H.H., & Faghihi, V. (2022). Optimizing sustainability of infrastructure projects through the integration of Building Information Modeling and envision rating system at the design stage. *Sustainable Cities and Society*, 84, article number 104013. doi: 10.1016/j.scs.2022.104013.
[22] McPherson, M., *et al*. (2022). Open-source modelling infrastructure: Building decarbonization capacity in Canada. *Energy Strategy Reviews*, 44, article number 100961. doi: 10.1016/j.esr.2022.100961.
[23] Moudgil, V., Hewage, K., Hussain, S.A., & Sadiq, R. (2023). Integration of IoT in building energy infrastructure: A critical review on challenges and solutions. *Renewable and Sustainable Energy Reviews*, 174, article number 113121. doi: 10.1016/j.rser.2022.113121.
[24] Nasab, A.R., Malekitabar, H., Elzarka, H., Tak, A.N., & Ghorab, K. (2023). Managing safety risks from overlapping construction activities: A BIM approach. *Buildings*, 13(10), article number 2647. doi: 10.3390/buildings13102647.
[25] Noor, R.N.H.R.M., Ibrahim, C.K.I.C., & Belayutham, S. (2022). Exploring the key attributes influencing social collaboration based BIM projects among actors: A Malaysian case study. *AIP Conference Proceedings*, 2532, article number 090002. doi: 10.1063/5.0113004.
[26] Oreto, C., Biancardo, S.A., Abbondati, F., & Veropalumbo, R. (2023). Leveraging infrastructure BIM for life-cycle-based sustainable road pavement management. *Materials*, 16(3), article number 1047. doi: 10.3390/ma16031047.
[27] Prokopenko, T., & Povolotskyi, Ya. (2022). A system of criteria for evaluating the efficiency of projects in the field of information technologies. *Bulletin of Cherkasy State Technological University*, 4, 23-30. doi: 10.24025/2306-4412.4.2022.271448.
[28] Raouf, A.M.I., & Al-Ghamdi, S.G. (2018). Building Information Modelling and green buildings: Challenges and opportunities. *Architectural Engineering and Design Management*, 15(1), 1-28. doi: 10.1080/17452007.2018.1502655.
[29] Rodríguez-Amigo, A., Fernández-Alvarado, J.F., & Fernández-Rodríguez, S. (2022). Case of study on a sustainability building: Environmental risk assessment related with allergenicity from air quality considering meteorological and urban green infrastructure data on BIM. *Science of the Total Environment*, 838(1), article number 155910. doi: 10.1016/j.scitotenv.2022.155910.
[30] Sakr, M., & Sadhu, A. (2023). Visualization of structural health monitoring information using Internet-of-Things integrated with Building Information Modeling. *Journal of Infrastructure Intelligence and Resilience*, 2(3), article number 100053. doi: 10.1016/j.iintel.2023.100053.
[31] Schults, R., Annenkov, A., Bilous, M., & Kovtun, V. (2016). Interpretation of geodetic observations of the high-rise buildings displacements. *Geodesy and Cartography*, 42(2), 39-46. doi: 10.3846/20296991.2016.1198566.
[32] Shalbolova, U., Chikibayeva, Z., & Kenzhegaliyeva, Z. (2021). Efficiency of investment projects to modernize facilities housing and communal services (case of Kazakhstan). *IOP Conference Series: Earth and Environmental Science*, 650, article number 012075. doi: 10.1088/1755-1315/650/1/012075.
[33] Sharafat, A., Khan, M.S., Latif, K., Tanoli, W.A., Park, W., & Seo, J. (2021). BIM-GIS-based integrated framework for underground utility management system for earthwork operations. *Applied Sciences*, 11(12), article number 5721. doi: 10.3390/app11125721.
[34] Sidliarenko, A. (2023). Mathematical models of road construction, reconstruction and repair under conditions of uncertainty. *Bulletin of Cherkasy State Technological University*, 3, 113-127. doi: 10.24025/2306-4412.3.2023.287845.
[35] Theißen, S., *et al*. (2020). Digitalization of user-oriented demand planning through Building Information Modeling (BIM). *IOP Conference Series: Earth and Environmental Science*, 588, article number 032004. doi: 10.1088/1755-1315/588/3/032004.

[36] van Eldik, M.A., Vahdatikhaki, F., dos Santos, J.M.O., Visser, M., & Doree, A. (2020). BIM-based environmental impact assessment for infrastructure design projects. *Automation in Construction*, 120, article number 103379. doi: 10.1016/j.autcon.2020.103379.
[37] Veerendra, G.T.N., Dey, S., Manoj, A.V.P., & Kumaravel, B. (2022). Life cycle assessment for a suburban building located within the vicinity using Revit Architecture. *Journal of Building Pathology and Rehabilitation*, 7, article number 56. doi: 10.1007/s41024-022-00199-6.
[38] von Soest, C. (2022). Why do we speak to experts? Reviving the strength of the expert interview method. *Perspectives on Politics*, 21(1), 277-287. doi: 10.1017/s1537592722001116.
[39] Wang, J. (2022). Optimized mathematical model for energy efficient construction management in smart cities using Building Information Modeling. *Strategic Planning for Energy and the Environment*, 41(1), 61-80. doi: 10.13052/spee1048-5236.4113.
[40] Weber, B., Achenbach, M., & Niederländer, A. (2023). Rechtskonformes Datenteilen im Bauprozess – Anforderungen des data governance act an common data environments. *Bauingenieur*, 98(3), 76-84. doi: 10.37544/0005-6650-2023-03-66.
[41] Yang, Y., Ng, S.T., Dao, J., Zhou, S., Xu, F.J., Xu, X., & Zhou, Z. (2021). BIM-GIS-DCEs enabled vulnerability assessment of interdependent infrastructures – a case of stormwater drainage-building-road transport Nexus in urban flooding. *Automation in Construction*, 125, article number 103626. doi: 10.1016/j.autcon.2021.103626.
[42] Yang, Z., Zhu, C., Zhu, Y., & Li, X. (2023). Blockchain technology in building environmental sustainability: A systematic literature review and future perspectives. *Building and Environment*, 245, article number 110970. doi: 10.1016/j.buildenv.2023.110970.

Гентжана Реджай
Магістр інженерних наук
Університет Менделя в Брно
613 00, вул. Земнєдєлська, 1665/1, м. Брно, Чехія
https://orcid.org/0009-0003-1709-4736

Роль інформаційного моделювання будівель у впровадженні сталих, екологічно чистих та соціальних інфраструктурних проектів

Анотація. Реалії XXI століття в умовах перенаселення, політичних змін та економічних викликів вимагають розробки та реалізації інфраструктурних проектів, які забезпечують сталість використання ресурсів та мають мінімальний негативний вплив на навколишні природні екосистеми. Метою даного дослідження є обґрунтування та оцінка основних аспектів інформаційного моделювання будівель, його можливостей та переваг при будівництві сталої інфраструктури в контексті енергоефективності, збалансованого використання ресурсів, впровадження екологічно чистих технологій, удосконалення принципів благоустрою територій та покращення якості життя людей. Використано низку загальнотеоретичних методів дослідження, зокрема: методи аналізу та синтезу, метод інтерв'ювання, метод дедукції та індукції. Аналіз наукових статей показав недостатню кількість публікацій, які розкривають особливості використання сучасних технологій інформаційного моделювання при проектуванні екологічно безпечної, сталої та соціально відповідальної інфраструктури. У дослідженні описано загальний вплив інформаційного моделювання будівель на екологічний аспект інфраструктурної діяльності. Обґрунтовано особливості застосування технології інформаційного моделювання будівель в оцінці впливу на довкілля. Також проаналізовано соціальний аспект інформаційного моделювання інфраструктурних проєктів. Підкреслено важливість побудови моделювання з використанням інтегрованих підходів для оцінки безпеки та прийняття управлінських рішень. Виявлено проблеми в обробці інформації моделей інформаційного моделювання будівель, які здебільшого стосуються соціально-технічних аспектів. Обґрунтовано структуру методології інформаційного моделювання будівель в контексті суттєвого зменшення шкідливих викидів, енергозбереження, використання екологічно чистих технологій та матеріалів. Практичне значення дослідження полягає в інтеграції інформаційного моделювання в процеси будівництва, планування, моніторингу та управління ризиками в довгостроковій перспективі, що дозволяє забезпечити ефективну реалізацію проектів та уникнути екологічних, технічних і соціальних проблем у майбутньому

Ключові слова: інтегровані технології; екологічний моніторинг та оцінка; енергоефективність; цифрові інновації; ризик та безпека

Architectural Studies
International Journal about Architecture

Volume 10, No. 1

UDC 902:72.02
DOI: 10.56318/as/1.2024.79

Aleks Trushaj*
Doctor of Archaeology, Associate Professor
University "Ismail Qemali" Vlore
9400, Kosova Str., Vlora, Albania
https://orcid.org/0009-0005-4251-4530

Blerina Xhelaj
Doctor of Historical Sciences
University "Ismail Qemali" Vlore
9400, Kosova Str., Vlora, Albania
https://orcid.org/0009-0008-9169-4146

Modern technologies in archaeology and their application in architectural object

Abstract. The study of modern technologies in archaeology and the restoration of architectural objects is extremely important because of the possibility of using them to preserve cultural heritage, discover new artefacts and improve scientific research methods. The aim of this study was to analyse the possibilities of using modern technologies for the rehabilitation and visualization of cultural heritage. The methods used in the course of the study included photogrammetry, comparative method, and analysis. The results of the study showed the significant potential of modern photogrammetry technologies in the preservation and visualization of cultural heritage. In particular, the use of aerial photogrammetry using a drone and ground photogrammetry using a digital camera made it possible to create three-dimensional models of architectural objects with high accuracy and detail. For example, 267 images were collected and processed using a drone for the Marinid Madrasa, Al-Mariniya Madrasa, and the Roma settlement. This data allowed for the creation of detailed three-dimensional models that were used to generate orthophotomaps and a visual inspection of the site. In addition, the export of 2D data and models proved to be effective for further modelling and analysis. This allowed for the development of a three-dimensional digital model that can be visualized, modified, and adapted at any time, which has become a valuable tool for architectural research and documentation. The results of the study confirmed the practical effectiveness of photogrammetric methods in the preservation and documentation of historical heritage. The use of digital models and orthophotomaps can facilitate visual analysis of objects, further research and archiving of cultural property. This approach has the potential for educational and tourism initiatives, engaging a wide audience in the study and appreciation of historical heritage

Keywords: photogrammetry; cultural heritage; 3D visualization; restoration of historical values; model detailing

INTRODUCTION

Modern technologies in archaeology and the restoration of architectural objects are important tools for preserving and understanding world history. The discovery and study of archaeological and architectural sites not only provides an opportunity to better understand the past, but also helps to identify and shed light on the development of human civilization and the cultural and technological achievements of past eras. However, the problem associated

Suggested Citation:
Trushaj, A., & Xhelaj, B. (2024). Modern technologies in archaeology and their application in architectural object restoration. *Architectural Studies*, 10(1), 79-91. doi: 10.56318/as/1.2024.79.

Journal homepage: https://arch-studies.com.ua/en
Architectural Studies, 10(1), 79-91
Received: 19.02.2024 Revised: 12.05.2024 Accepted: 20.06.2024

*Corresponding author

with the research and restoration of archaeological and architectural sites is the complexity and limited access to materials and resources. Many sites are located in inaccessible places or are under threat of destruction due to a variety of factors, including natural disasters, climate change, and human activity. It is also important to keep in mind that even with financial resources, a lack of qualified personnel and equipment can complicate the research and restoration process.

That is why modern technologies can solve these problems, providing new opportunities for research and preservation of cultural heritage. For example, new technologies make it possible to survey large areas, discover new archaeological sites and study changes in the landscape over time. They also allow scanning and obtaining detailed topographic data, creating accurate 3D models of archaeological structures. These technologies help to increase the speed and accuracy of research, and reduce the risk of damage to artefacts and structures during restoration work. The use of computer modelling and virtual reality can allow archaeologists and conservators to effectively plan and restore architectural sites, reducing the risk of errors and increasing the efficiency of work. Such technologies can also be used to recreate ancient landscapes and environments, allowing researchers to better understand the context and cultural practices of past civilizations (Prychepii, 2022). Importantly, modern technologies are opening up new horizons for archaeological and architectural research, making it more accessible, accurate and efficient.

According to A. Cilek *et al*. (2020), 3D restoration technology is an extremely important tool for preserving and recreating cultural heritage. This technology allows creating virtual models of architectural objects with high detail, which can be used for the restoration and reconstruction of damaged or destroyed structures. Through the use of 3D scanning and modelling, this technology allows for the accurate reproduction of architectural details, dimensions, and shapes of objects, which is important for preserving their historical identity.

In a study by E. Mustafaraj *et al*. (2021), the authors proved that virtual 3D models open up many opportunities for analysing and studying the architectural features of objects. By examining these models, restorers can examine each element of the structure in detail, from the smallest details to the overall composition, which helps to develop effective strategies for the preservation and restoration of cultural monuments. Moreover, the paper argues that virtual reality allows researchers to study objects from different angles and recreate different historical contexts, which contributes to a deeper understanding of their structure and meaning. This opens up new possibilities for restoration, as it allows for more accurate and informed interventions aimed at preserving and restoring valuable historical objects.

In conformity with E. Petërçi (2022), virtual 3D models not only provide the ability to create videos and animations for visualizing objects, but also open up a wide range of other possibilities. For example, they can be used to create measuring supports that allow obtaining accurate measurements of the size and proportions of objects directly from the virtual model. It is also argued that virtual models can be used to generate 2D plans and sections that allow for a detailed study of the architectural features of objects from different angles. This data can be used for further analysis and research, as well as for creating detailed profiles of objects that help to identify changes in their structure and reveal their history and evolution over time.

According to A. Pagliano (2022), the use of such a 3D model allows not only creating realistic 3D models of architectural objects, but also introducing innovative methods of analysis and interaction with these models. For example, this technology can include augmented reality, which allows users to interact with virtual objects in real time using special devices such as virtual reality headsets or mobile applications. This interactive capability allows users to explore and learn about architectural objects in a new format, opening up a wide range of opportunities for them to learn about history, culture, and architecture. The use of augmented reality can also contribute to a deeper understanding of objects and their importance in the context of cultural heritage, as well as to attracting a wider audience to the study and appreciation of these objects (Gryglewski *et al*., 2020).

The study by M. Bercigli *et al*. (2022), which focused on the use of such technology in the restoration of architectural objects, notes that it can open up new perspectives for the reconstruction and analysis of historical buildings. This technology, distinguished by its innovative approach, uses a combination of artificial intelligence and deep learning to automate the analysis of structural details of objects. This approach has made it possible to detect the smallest changes and damages that might otherwise go unnoticed under normal circumstances. In addition, it is particularly emphasized that this technology allows for more efficient planning and execution of restoration processes, providing a more detailed and objective analysis of the condition of architectural objects (Shumka, 2022).

Since the above-mentioned studies were aimed at a more general study of the use of modern technologies in the restoration of architectural objects, the purpose of this work was to investigate specific methods and technologies that can be used for the effective restoration of archaeological sites, using the practical example of the Marinid Madrasa, Al-Mariniya Madrasa, and the Roma settlement in Morocco.

MATERIALS AND METHODS

This study used the photogrammetry method to obtain three-dimensional models of objects, a comparative method to analyse different approaches to documenting historical buildings, and an analysis to assess the effectiveness of the applied methods. These methods made it possible to obtain a detailed three-dimensional reconstruction of the objects, compare different approaches to digitizing heritage, and draw conclusions about their effectiveness. During the practical part of the study, several prominent

archaeological sites in Morocco in the cities of Salé and Rabat, which are key centres of Moroccan cultural heritage, were examined. The sites include the Madrasa of Marinid Abu Al-Hassan, the Madrasa of Al-Mariniya, and the Roma settlement. These sites are important because they play a significant role in preserving and understanding the cultural heritage of the region.

A Nikon D5600 digital camera (China) was used to collect data and document the sites, which ensured high accuracy and allowed capturing images of numerous points. By collecting a series of overlapping images, detailed data was obtained, which was used to create accurate and realistic digital models of the objects. More detailed characteristics of the camera are shown in Table 1.

Table 1. Characteristics of a digital camera

Matrix resolution	24.2 megapixels
Image processor	EXPEED 4
ISO range	100-25600
Auto focus	39 AF points with phase detection support

Source: compiled by the authors

A DJI Mavic Pro unmanned aerial vehicle (China) equipped with a 1-inch sensor camera was also used to obtain images. This camera has a multi-format sensor that provides a resolution of up to 12 megapixels. This resolution makes it possible to obtain detailed images necessary for accurate mapping and modelling of objects. More detailed characteristics of the camera on the unmanned aerial vehicle are shown in Table 2.

Table 2. Characteristics of the camera on the unmanned aerial vehicle

Resolution	up to 12 megapixels
Diaphragm	f/2.2
Focal length	28 mm (equivalent to 35 mm)
Viewing angle	78.8°
Sensor	1/2.3" CMOS

Source: compiled by the authors

For the documentation, 267 images were taken using an unmanned aerial vehicle. The height from which the images were taken ranged from 5 to 25 m, which allowed obtaining images of objects from different angles and in different detail. The overlap provided along the lateral circle and the track was 85%, which ensured that there was sufficient overlap between images for accurate reconstruction of the objects.

Agisoft Metashape, a software program based on the Structure from Motion (SfM) method, was used to process the digital images, and create three-dimensional spatial data. Agisoft Metashape uses the Scale-Invariant Feature Transform (SIFT) algorithm, which has several processing stages. The first stage is to detect scale-spatial extremes, where a Gaussian difference function (1) is applied to identify potential points of interest (Karwel & Markiewicz, 2022):

$$L(x, y, \sigma) = G(x, y, \sigma) * I(x, y), \quad (1)$$

where: $*$ – collapsing operator; $G(x, y, \sigma)$ – a Gaussian scale variable; $I(x, y)$ – the input image.

To determine the localization of key points in the scale space, the principle of difference of Gaussian numbers was used. It made it possible to find the extremes of the scale space, which is a three-dimensional function $D(x, y, \sigma)$, where x and y are spatial coordinates and σ is a scale parameter. The difference of Gaussian numbers was calculated as the difference between two images, one of which has a scale k times larger than the other. The function $D(x, y, \sigma)$ (2) is described by an expression that depends on the spatial coordinates and the scale parameter (Rodríguez-Martín & Rodríguez-Gonzálvez, 2020):

$$D(x, y, \sigma) = L(x, y, k\sigma) - L(x, y, \sigma). \quad (2)$$

The key point descriptor is a tool for describing the features that define each key point in an image. One of the key aspects of the descriptor is its rotation invariance, which means that it remains robust to changes due to image rotation. The approach used to determine the orientation of a key point is as follows (3, 4):

$$M(x, y) = \sqrt{(L(x+1, y) - L(x-1, y))^2 + (L(x, y+1) - L(x, y-1))^2}, \quad (3)$$

$$\varphi(x, y) = \tan\left(\frac{L(x, y+1) - L(x, y-1)}{L(x+1, y) - L(x-1, y)}\right). \quad (4)$$

First, the local luminance gradient in the vicinity of the key point was calculated. Then, a histogram of the gradient directions was determined, which shows the distribution of the gradient in different directions. The direction with the highest gradient strength is considered to be the main direction of orientation of the key point. The resulting three-dimensional models were further used to analyse architectural details, recreate the structure of objects, and perform virtual visual inspections. The photogrammetry method resulted in detailed and realistic three-dimensional models of objects, which greatly simplified their study, preservation, and documentation.

The comparative method was used to conduct a detailed assessment of different approaches to documenting and digitizing historical heritage sites. Based on this analysis, the most appropriate method was selected for further application in the study. The selected methods were used to obtain detailed three-dimensional models of the heritage objects, considering their geometric complexity and features. The results were analysed in detail and used to formulate conclusions and recommendations for the further use of digitization techniques in heritage research.

Detailed analysis also proved to be an important method in the study, allowing us to identify and analyse the key differences in the condition of architectural objects before and after the application of various restoration methods. A detailed comparison allowed determining the effectiveness of each method and defining their advantages and limitations. The analysis of the results proved to be an important step in determining the best approaches to the preservation and restoration of architectural heritage, contributing to the development of strategies that consider the unique characteristics of each object.

RESULTS

The restoration and conservation of archaeological sites is a complex and demanding process that requires great attention to detail and authenticity. However, with the advent of new technologies such as 3D modelling and digital documentation, this process is becoming more efficient and accessible, as 3D modelling allows archaeologists to create accurate and detailed virtual copies of objects, which facilitates their research and analysis.

The use of 3D modelling in archaeology has great potential not only for research, but also for the preservation and presentation of cultural heritage. It allows archaeologists to create realistic virtual exhibitions that can be accessed by a wide audience via the Internet or special applications. Such digital reconstructions can be used for teaching, visiting virtual museums, or simply for excursions into the past. The new possibilities offered by digital documentation and 3D modelling contribute to the integration of technology into the process of cultural heritage preservation and research. Thanks to the development of computer technology and digital photography, it is now possible to conduct more accurate and detailed research of archaeological sites. This allows for the preservation of significant artefacts and structures for future generations and a deeper understanding of history and cultural development (Ferdani *et al.*, 2020).

Virtual restorations are an important step in the recreation and preservation of cultural heritage based on scientific data and existing documentation. This process includes a number of methods that allow recreating the previous state of an object, taking into account its lost polychrome, identifying individual architectural elements and reconstructing the entire object. Virtual restorations can be displayed in the form of 3D models for distribution, or used to create physical copies using technologies such as 3D printing. However, it is important to keep in mind that virtual restoration is not an end in itself, but only the first step in the physical restoration process.

To achieve successful virtual restoration, it is necessary to have access to detailed archaeological and historical information about the site. This may include archaeological finds, historical documents, photographs, and other sources that allow reconstructing the appearance of the object in the past. After collecting this data, it is analysed and processed in detail to create an accurate virtual model of the object. Another important aspect of virtual restoration is its scientific validity. The process of virtual reconstruction should be based on reliable data and scientific principles to ensure the accuracy and authenticity of the object's reconstruction. In this regard, expert assessment, and consultation with specialists in the field of archaeology, conservation, and history play an important role. Only scientifically based virtual reconstruction can serve as an effective basis for further actions in the restoration and preservation of cultural heritage. Figure 1 represents more details on the possibilities of using 3D models for the restoration of objects.

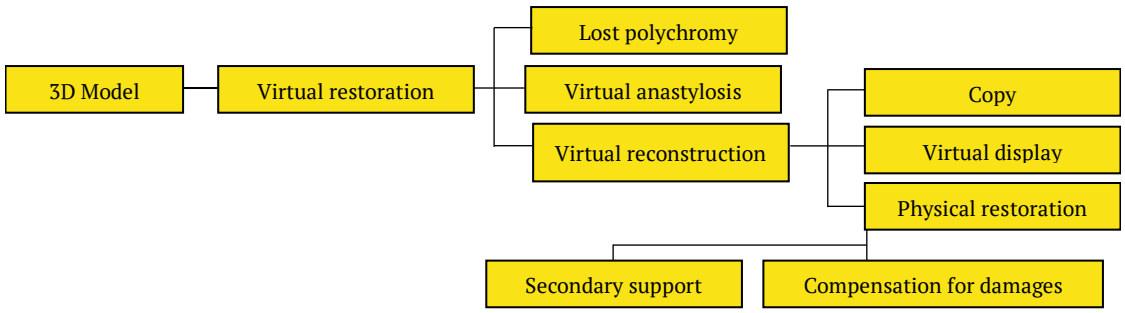


Figure 1. Possibilities of using 3D models for object restoration
Source: compiled by the authors based on L. Acke *et al.* (2021)

Virtual reconstruction of architectural objects is the recreation of their appearance, structure, and functionality in a virtual environment. This process begins with the analysis of archaeological data, including archival materials, photographs, drawings, plans, and any other available information about the object. Based on this data, a digital model of the object is created that reflects its appearance in the past.

During the virtual reconstruction, it is necessary to consider the architectural styles and techniques that were typical for a particular era or region. This allows recreating an object with maximum accuracy and authenticity. In addition, the virtual reconstruction process can use specialized software tools and technologies, such as computer graphics and modelling, to create detailed and realistic virtual models. One of the key aspects of virtual reconstruction is the ability to recreate lost or damaged elements of an object. This allows restoring the original appearance and structure of an object that may have been lost as a result of natural or anthropogenic impacts. This approach allows researchers and conservators to get an idea of how the object looked in the past and what architectural details were typical for it (Pietroni & Ferdani, 2021).

Virtual reconstruction can be used to study and analyse various aspects of an object, such as its functionality, structure, and relationship with other architectural objects or the environment. This allows revealing various aspects of history and culture associated with the object and studying it in the context of the socio-cultural environment.

Lost polychromy and virtual analogues are important aspects of virtual reconstruction of architectural objects that help to recreate their original appearance and atmosphere. Polychromy in architecture refers to the use of different colours and patterns on the surface of a building to give it an artistic expression. However, sometimes these colours can fade or lose their brightness due to natural factors or human activity. Virtual reconstruction of lost polychromy allows restoring the colour scheme and ornaments of an object by analysing archaeological data, archival sources, and specialized software tools. This helps to give the object a realistic and authentic look that matches its historical context and style (Fazio *et al.*, 2022).

Virtual analogues play an important role in the process of virtual reconstruction, especially for objects that have been damaged or destroyed in the past. Analogue is a method of restoring an architectural object when the restored parts are combined with the original ones using modern materials to restore its original appearance and functionality. In virtual analogues, archaeologists and conservators can use 3D models to accurately recreate damaged parts of an object and integrate them with original elements. This allows them to restore the object in its original form and preserve its cultural and historical value for future generations.

The use of photogrammetry for documenting and analysing archaeological sites is also of great importance for preserving and enhancing access to cultural heritage. This method provides accurate and detailed information about objects, including their geometry, size, and structure. It is important to note that photogrammetry allows obtaining this information directly from photographs, which makes the documentation process more efficient and affordable.

The creation of 3D models of archaeological sites is an important step in the preservation and recreation of these monuments. These models provide not only a visual representation of the object, but also the ability to use geometric data to develop restoration and virtual recovery plans. In addition, 3D models can be used to create virtual tours and exhibitions, allowing a wide audience to learn about cultural heritage. The successful implementation of digital technologies in the documentation and restoration of archaeological sites can greatly facilitate the work of archaeologists and conservators. They get the opportunity to work with high-precision data and access new methods of analysis and visualization. This, in turn, helps to improve the level of cultural heritage preservation and increase its accessibility for further research and study.

Choosing the right method for 3D modelling plays a key role in the process of documenting architectural objects, as it affects the quality and accuracy of the resulting model. In order to achieve the desired level of detail and accuracy, combined approaches are often used that combine the use of digital cameras, unmanned aerial vehicles and image data analysis. This approach aims to create models of architectural objects using a variety of data sources, such as photographs and images captured by digital cameras and unmanned aerial vehicles. This process allows obtaining a complete and detailed model of the object that reflects its real appearance and structure.

In the case of the Abu Al-Hassan Madrasa, the Roman remains, and the Al-Mariniya Madrasa, which will be discussed further below, the combined approach allows for the collection of sufficient and comprehensive data to document and assess the condition of these historic sites. The analysis of the data allows for the identification of physical damage and the identification of necessary interventions and conservation methods aimed at preserving these valuable cultural monuments for future generations. This method of documenting and archiving historical data helps to preserve and study cultural heritage with maximum accuracy and detail.

The sites selected for the study are located in the cities of Salé and Rabat, which are prominent cultural heritage sites in Morocco. In 2012, these sites were inscribed on the UNESCO World Heritage List, recognized as world treasures of history and culture. The first site is the Madrasa Marinid Abu Al-Hassan, which served as a Quranic school, college, and hostel. This architectural masterpiece serves not only as an educational institution but also as an important symbol of religious and cultural heritage (Škrabić Perić *et al.*, 2021).

The second object is the Al Mariniya Madrasa, which occupies an important place in the history of Morocco. Built in the first half of the 14th century during the reign of the Marinid Sultan Abu Al-Hassan bin Uthman, it is a symbol of the glorious dynasty that ruled the country for almost two centuries. The Al Mariniya Madrasa is not only an architectural masterpiece, but also a witness to a great era in Moroccan history, marking the cultural and religious development of the country.

The third object of the study is a Roma settlement that dates to 25 BC. Based on the results of archaeological excavations and research, there is a great opportunity to

restore the life of the city of Sala during the reign of Juba II. This city was distinguished by its architecture, which was organized on the principle of terraces, which was typical for many large centres of the Hellenistic East. Numerous buildings from the pre-Roman period were found on the territory of these narrow terraces, some of which were later incorporated into buildings from the Roman era. This shows that some structures have survived subsequent eras, retaining traces of past eras and cultural influences.

Archaeological findings allow researchers to create a portrait of the city's inhabitants' lives, customs, economic activity, and social organization. This provides a unique opportunity to better understand and reconstruct the history and culture of the ancient cities of Sala and Rabat (Fig. 2), which is an important step in the uncovering and interpretation of archaeological data. These sites are important witnesses to the past, demonstrating the richness and diversity of Morocco's cultural heritage. They are not only architectural monuments, but also symbols of history, reflecting the greatness of ancient civilizations and cultural traditions that continue to live in the heart of this country (Mandor & Mostafa, 2022).

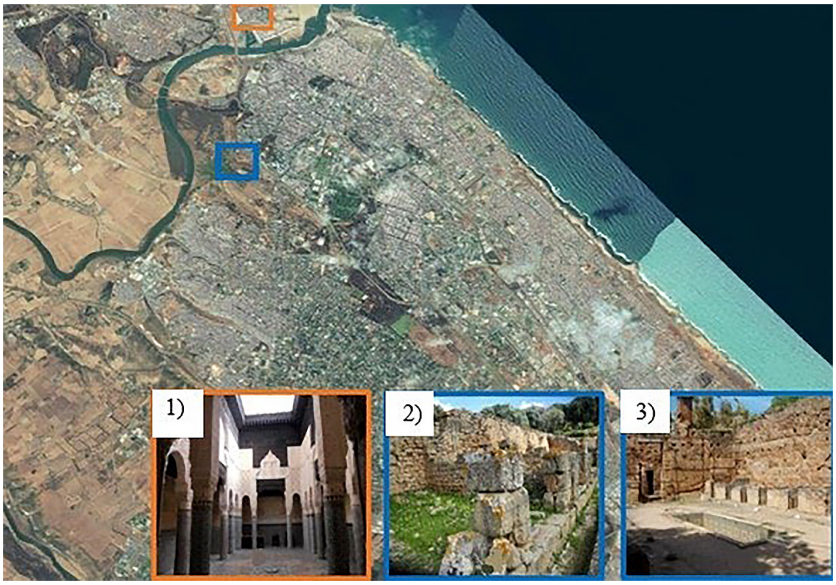


Figure 2. Place of practical research
Notes: 1 – Al-Mariniya Madrasa; 2 – Roma settlement; 3 – Marinid Abu Al-Hassan Madrasa
Source: compiled by the authors

It should be noted that photogrammetry is an important and powerful measurement technique that allows creating high-quality 2D or 3D digital models of objects. This process is not limited to the use of photographs; it can use any type of image, such as radar data or scanning devices. The main idea is to obtain the maximum number of points on the monitored object using the available technical means (Fiz *et al.*, 2022). In the process of measuring various architectural structures using a camera and unmanned aerial vehicles, it is necessary to take into account their complexity and shape, which determines the need for measurements from different angles. To ensure the required quality and accuracy of measurements, it is important to achieve a minimum image recovery rate of 75% (Fig. 3). This means that when a surface is digitized, a certain fragment of the image is shifted parallel to the digitized surface to obtain the next image.

Figure 3. Recovery process using sequential images as an example
Source: compiled by the authors

So, for example, in Figure 4, which represents a length of 1 m, the digitized surface is shifted by 25% of this length, which is 0.25 m, to digitize the next part of the surface. This approach ensures high quality and accuracy of measurements for further analysis and research of architectural structures (Putch, 2017).

Figure 4. Photos used in the process of digitizing the surface
Source: compiled by the authors

Figure 5 shows a grey triangle indicating the position of the camera during capture. It is important to ensure that the edges of the object are visible in multiple images, as this allows covering not only the central elements, but also the corners and edges. To achieve this, images of the object were taken outside its boundaries to capture extreme points and corners. This is necessary for effective object reconstruction. It is also important that a point of the object is visible in at least two images to ensure that it can be reconstructed. The surface that needs to be digitized may have a corner, so to connect the two surfaces, it is required to move around the corner. This motion should provide a minimum overlap of 75% and typically include at least six photos at the corner. For example, to scan a column 360° around the object, 36 steps of 10° each were taken.

Figure 6 demonstrates pre-processing of the point region, where unwanted points in the image are removed for further analysis and object reconstruction.

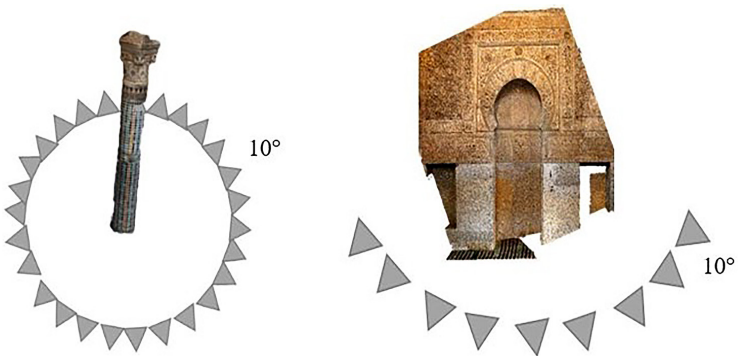


Figure 5. Camera position during angular scanning
Source: compiled by the authors

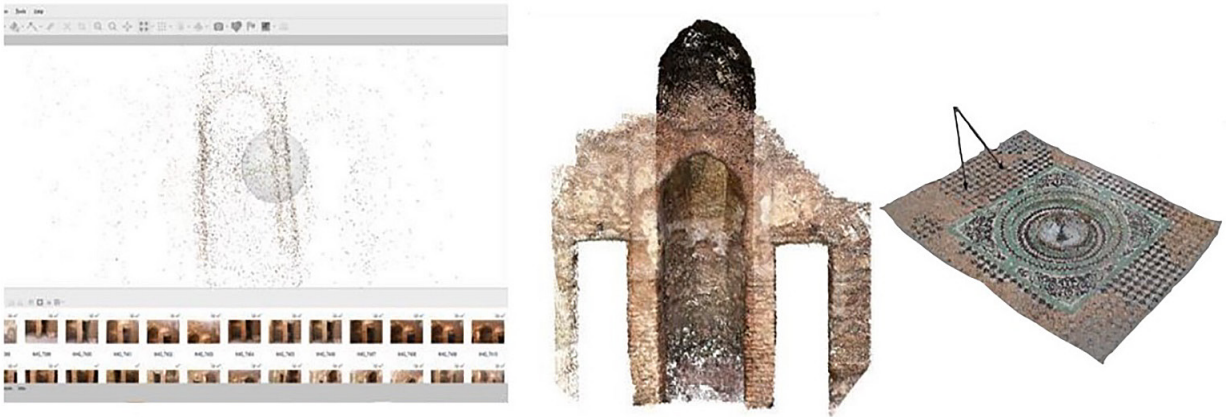


Figure 6. Process pre-processing
Source: compiled by the authors

At the end of the SIFT process, unique descriptors are calculated for each key point. This step is important so that each key point can be uniquely identified in the image. The local environment of each key point is used to calculate the descriptors. This environment includes the pixels surrounding the key point and allows extracting the unique features of this point. Each descriptor is a vector of numerical values that characterize the features of the corresponding key point. These descriptors can be used to compare key points between different images, which allows searching for objects in images, identifying relationships between objects, and performing other image processing tasks (Zhong & Li, 2019).

At the stage of obtaining consistent data (Fig. 7), it is necessary to perform pre-processing to help reduce unwanted effects and noise in the point cluster. This phase is important for keeping only those points that are interesting and important for modelling. After that, it is possible to start creating digital models based on these point clusters.

Figure 7. Examples 3D modelling of some objects
Source: compiled by the authors

The resulting digital models are quite simple, as they are created from field data. However, these models have several applications, including video and animation. Furthermore, they can be used to create measurement supports (Fig. 8), generate 2D plans and sections (Fig. 9), and create profiles. These data processing products allow not only visualizing objects and terrain, but also analysing their geometry and properties in detail. They can become important tools for archaeologists, geologists and other specialists to study and investigate natural and cultural sites.

Figure 8. Example point area for measurements
Source: compiled by the authors

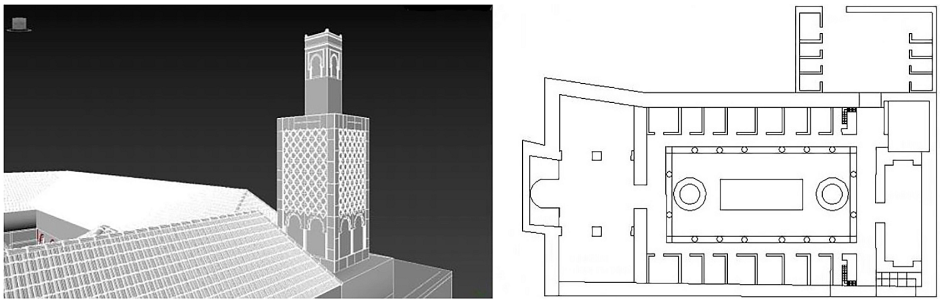


Figure 9. 3D model and 2D plan of the object

Source: compiled by the authors

Drone images play an important role in various aspects of geospatial analysis and visual documentation. First and foremost, they are used to generating 3D models that provide a detailed three-dimensional image of the area or object under study. These 3D models become an important tool for analysing the geometric characteristics of objects, displaying their structure and shape. The resulting images are also used to create high-precision orthophotomaps. Orthophotomaps are orthogonal images of the earth's surface that are used to measure and analyse geographical objects such as buildings, roads, terrain. These orthophotomaps are an important source of geospatial data for a variety of industries, including geodesy, geographic information systems, and urban planning. The resulting images provide a visual inspection of the site in its current state, which allows analysing changes over time, identifying possible problems or potential threats to the environment, and determining the need for additional research or interventions. This visual approach allows for effective management and monitoring of sites using the latest data collection technologies.

Once the photogrammetric process is complete, the resulting 2D data and models can be transferred to the 3Ds Max platform for further processing and modelling (Kaimaris *et al.*, 2022). This process allows for the creation of realistic three-dimensional models, as well as provides flexibility and efficiency in work and accuracy in the result (Fig. 10).

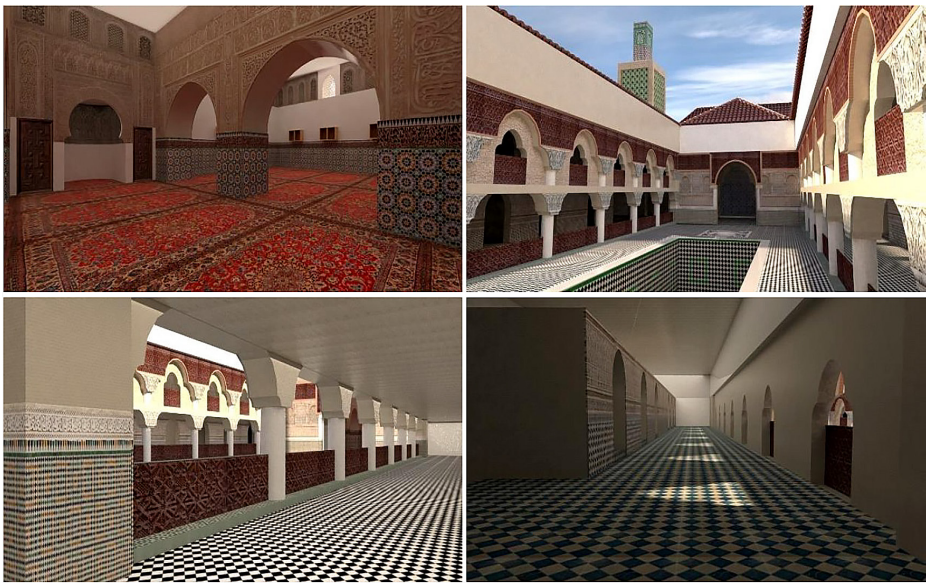


Figure 10. Photorealistic 3D object model

Source: compiled by the authors

Thus, the use of photogrammetry and modern technologies in restoration techniques proves to be extremely useful and promising. This approach not only allows for detailed documentation and analysis of archaeological sites, but also provides the possibility of virtual reconstruction, restoration of lost polychromy, and solving numerous problems related to the conservation and restoration of cultural heritage.

Thanks to digital models obtained through photogrammetry, experts can thoroughly examine the condition of objects, identify damage and losses, and develop effective conservation and restoration strategies. In addition, the ability to create virtual analogues allows viewers to travel back in time and see objects in their original glory, making cultural heritage accessible and fascinating to a

wide audience. However, it should be borne in mind that the use of digital technologies in restoration requires a great deal of awareness and professionalism on the part of specialists, as well as consideration of ethical, cultural, and historical aspects. Nevertheless, with the right approach, these methods open up new opportunities for preserving and restoring cultural heritage, ensuring its accessibility and preservation for future generations.

DISCUSSION

Archaeological sites are not only witnesses of past eras, but also an inexhaustible source of knowledge about history, culture, and heritage. They reflect the secrets of past civilizations and reveal many layers of cultural heritage that define modern society. The excavation of archaeological sites arouses interest and fascination not only among scientists but also among the public, as they allow delving deeper into the world of the past and better understanding our roots. However, many archaeological sites are often exposed to natural factors and other negative influences, which can lead to their damage or destruction. Therefore, it is important to take measures to preserve and restore them. In this context, modern technologies are becoming very useful tools for archaeologists and restorers. Such technologies can allow scientists to obtain detailed information about the condition of archaeological sites, recreate their original forms and structures, and preserve this heritage in a virtual format for future research and generations. Technologies can also be used to identify and register archaeological sites over large areas, which contributes to more efficient organization and coordination of their preservation and research. One of the most important areas of application of modern technologies in archaeology is their use for the study and restoration of architectural objects. Photogrammetry, laser scanning, virtual reality and other digital tools help preserve the uniqueness and cultural heritage of architectural monuments for future generations (Karpov, 2023). They help to reconstruct and recreate destroyed parts of buildings, while preserving their original appearance and authenticity. Such technologies can also allow for the study of techniques and styles used in construction and reveal many other aspects of architectural heritage.

In their work, I.M.E. Zaragoza *et al*. (2021) provide examples of the use of digital technologies and virtual reality for the restoration of architectural objects. Specifically, the study described the use of laser scanning to create an accurate three-dimensional model. After that, the study also used computer programs to virtually reconstruct the model in its original form based on the data obtained. It is noted that this method allowed archaeologists to get a detailed picture of the condition of the object and identify its damage or changes in structure. Compared to the study by the researchers, the results of this study demonstrate similar and additional benefits of using advanced technologies in the restoration of architectural objects. Some similarities can be observed in the use of 3D modelling and analysis of architectural features of objects. However, the results of this work emphasize the role of photogrammetry as a key tool in this process, in particular, the use of ground and aerial photogrammetry to create detailed 3D models. The combination of these methods has resulted in not only high-quality 3D models, but also enhanced orthophotos and 3D files that have become a valuable addition to the site documentation. In addition, the results obtained indicate the importance of photogrammetry technologies in the restoration and preservation of cultural heritage, providing an opportunity for effective analysis and rehabilitation of historical objects with a high level of accuracy and detail.

The study by M. Atik *et al*. (2023) also notes that virtual reality can be used to make an interactive virtual journey around an architectural object, recreating it in detail, and even allowing users to interact with it in a virtual environment. It is emphasized that this approach allows the audience to better understand the historical significance and architectural features of the object without the need to be physically present on site. In general, in the research of the researchers, it was concluded that digital technologies and virtual reality are truly effective tools for the restoration of architectural objects, allowing to preserve their historical value and authenticity. Compared to the study by the researchers, the results of this work add a new dimension to the understanding of the use of digital technologies in the restoration of architectural objects. Although the work of the researchers focuses on the use of virtual reality to create interactive virtual tours around objects, the results of this study extend this understanding by showing the variety of technologies that can be used for detailed restoration and preservation of architectural monuments. Thus, the findings complement and extend the conclusions, showing that photogrammetry, together with other digital technologies, can be an effective tool in the preservation and restoration of architectural heritage, providing a detailed and authentic approach to restoration projects.

As a result of a study by V. Barrile *et al*. (2022), which focused on the possibilities of using 3D models for the restoration of objects, emphasizes that they can be used to restore architectural objects in a virtual environment, and make it possible to study their structure and recreate their appearance in different historical eras. This is an important aspect, as it allows restorers to work effectively to restore details and elements of architecture, which can be important for preserving the historical value of objects. Comparing both studies, the results of this paper demonstrate a similar approach to the use of 3D models for the restoration of architectural objects. Both studies emphasize the importance of digital technologies in recreating architectural objects in a virtual environment and the possibility of using these models to study their structure and recreate their appearance in different historical eras. However, the results of this work may additionally highlight certain shortcomings or limitations of this approach. For example, although the virtual environment allows for the recreation of architectural objects in detail, it may not be able to recreate the sense of physical presence and comprehension

of the scale and proportions of objects (Dokolova, 2023). In addition, depending on the quality and accuracy of the modelling, some details, or features may be lost or distorted. Thus, although the use of 3D models for restoration has its advantages in the recreation and research of architectural heritage, it is important to consider their limitations and to carry out additional checks and corrections to ensure the accuracy and reliability of restoration projects.

According to C.A. Jones & R. Church (2020), photogrammetry is considered one of the most effective technologies in modern archaeology for creating accurate and detailed digital models of architectural objects. This method allows obtaining high-resolution three-dimensional images by analysing two-dimensional photographs. It is noted that the use of photogrammetry allows archaeologists to carry out non-invasive surveys of objects, which is especially important for preserving their integrity. In addition, this technology allows for the creation of digital copies of objects that can be used for detailed study, reproduction, and virtual travel, as well as for archiving and preservation of cultural heritage. The study argues that photogrammetry also opens up opportunities for visualizing and researching architectural objects from different angles and perspectives, helping to reveal their history and significance. The results of this study additionally confirm the high efficiency of photogrammetry in archaeological research, in particular, in the restoration of architectural objects. Similar to the study by the researchers, this study also identified photogrammetry as one of the most effective technologies for creating accurate and detailed digital models. The use of photogrammetry in the study made it possible to obtain high-resolution three-dimensional images, which was an important prerequisite for the reproduction of architectural objects in a virtual environment. Thus, the results of this work confirm and extend the findings of C.A. Jones & R. Church on the effectiveness of photogrammetry in the reproduction and study of architectural objects.

According to a study by L. Mantovan & L. Nanni (2020), artificial intelligence and machine learning are promising technologies for the restoration of architectural objects. It is emphasized that these methods can be used to analyse large amounts of data and recognize patterns in damaged or lost structural elements. This technology makes it possible to automate the process of recovery and restoration, reducing the time and effort required for restorers. In addition, the study found that machine learning can be used to improve recognition and restoration algorithms, which helps to improve the quality and accuracy of work. The findings indicate that this approach can become an effective tool in the restoration of even the most complex architectural structures, allowing them to preserve their historical and cultural value for future generations. The results of this study complement and extend the conclusions of the researchers regarding the potential use of artificial intelligence and machine learning in the restoration of architectural objects. As indicated in the conclusions of the researchers, such technology can be a promising tool for analysing large amounts of data and recognizing patterns in damaged or lost structural elements. However, in contrast to this approach, this study focuses on the use of physical restoration methods, such as photogrammetry, which provides high accuracy and detail in creating digital models of architectural objects. While artificial intelligence and machine learning can automate the recovery and restoration process, they can require significant amounts of data to train and need to be updated regularly to maintain accuracy (Nesterov, 2023). Effective implementation of such technologies requires careful planning, including the collection and processing of large amounts of data and ongoing training of models to ensure accuracy and quality of results.

In general, the results of research conducted in this area indicate significant progress in the use of modern technologies in the restoration and preservation of architectural objects. The introduction of digital technologies can greatly facilitate the process of analysing, reconstructing, and preserving cultural heritage. Innovative methods, such as artificial intelligence and machine learning, open up new opportunities for automating and optimizing restoration processes, which helps preserve historical sites for future generations. However, it is important to bear in mind that the effective use of these technologies requires a deep understanding and expertise in archaeology and restoration, as well as continuous improvement and refinement of methods. The development and implementation of digital technologies in the field of archaeology is a key factor in preserving and promoting cultural heritage for future generations.

CONCLUSIONS

This study has shown that the reliance on the use of advanced technologies in everyday life leads to improved conservation and restoration of archaeological sites. The effective restoration of the damaged mihrab of the Marinid Madrasa, Al-Mariniya Madrasa, and the Roma settlement, in particular, is an example of such an improvement, where the immediate value of the site slowed down the loss of its individual value and the architectural complex as a whole. Overall, it is important to note that the demand for 3D technologies for heritage digitization is growing rapidly, offering a promising way forward for the future of cultural heritage development.

This study has shown that the use of photogrammetry allows historical remains to be digitally recorded at a high level of detail, facilitating the rehabilitation and effective analysis of cultural sites. The use of ground and airborne photogrammetry in this study allowed for the creation of high-quality three-dimensional models of architectural objects, including enhanced orthophotos and 3D models. Photogrammetry technologies also proved useful for modelling and analysing architectural structures with high accuracy and detail. Selected virtual 3D models have proven to be efficient and fast in analysing structural elements and associated data. These technologies open up new opportunities for the management and preservation of cultural heritage,

as well as for tourism and educational initiatives aimed at bringing this heritage closer to new generations. The results of this study confirm the significant potential of photogrammetry technologies for the preservation, restoration, and accessibility of cultural heritage for future generations.

Areas for further research in this area may include the development of new methods for analysing and interpreting the data obtained to better understand cultural sites and their history. It is also important to consider in detail the possibilities of using virtual reality and augmented reality for interactive study and promotion of cultural heritage among the public. Conducting such research with the use of various modern technologies can help expand the knowledge base and improve the practical application of new methods in the preservation and research of archaeological sites.

ACKNOWLEDGEMENTS

None.

CONFLICT OF INTEREST

None.

REFERENCES

[1] Acke, L., De Vis, K., Verwulgen, S., & Verlinden, J. (2021). Survey and literature study to provide insights on the application of 3D technologies in objects conservationд and restoration. *Journal of Cultural Heritage*, 49, 272-288. doi: 10.1016/j.culher.2020.12.003.

[2] Atik, M.E., Duran, Z., Yanalak, M., Seker, D.Z., & Ak, A. (2023). 3D modeling of historical measurement instruments using photogrammetric and laser scanning techniques. *Digital Applications in Archaeology and Cultural Heritage*, 30, article number e00286. doi: 10.1016/j.daach.2023.e00286.

[3] Barrile, V., Bernardo, E., Fotia, A., & Bilotta, G. (2022). Integration of laser scanner, ground-penetrating radar, 3D models and mixed reality for artistic, archaeological and cultural heritage dissemination. *Heritage*, 5(3), 1529-1550. doi: 10.3390/heritage5030080.

[4] Bercigli, M., Miho, E., & Lamaj, J. (2022). Digital survey for the valorization and conservation of the church of St. Mary in Leusë. In R. Volzone & J.L. Fontes (Eds.), *Architecture of soul. Diachronic and multidisciplinary readings* (pp. 363-378). Lisbon: Institute of Medieval Studies.

[5] Cilek, A., Berberoglu, S., Donmez, C., & Cilek, M.Ü. (2020). Generation of high-resolution 3-D maps for landscape planning and design using UAV technologies. *Journal of Digital Landscape Architecture*, 5(1), 275-284. doi: 10.14627/537690029.

[6] Dokolova, A. (2023). Features of digital public art of the twenty-first century: Art of Physical and virtual space. *Notes on Art Criticism*, 43, 3-8. doi: 10.32461/2226-2180.43.2023.286827.

[7] Fazio, L., Lo Brutto, M., Barsanti, S.G., & Malatesta, S.G. (2022). The virtual reconstruction of the Aesculapius and Hygeia statues from the sanctuary of Isis in Lilybaeum: Methods and tools for ancient sculptures' enhancement. *Applied Science*, 12(7), article number 3569. doi: 10.3390/app12073569.

[8] Ferdani, D., Demetrescu, E., Cavalieri, M., Pace, G., & Lenzi, S. (2020). 3D modelling and visualization in field archaeology. From survey to interpretation of the past using digital technologies. *Groma. Documenting Archaeology*, 4, 1-21. doi: 10.12977/groma26.

[9] Fiz, J.I., Martín, P.M., Cuesta, R., Subías, E., Codina, D., & Cartes, A. (2022). Examples and results of aerial photogrammetry in archeology with UAV: Geometric documentation, high resolution multispectral analysis, models and 3D printing. *Drones*, 6(3), article number 59. doi: 10.3390/drones6030059.

[10] Gryglewski, P., Ivashko, Yu., Chernyshev, D., Chang, P., & Dmytrenko, A. (2020). Art as a message realized through various means of artistic expression. *Art Inquiry*, 22, 57-88. doi: 10.26485/AI/2020/22/4.

[11] Jones, C.A., & Church, E. (2020). Photogrammetry is for everyone: Structure-from-motion software user experiences in archaeology. *Journal of Archaeological Science: Reports*, 30, article number 102261. doi: 10.1016/j.jasrep.2020.102261.

[12] Kaimaris, D., *et al*. (2022). Use of archaeological archives: 3D visualization of old two-dimensional drawings. In *Proceedings of the 16th ICA conference "Digital approaches to cartographic heritage"* (pp. 230-243). Thessaloniki: Aristotle University of Thessaloniki.

[13] Karpov, V. (2023). Restoration of monumental painting in Ukraine in the 1950-1960s. Social aspirations and ideological collisions. *Culture and Contemporaneity*, 2, 88-94. doi: 10.32461/2226-0285.2.2023.293868.

[14] Karwel, A.K., & Markiewicz, J. (2022). The methodology of the archival aerial image orientation based on the SfM method. *Sensors and Machine Learning Applications*, 1(2). doi: 10.55627/smla.001.02.0015.

[15] Mandor, A.F., & Mostafa, K.S. (2022). The role of the UNESCO in protecting the background archeological global heritage in Egypt for achieving sustainable development a comparative study with Marocco. *Journal of Environmental Science*, 51(7), 119-152. doi: 10.21608/jes.2022.140434.1240.

[16] Mantovan, L., & Nanni, L. (2020). The computerization of archaeology: Survey on artificial intelligence techniques. *SN Computer Science*, 1, article number 267. doi: 10.1007/s42979-020-00286-w.

[17] Mustafaraj, E., Luga, E., Corradi, M., Borri, A., Muceku, Y., & Zharkalli, A. (2021). Physical-mechanical properties of stone masonry of Gjirokastër, Albania. *Materials*, 14(5), article number 1127. doi: 10.3390/ma14051127.

[18] Nesterov, V. (2023). Integration of artificial intelligence technologies in data engineering: Challenges and prospects in the modern information environment. *Bulletin of Cherkasy State Technological University*, 28(4), 82-92. doi: 10.62660/2306-4412.4.2023.82-90.

[19] Pagliano, A. (2022). Digital technologies for the knowledge and valorisation of inaccessible archeological sites in Phlagraean Fields. In *ICAUD 2021 – international conference on architecture and urban design*. Tirana: Epoka University.
[20] Petërçi, E. (2022). The virtual representation of converted sacred spaces. The case of Saint Nicholas Church in Albania. In *ICAUD 2021 – international conference on architecture and urban design*. Tirana: Epoka University.
[21] Pietroni, E., & Ferdani, D. (2021). Virtual restoration and virtual reconstruction in cultural heritage: Terminology, methodologies, visual representation techniques and cognitive models. *Information*, 12(4), article number 167. doi: 10.3390/info12040167.
[22] Prychepii, Ye. (2022). Structures of the cosmos and sacred sets on the artefact of the paleolithic. *Interdisciplinary Cultural and Humanities Review*, 1(1), 30-39.
[23] Putch, A. (2017). *Linear measurement accuracy of DJI drone platforms and photogrammetry*. San Francisco: DroneDeploy.
[24] Rodríguez-Martín, M., & Rodríguez-Gonzálvez, P. (2020). Suitability of automatic photogrammetric reconstruction configurations for small archaeological remains. *Sensors*, 20(10), article number 2936. doi: 10.3390/s20102936.
[25] Shumka, L. (2022). Particularities of wooden carved iconostases in selected post-Byzantine churches of Albania. *Muzeologia a Kulturne Dedicstvo*, 10(4), 79-88. doi: 10.46284/mkd.2022.10.4.6.
[26] Škrabić Perić, B., Šimundić, B., Muštra, V., & Vugdelija, M. (2021). The role of UNESCO cultural heritage and cultural sector in tourism development: The case of EU countries. *Sustainability*, 13(10), article number 5473. doi: 10.3390/su13105473.
[27] Zaragoza, I.M.E., Caroti, G., & Piemonte, A. (2021). The use of image and laser scanner survey archives for cultural heritage 3D modelling and change analysis. *ACTA IMEKO*, 10(1), 114-121. doi: 10.21014/acta_imeko.v10i1.847.
[28] Zhong, B., & Li, Y. (2019). Image feature point matching based on improved SIFT algorithm. In *2019 IEEE 4th international conference on image, vision and computing (ICIVC)* (pp. 489-493). Xiamen: Institute of Electrical and Electronics Engineers. doi: 10.1109/ICIVC47709.2019.8981329.

Алекс Трушай
Доктор археологічних наук, доцент
Університет «Ісмаїл Кемалі» Вльора
9400, вул. Косова, м. Вльора, Албанія
https://orcid.org/0009-0005-4251-4530
Блеріна Джелай
Доктор історичних наук
Університет «Ісмаїл Кемалі» Вльора
9400, вул. Косова, м. Вльора, Албанія
https://orcid.org/0009-0008-9169-4146

Сучасні технології в археології та їх застосування у реставрації архітектурних об'єктів

Анотація. Вивчення сучасних технологій в археології та реставрації архітектурних об'єктів є надзвичайно важливим через можливість їх використання для збереження культурної спадщини, відкриття нових артефактів та вдосконалення методів наукових досліджень. Метою цього дослідження було проаналізувати можливості використання сучасних технологій для реабілітації та візуалізації об'єктів культурної спадщини. У ході дослідження були використані такі методи, як фотограмметрія, порівняльний метод та аналіз. Результати дослідження показали значний потенціал сучасних технологій фотограмметрії у збереженні та візуалізації культурної спадщини. Зокрема, використання повітряної фотограмметрії за допомогою дрона та наземної фотограмметрії за допомогою цифрової камери дозволило створити тривимірні моделі архітектурних об'єктів з високою точністю та деталізацією. Наприклад, за допомогою дрона було зібрано та оброблено 267 знімків медресе Марінід, медресе Аль-Марінія та ромського поселення. Ці дані дозволили створити детальні тривимірні моделі, які були використані для створення ортофотопланів і візуального огляду місця. Крім того, експорт 2D-даних і моделей виявився ефективним для подальшого моделювання та аналізу. Це дозволило розробити тривимірну цифрову модель, яку можна візуалізувати, модифікувати та адаптувати в будь-який час, що стало цінним інструментом для архітектурних досліджень та документації. Результати дослідження підтвердили практичну ефективність фотограмметричних методів у збереженні та документуванні історичної спадщини. Використання цифрових моделей та ортофотопланів може полегшити візуальний аналіз об'єктів, подальші дослідження та архівування культурних цінностей. Такий підхід має потенціал для освітніх та туристичних ініціатив, залучення широкої аудиторії до вивчення та поцінування історичної спадщини

Ключові слова: фотограмметрія; культурна спадщина; 3D-візуалізація; реставрація історичних цінностей; деталізація моделей

Architectural Studies
International Journal about Architecture

Volume 10, No. 1

UDC 711.4:72.012
DOI: 10.56318/as/1.2024.92

Yuliya Idak*
Doctor of Architecture, Professor
Lviv Polytechnic National University
79000, 12 Stepan Bandera Str., Lviv, Ukraine
https://orcid.org/0000-0002-1123-5759
Olha Lysenko
PhD in Architecture, Associate Professor
Lviv Polytechnic National University
79000, 12 Stepan Bandera Str., Lviv, Ukraine
https://orcid.org/0000-0001-6230-5350

Preservation of urban form: A critical analysis of modern development strategies and the importance of compositional integrity

Abstract. The relevance of the study stems from the need to analyse modern urban development strategies, with a special emphasis on the importance of preserving the urban form in the context of its unique visual characteristics and overcoming spatial chaos in densely populated residential areas. The purpose of the study was to identify specific features and properties that are manifested at the level of implementation of specific goals in relation to the development of the city at the macro level. The research methodology was based on historical and typological, structural and functional, and historical and comparative analysis of historically formed components of such cities as Lviv and Ivano-Frankivsk (Ukraine), Athens (Greece), Neuf-Brisach (France), Philadelphia (USA), and Berlin (Germany). The authors emphasised the importance of ensuring the compositional integrity and unity of urban space, especially in the relationship between its form and function. Focusing on such relationships, special attention was paid to the contextuality of historical cities and its material content through the prism of cultural potential. The main areas of development of formal structures are defined graphically, emphasising their connection with cultural function. It was noted that the cultural cluster as a component of many significant cities is not only a place for the preservation and development of spiritual values, but also a means of expressing originality and ensuring the integrity of its appearance. It was noted that the introduction of the latest concepts leads to the loss of uniqueness of historically formed structures and chaos in modernist areas of large cities. The reason for this is the emphasis on the deprivation of individuality through the introduction of typical aesthetic content with an emphasis on functional expression and economic feasibility. The conclusions of the study indicate the importance of integrating cultural potential into the urban development strategy, ensuring the viability and uniqueness of cities in a global context. Understanding these outcomes will help to focus on the needs and increase the effectiveness of measures aimed at supporting cultural diversity, social inclusion, and the overall well-being of residents and visitors

Keywords: historical city; theory of urban planning; growth; heritage

INTRODUCTION

Given the current problems and challenges facing Ukraine in 2024, and considering the significant efforts and scientific research aimed at preserving the identity of urban space and recreating its tradition, there are several aspects that remain unresolved. These aspects require even more attention and scientifically based developments, in

Suggested Citation:
Idak, Yu., & Lysenko, O. (2024). Preservation of urban form: A critical analysis of modern development strategies and the importance of compositional integrity. *Architectural Studies*, 10(1), 92-103. doi: 10.56318/as/1.2024.92.

Journal homepage: https://arch-studies.com.ua/en#
Architectural Studies, 10(1), 92-103
Received: 14.12.2023 Revised: 30.03.2024 Accepted: 20.06.2024

*Corresponding author

particular, within the framework of the theory and practice of urban planning.

As of 2024, in the context of a difficult socio-economic and political situation, in particular in Ukraine, issues of physical security of the residential environment, preservation of the identity of urban space or reproduction of its tradition based on the principles of neo-urbanism philosophy, have become relevant. F. Treffers (2023) suggests that the old development models and regulatory frameworks are not able to contribute to the optimal recovery of Ukraine. J. Bergmann & I. Romanyshyn (2022) note that the plans for the restoration of Ukraine are closely coordinated with the norms and standards of the European Union. European experience shows that the successful implementation of the reconstruction process is associated with the development and implementation of a comprehensive methodology based on regional features of urban areas in relation to the implementation of the concept of sustainable development. The paper by Yu. Idak (2022) evaluated such actions. It was noted that the implemented project proposal did not violate the integrity and imagery of either the city as a whole or its individual fragments.

Yu. Idak & R. Frankiv (2022) note that due to the active housing development in Ukraine at the beginning of the 21st century, a new form of organisation of the material and spatial environment of human life became widespread. It is aimed at creating a safe physical space. At the same time, this trend contradicted the concept of development of a modern city, which is based on the principles of openness and accessibility. Despite active discussions about environmental sustainability and scientific interest in urban society, the focus was mainly on current reality, current management, and future planning. This distracts the eye and limits understanding of the challenges of growing up and living in cities, focusing solely on current challenges. In this light, according to B.N. Vis (2018), many alternative models that indicate the versatility of urban opportunities are ignored. On the other hand, A. Fedak & S. Linda (2022) noted that at the beginning of the 20th century, a change in approaches to solving current problems of spreading the ideas of an ideal city, the rejection of the city as a desirable model of human settlement and an attempt to return to nature, and the introduction of environmental technologies, were the reason for the development of utopian ideas in urban planning.

With the growth of cities and their adaptation to new challenges, including those that actualise the problem of achieving sustainability, the issue of preserving the identity of the urban environment is quite important. O. Musiyezdov & K. Maryniak (2020), based on empirical experience in Kharkiv and Lviv, suggested that urban identity exists in the context of an "imaginary community". This is conditioned by the fact that residents of cities, depending on their social, economic, and cultural potential, create and defend their individual image. Consequently, the individual needs and views of city residents in developing strategies to preserve the urban form and ensure the viability and harmony of the urban environment remain desirable.

In the light of these challenges, tasks related to the development of theoretical concepts and the implementation of practical ideas for urban development become topics of broad discussion. To a greater extent, they are aimed at achieving optimal functioning of the urban environment. Both practical solutions to these problems and theoretical approaches to developing effective urban development strategies are discussed and considered in various aspects. For example, the concept of the city of Poundbury (Poundbury – design and..., 2019) is widely discussed in scientific communities. Contrary to popular technological and innovative projects, it has implemented a traditional medieval urban structure of high-density and low-rise buildings. Similarly, the city of Coventry has become the subject of a thorough scientific analysis due to numerous changes in urban space under the influence of socio-economic globalisation challenges (Begley *et al.*, 2019).

Due to the significant variations in approaches to the study of the urban environment, it is proposed to consider such issues through the prism of the cultural potential of the city, the uniqueness of their formal structures and the contradictions that lead to the implementation of the latest development strategies. This approach will expand the understanding of the specifics of the city's functioning and the development of development strategies, in particular, considering the preservation of its unique form. The purpose of the study was to assess the current urban development strategies and to argue the hypothesis that in the process of implementing innovative solutions, it is necessary to consider the individual characteristics of the city, which take place at the level of expression of its formal structures. Particular emphasis is placed on those aspects that cause disorder in the urban environment, which is characterised by a rather high level of development. This is due to the lack of interaction between the form and function of the city, especially at the level of their cultural potential.

MATERIALS AND METHODS

The methodological basis of the study was a detailed analysis of the formal structures of cities, which are distinguished by unique features in the context of architecture and urban planning. They have a deep history and a diverse culture, which largely determines their economic potential and contributes to the development of the tourism industry. They are: 1) Lviv (Ukraine), where as of 2024 there are 2,422 monuments of architecture, urban planning, history, art, and archeology (Lviv City Council, 2023); 2) Neuf-Brisach (France), the last fortress designed and built by the military engineer Sebastien Le Prestre de Vauban and the only one where the author managed to implement the most complex "third system" of defensive fortifications (Balliet, 2008). It played a key role in protecting the country from foreign invasions, and all implemented objects have a continuum between form and function; 3) Philadelphia (USA) – one of the oldest

cities in America. The orthogonal planning grid (Historical Society of Pennsylvania, n.d.), has been preserved to this day and became the basis for further development. In the 21st century, next to the preserved planning structure, the border between the city and its surroundings is levelled; 4) Athens (Greece) in the past was the centre of ancient Greek culture. After the proclamation of the London Protocol of 1830, Greece gained political independence and became the legal successor of ancient Greek culture (International Human Rights Instruments..., 2018). All historically significant archaeological sites located in a 7 km^2 area (Dimopoulou *et al.*, 1999); the entire historical heritage of the city demonstrates a continuum of architectural and urban planning solutions and cultural achievements of various stages of development over 2,500 years. On the example of the planning structure of the city of Ivano-Frankivsk (Ukraine) in the 18th-19th and 20th-21st centuries, the change in the form and structural organisation of its territory was traced, and on the example of the Berlin Museum quarter (Germany), and many museums in Lviv (Ukraine) and Athens (Greece) located close to each other, it was noted that cultural heritage is an important factor for ensuring the functional and compositional integrity of the central part of the city.

The study was conducted in three stages. Due to the rapid pace of urbanisation, papers related to determining promising models of urban development have become widespread. At the first stage, the method of theoretical analysis was implemented and an analytical review of modern urban development strategies was conducted. Historical and typological analysis was applied to identify trends in the preservation of the city's form. The second stage of the study was implemented within the framework of a structural and functional approach and was devoted to the spatial analysis of the cities under consideration and their fragments. To visualise the obtained data, the method of graphical modelling of urban planning structures was used and implemented in the following sequence: conceptualisation – solving questions about the nature of the model and its main elements → determining contextual characteristics → development of the model. This became the basis for providing a qualitative assessment of the formal structures of the city in terms of their spatial organisation and functional content of such cities as Lviv (Ukraine), Neuf-Brisach (France), Philadelphia (USA), and Ivano-Frankivsk (Ukraine). There was also a spatial analysis of the context of historical cities and their material basis through the prism of cultural potential. At the third stage, a historical and comparative analysis was applied to identify general trends in the development of the city. Changes in urban planning practices and their impact on the development of urban space in areas of high-rise residential development were revealed. The analysis methodology was accompanied by the use of cartographic materials to investigate the organisation of cultural objects in the urban structure and other factors affecting the formal structure of the city and its functioning.

RESULTS

The material nature of the urban environment includes formal structures whose characteristic feature is borders (Vis, 2018). They affect visual perception, interaction opportunities, and the use or development of an urban area. The formal structures of the European city evolutionarily developed until the 18th century. This was followed by a time of imbalance in the urban environment and form (Fig. 1). This was conditioned by the general direction of thinking of the liberal economic order and logically led to the spread of the idea of "city without borders" (Sassen, 2001) or "city beyond borders" (Kenny & Madgin, 2017). T. Hall (2003) suggested that it is in the planning structure of the city that the origins of its current spatial condition should be sought.

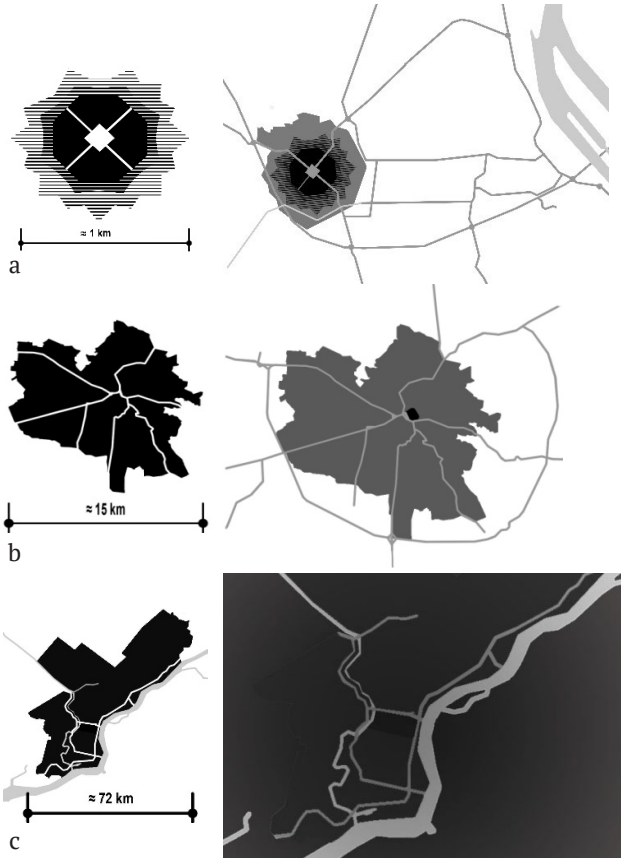


Figure 1. Shape of city
Notes: a – Neuf-Brisach, France (preserved city contour and planning structure); b – Lviv, Ukraine (transformed city contour); c – Philadelphia, USA (lost city contour)
Source: developed by the authors

In the concept of "city without borders", the key idea is that the development process requires the city to constantly find a balance between the disturbed formal balance and determining how to develop in the absence of external restrictions. This problem remains unresolved, and the object of criticism may be the postulates of functionalism in the 1920s and 1950s regarding the functional delineation and zoning of urban territory (Mumford, 1992). In them, one of

the main specific reasons is considered to be the replacement of the traditional form of "city" with a non-traditional one – the form of "non-city", due to the fragmentation of the urban body into separate parts (Böhme & Martin, 2019) and the loss of the integrity of the urban environment and form. The example of the city of Ivano-Frankivsk (Fig. 2) clearly demonstrates changes in the original form and loss of integrity and compositional expressiveness.

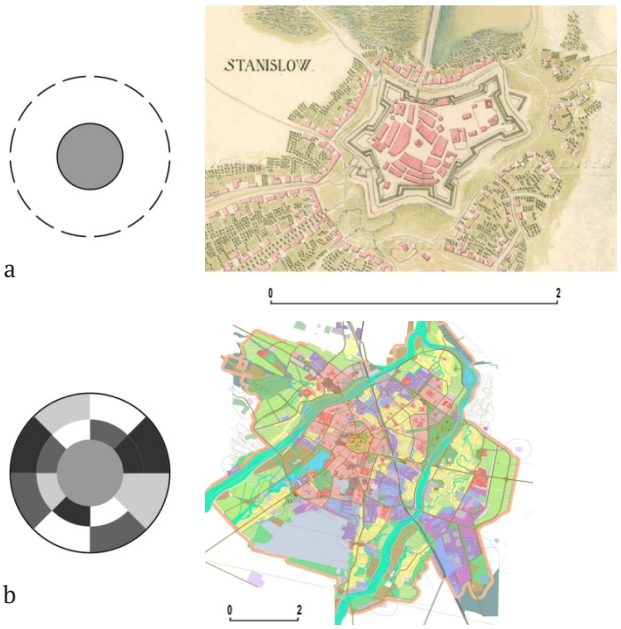


Figure 2. Ivano-Frankivsk
Notes: a – conceptual model of the formal structure of the city in the 18th-19th centuries; b – conceptual model of the formal structure of the city in the 20th-21st centuries
Source: developed by the authors based on Map of Stanislow in 1800 (n.d.) and General plan of Ivano-Frankivsk city (2001)

Discussions have become popular that modern cities should find their traditional spatial form, which would be created precisely through the organic combination and mutual complementation of various functions, mainly residential, administrative, industrial, commercial and cultural. This approach was the basis of urban planning in the 20th century. In the context of urban integration, especially in large metropolitan cities, special emphasis has been placed on the means of territorial unity, including overcoming differences in population density, distance, and social division (Medeiros, 2019). However, it can be assumed that the decisive element of this complex problem is the historical heritage of the city (Marmo *et al.*, 2018), which is concentrated in the central districts.

The complexity of the structure and cultural content of metropolitan areas reflect the diversity and complexity of the world as a whole. The example of the museum quarter in Berlin (Germany), the central part of Lviv (Ukraine) and Athens (Greece) suggests that the typical symbol of a modern European city is a museum, since the city can be considered as an environment for the existence and storage of various aspects of human life in their diversity, integrity and unity (Fig. 3). The historic city, due to its long historical development, is the largest repository of various cultural artefacts compared to any other objects and institutions. Human life activity is concentrated in the urban environment, which is manifested in technological processes and in architectural and urban planning forms. It can be stated that a metropolitan city is the best instrument of memory created by man (Posatskyi, 2007).

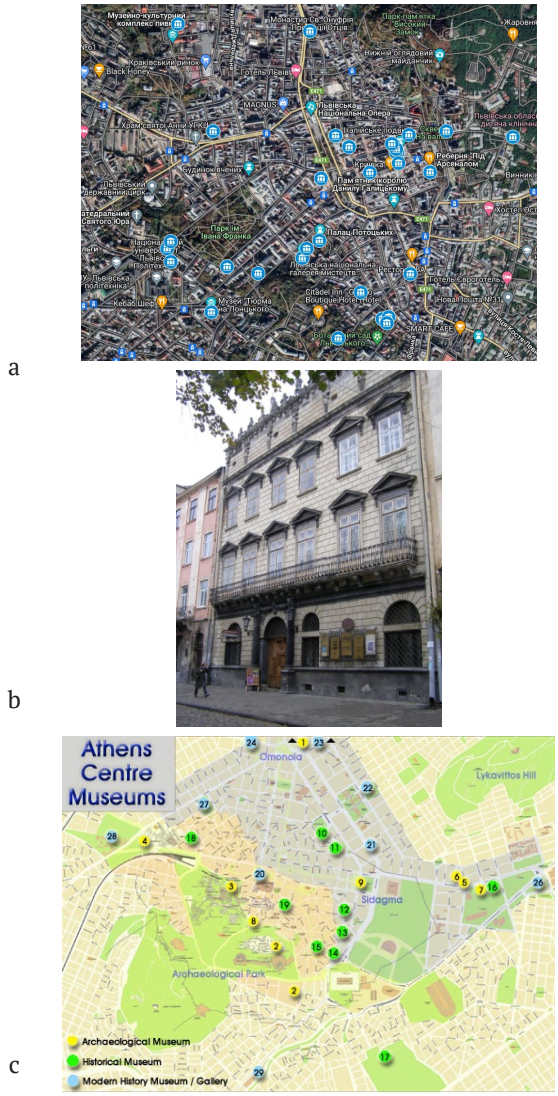


Figure 3. Museums of the big city
Notes: a – map of museums in the central part of Lviv; b – Lviv Historical Museum (one of the oldest museums in Ukraine); c – map of museums in the central part of Athens (Greece)
Source: a – Google My Maps (2023); b – History of Lviv Historical Museum (n.d.); c – Main Museums in the centre of Athens (n.d.)

In the public consciousness and theory of urbanism, there are intentions to return to the traditional form of the city, which are described by the motto "faith in the city"

and "spirit of the place". These concepts can define the unique features of each city (Nientied *et al.*, 2022), such as its natural conditions, its central part, and its overall functional planning organisation. It is considered important to pay attention not only to utilitarian items and solutions, but also to the "intangible qualities of the urban environment" (Siláči & Ebringerova, 2019). Among them: people's understanding of the scale of architectural forms and urban planning objects, and the ability of residents to identify with the current and future image of the city (Fig. 4).

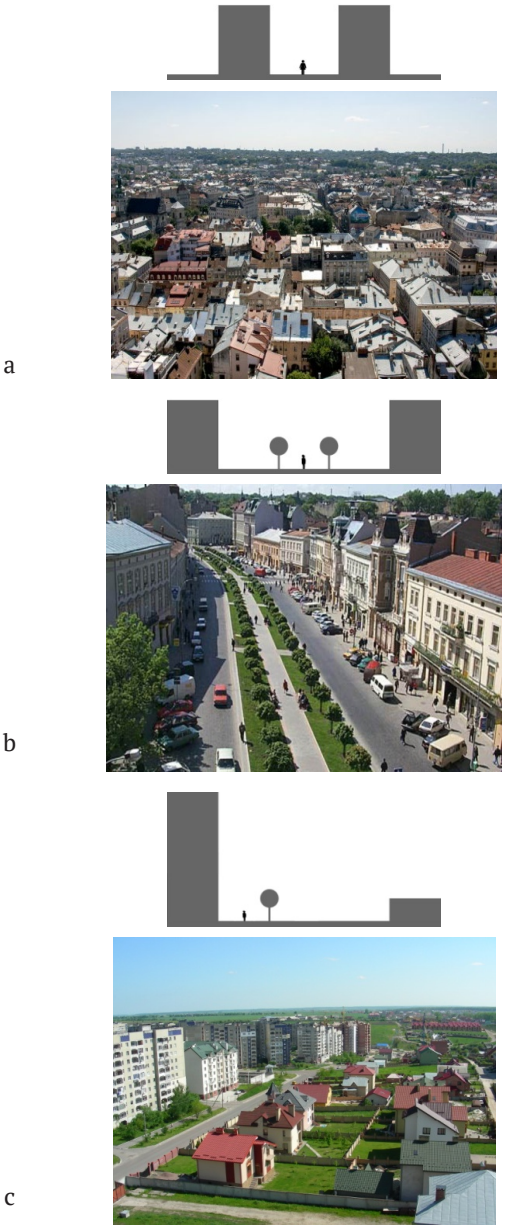


Figure 4. Street scale
(on the example of Lviv), diagrams and photos
Notes: a, b – street of the historical centre of the city (human scale); c – main street of the neighbourhood unit built in the 1980s (human unscale)
Source: diagrams – developed by the authors; photo: a – R. Metelsky (2015); b, c – Lviv City Council (n.d.)

This also applies to the combination of old and new urban forms, their coexistence, giving a clear structure to urban space and a variety of its elements. In modern cities, on the one hand, the functional and planning structure is growing and becoming more complex, and on the other hand, the practice of transmitting certain information to residents and guests from spatial representatives of the form is narrowing. This is due to the lack of imagery and stereotyping of mass architecture, and the similarity of new territorial objects in different cities, regions, and countries.

The characteristics and traits of urban space are determined by the process of its perception by residents and can facilitate or complicate it. Spatial characteristics of the environment are evidence of the general culture of society and demonstrate its level at one time or another, reflecting periods of development or stagnation, rise, or decline. An urban environment can become a social symbol when its spatial forms are perceived as an expression of public institutions (national, regional, local) and when its social significance becomes leading in comparison with other functions.

The historical urban environment in many developed countries as of the beginning of the 21st century is generally not of primary social importance. For example, the city of Oslo (Norway) has a rich history, replete with modern architectural and urban planning objects, devoid of historical continuity and aimed at finding the unique shape of individual objects. During the reconstruction of the Fjordbyen harbour, giving preference to the search for uniqueness, the authorities and city planners focused on innovative design and experiments with forms, trying to create a new image of the city. Historical architectural and urban planning objects are of interest mainly for aesthetic and religious reasons and for a sense of patriotism. However, it is these factors that have great weight in societies that have long been deprived of their own statehood and only relatively recently received it. A typical example of this is the situation in Ukraine.

The importance of the symbolic functions of architecture can be explained by the following. As of 2024, there is spatial chaos in the cities of Ukraine and its peripheral areas due to excessive compaction and the need for housing. In the context of competition in the real estate market, the emphasis is on promoting "modern" approaches to the creation of residential complexes, which are perceived as a response to the needs of buyers. Among the most common measures to overcome such chaos in Ukrainian cities is the construction of new sacred objects, which in their form convey symbols that are understandable to the general public and at the same time are traditionally designed to be compositional accents of urban space. The most popular such object in 2009 was the Greek Catholic Church of the Nativity of the Holy Virgin Mary in the Sykhiv residential area on the periphery of Lviv (Fig. 5), built in 1995-2001 according to the design of Radoslav Zhuk (Cherkes, 2009).

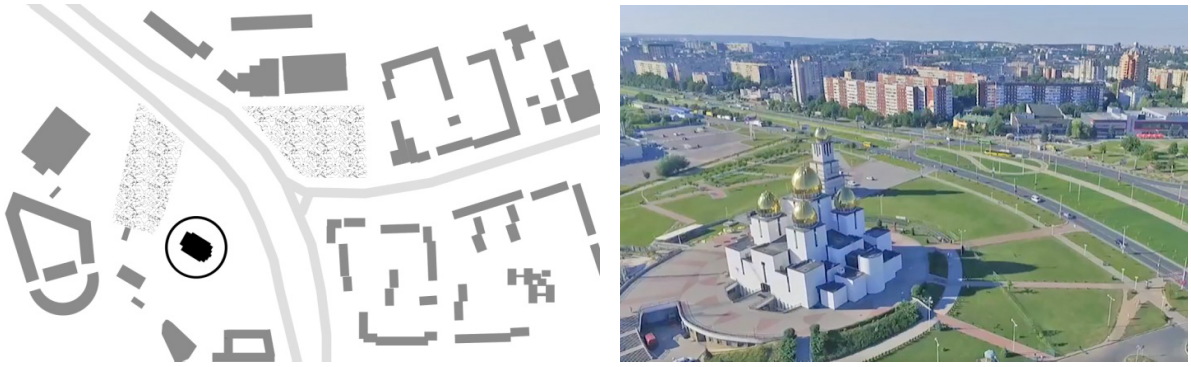


Figure 5. Compositional centre of urban space of a big city:
on the example of the Nativity of the Holy Virgin Church in Lviv
Notes: a – plan diagram; b – general view of the church
Source: a – developed by the authors; b – frame from "Blog 360" Youtube Channel (2017)

The example of Lviv illustrates the importance of understanding the city's space from the standpoint of art, which is once again becoming relevant. Back at the end of the 19th century, K. Zitte argued that the city space should be considered as a work of art with an important social function (Habrel, 2021). The main idea in this concept is the thesis about the integrity of space and form, which the city itself creates in the course of its existence. However, in the modern city of the early 21st century, the integrity of the urban planning form is disintegrating mainly under the pressure of motorisation, for the same reason, the quality of the urban environment as a whole sharply deteriorates. For example, high-speed road transport increases the size of suburban areas, leading to increased paved areas, heat effects and urban air pollution, household consumption of goods, and loss of agricultural land, forests, and biodiversity (Tranter & Tolley, 2020). In 2018, global carbon dioxide (CO_2) emissions from transport totalled 8 billion tonnes, of which 74% came from road transport (Understanding traffic & air quality..., 2023). Even with significant improvements in efficiency, global energy demand is projected to grow markedly over the course of this century, as a result of which zero-emission energy system concepts are being developed (Davis *et al*., 2018). New urban concepts such as smart growth, new urbanism, and transport-oriented development aim to create pedestrian and accessible areas that support non-motorised transport and connect different parts of the city to public transport (Piracha & Chaudhary, 2022).

During the 20th century, numerous theoretical and design concepts were developed to preserve the integrity of the urban organism by spatial differentiation of transport and pedestrians and the corresponding organisation of urban transport networks (Dittmar & Ohland, 2022). In this context, the significance and role of the city street – an important component of the urban environment and one of the main urban planning forms – was reviewed. The development of new (or reconstruction of existing) public spaces, the main elements of which are pedestrian-friendly streets and squares, is becoming widespread.

After more than half a century of providing benefits to private individual vehicles at the end of the 20th century, the concept of organising integrated public transport systems in large cities is being increasingly promoted and implemented (Spink *et al*., 2022). These include the combined systems of the underground (metro) and surface (city railway, bus) transport network, which can free the central part of the city from the movement of individual vehicles. It is worth noting that freeing the central city centre from individual transport is more or less realistic in small cities, but in large cities (not to mention the most significant ones) it turns into a very complex set of problems. A characteristic feature of new technical capabilities in the organisation of urban transport networks is the mass use of helicopters in passenger transportation in the most significant cities of the world: New York (USA), Tokyo (Japan), São Paulo (Brazil).

At the beginning of the 21st century, when popular science publications became available to a wide audience, it became obvious that the city's environment is an object of interest for many areas of scientific research. Although different disciplines are involved in the analysis of the urban environment (Dastjerdi & Nasrabadi, 2022), architecture and urban planning remain the main ones. However, it is important to note that these areas were in a transitional state at the end of the 20th century, associated with a change in paradigms and approaches in urban planning practice. In the past, the practice of urban planning was aimed at simplifying their structure, which led to a decrease in their functional efficiency. In the late 20th and early 21st centuries, attention was focused on maintaining and creating functional complexity (Marshall, 2012), which is important for ensuring their effectiveness, meeting the needs of residents, and resilience to change. Reform in urban planning and architecture was influenced by the development of new technologies, changes in social values, and under the influence of globalisation and challenges of sustainable development.

Urban planning problems, by their very nature, are interdisciplinary, since their solution requires the interaction of various scientific and professional areas. Successful

solutions require not only technical knowledge of planning and engineering, but also an understanding of social needs and cultural aspects. In addition, urban planning activities have an important artistic component, which is revealed through various forms of visual expression of architectural objects in the urban environment. However, in the 20th century, urban planning practices began to focus mainly on technocratic and economic factors based on weighted average criteria and statistical data. In accordance with this, urban planning in general was subject to interdisciplinary compromises, which led to the predominance of economic planning for urban development. It is this understanding of the problem that leads to departmental limitations and does not allow organising the space and shape of the city as a whole in a satisfactory way.

Master plans of cities do not contain a generalised concept of the spatial form of the city in the sense of the basis for the development of its urban planning composition, the same applies to the rules of use and development of urban territories (so-called zoning). In fact, the indiscriminate application of the postulates of the American version of zoning in the environment of the historical European, and therefore Ukrainian city, can lead to further deformation of the urban environment in the artistic sense. Therefore, during the development of a new urban planning policy in Ukraine, it is necessary to rely on the postulates of planning and design.

The urban planning form is directly and concretely manifested in the projects and implementation of large territorial complexes. However, there is a tendency to solve, first of all, specific tasks related to individual buildings or structures, while the urban planning context remains ignored. During the 1960s and 1980s, urban planning forms that provide a high degree of concentration and integration of various urban functions, the so-called megastructures, became widespread in cities in the United States and Western Europe (Kantor & Savitch, 2010). A striking example of multifunctional structures is the Prater district in Vienna (Austria). As of 2024, a megastructure is organised on the territory of more than 200 hectares, where all possible functions of the European metropolis are concentrated: educational (Vienna University of Economics), entertainment (a large park with vintage attractions), cultural (Vienna Exhibition Congress Centre, museums), commercial (office centres), residential (houses for temporary and permanent residence of both guests and residents of the city), sports (track for racing and Ernst-Happel-Stadion), recreational (parks and green areas with reservoirs), engineering structures (parking lots and transport hubs), etc.

Modern megastructures play a key role in the structure of urban centres, combining various objects around large public spaces at different levels – underground and aboveground. They create favourable conditions for communication and various types of urban activity, reflecting the prevailing trends in the culture and civilisation of the new millennium. One of these trends is massification, which is manifested in unimpeded access to various items, including those belonging to mass culture, due to developed forms of mass services that operate on the principle of "everything is available to everyone".

The need for widespread distribution of certain items is associated with changes in the fashion world, as new styles attract consumers and generate demand for new products. This trend, supported by the demands of wealthy clients, permeated architecture in the late 20th century (Leach, 2010), with architectural forms becoming a fashionable phenomenon. It was based on short cycles, requiring the architect to constantly update. Consequently, a new technical culture is being developed, which considers the city as a "machine for making money" (Busà, 2017), that is, economic priorities dictate the forms of organisation of space according to the requirements for ensuring the greatest economic feasibility. The same megastructures are characterised by the similarity and uniformity of the main spatial characteristics, subordinated to commercial needs.

On the other hand, trends of universalisation cause resistance and negative reactions of those who defend the values of national or regional culture, seeing them as the basis of cultural sovereignty. At the turn of the millennium, opposition to universalisation and globalisation became a prominent phenomenon in European culture. At the forefront is the demand to form a humane, human-friendly urban environment in unity with the natural environment based on traditional urban forms. This trend is embodied in large-scale measures to preserve the cultural landscape and historical and architectural heritage in the countries of Western and Central Europe at the regional and local levels. Historical associations are designed to enrich the shape of the city, however, the literal transfer of historical forms to the environment of a modern city, as a rule, does not give the desired result. But the search continues for a modern equivalent of historical values in the sphere of the city's form. This task is difficult and time-consuming, as the modern city is characterised by extremely contradictory background contexts that did not exist in the historical city. It is suggested that "... the only perceivable visual organisation for the inhabitants of a modern metropolis is the metro plan and road signs".

However, in the last decade of the 20th century, attempts to return to the historical urban planning context became noticeable. In England, the construction of the town of Poundbury with an area of 160 hectares and a planned number of 5 thousand inhabitants has begun. The programme thesis of the designers (urban planning concept by L. Krier and L. O'connor) was the construction of the city according to the English rural tradition. The project provided for the greatest variety of types of buildings (detached, blocked), alleys, playgrounds, and courtyards. Thus, it was planned to create a very attractive urban landscape (Knupfer *et al.*, 2018). The planning structure of the already implemented town consisted of several polygonal blocks separated by broken streets, and the built-up area was surrounded by meadows and fields. The initial principle in the construction of the town was to observe the traditional

spatial scale and architectural forms for English small towns and the use of regional construction technologies.

DISCUSSION

Due to the significant immersion in the problems of the development of the urban environment, the paers by S. Kostof (2005) and G. Curdes (1996) remain relevant in the modern urban planning discourse. This is conditioned by the fact that they have generalised characteristics of the urban form. If the study by S. Kostof (2005) is a theoretical generalisation and definition of the maximum set of characteristics of a formal city expression with an emphasis on historical continuity, then the study by G. Curdes (1996) has a methodological focus. It substantiates the importance of observing the laws of development and change of an urban structure, in accordance with the logic of spatial orders.

In 2024, the relevant practical recommendations for the organisation of the urban environment set out in the book by Duany *et al*. (2010). The researchers' ideas were based on the principles of neo-urbanism and focused on the importance of compact development, creating accessible spaces that promote pedestrians and cyclists, preserving natural resources and reducing car addiction. But it is important to keep in mind that excessive emphasis on compact buildings leads to some negative consequences. For example, too dense development changes the traditional silhouette of the city, violates the compositional integrity of already formed urban structures, and leads to an increase in traffic load and deterioration of air quality. In addition, it is important to consider the diversity of needs and wishes of residents, and not just to be limited to efficiently addressing construction requests. A more correct approach to the organisation of urban space seems to consider the need to introduce not only effective development methods, but also those aimed at comprehensive preservation of individuality and sustainability.

At the end of the 20th century, the form of the so-called "ecological city" was discussed quite intensively. Two concepts were compared in this discussion. Proponents of a compact, that is, intensively built-up city put forward arguments about lower energy costs for heating and transport needs, while emphasising that transportation can be reduced by replacing them with bicycle and pedestrian movements, which allows preserving the cleanliness of the environment and reduce fuel consumption. However, the compact city has certain drawbacks (Bibri *et al.*, 2020). In such a city, there are not enough open green areas, which are necessary for organising various forms of recreation and enriching the urban landscape. This suggests that the optimal from an ecological standpoint may be the linear shape of the city, which is formed from intensively built-up "island" territories that alternate with green areas or along massive natural components. An example of the first option is the city of Örebro in Sweden, which acquired "island"-type linear development in the second half of the 20th century. Acceptable for the second is Copenhagen (Denmark). This city is actively developing a strategy to create a living environment surrounded by water bodies and green spaces.

In the early 2000s, formal characteristics were the subject of considerable interest. Scientific research concerning the urban form has become particularly relevant. It was based on the studies of numerous geographer researchers who worked within the framework of three morphological schools proposed at the end of the 20th century by A.V. Moudon (1997). At the beginning of the 21st century, the border between the specifics of each of the morphological schools was levelled. Research related to sustainable urban development and within the competence of various fields of scientific activity, including architecture and urban planning, has gained popularity (Kropf, 2017; Idak, 2020). S. Kristjánsdóttir (2019) noted that urban morphology is in the field of interdisciplinary research and is used to describe the physical form or urban landscape of complex modern cities. For example, S. Vanderhaegen & F. Canters (2017) use form to determine the potential of urban metrics. They describe the availability and configuration of built-up and open urban areas to map different types of urban form and function at the city block level.

Along with the morphological discourse at the beginning of the 20th century, the one that concerns the introduction of effective models of city development was also developed. They were accompanied by conclusions on the optimisation of the urban form and its effective use (Oliveira, 2016). They were based on the problems of urban sprawl, with a particular focus on growing urbanisation, reduced area and accessibility to green areas, inefficient use of urban space, and general congestion of urban infrastructure. Researchers claim that the expansion of the city has led to inefficient use of land, loss of aesthetic qualities of space and the creation of too long routes. J.K. Brueckner (2000) touched upon one aspect of this problem in the early 20th century. Using the example of US cities, the researcher noted that urban expansion is not socially desirable and is mainly the result of three powerful factors: population growth, income growth, and falling travel costs. The Ukrainian experience is based on diametrically different problems related not to territorial expansion, but to the oversaturation of urban infrastructure (Liubytskyi, 2017), which leads to drastic changes, to a greater extent, in the traditional historical formal structures for Ukraine.

In 2016, the European Commission has updated the problem of uncontrolled urban development by presenting a joint report by the European Environment Agency (2016), which noted that urban sprawl develops through diverse and independent environmental impacts such as individual citizen actions, urban planning, production, land market, mobility, accessibility, and lifestyle changes. The definition of various types of stable models was substantiated, among which the most common was the compact city model (Jabareen, 2006), and later the slow city model (Pink, 2009). K. Mouratidis (2018) studied the Oslo metropolitan area (Norway), which covers both compact and extensive areas.

The result of the study was the conclusion that in compact cities, the standard of living is significantly higher than in sprawling cities. On the other hand, M. Neuman (2005) expressed doubts about the sustainability of a compact city, arguing that two key aspects are opposed in this context: process and form.

Given the interdisciplinary nature of the scientific discourse on cities, there are a significant number of studies. However, it is heterogeneous, since most research focuses on social and environmental aspects, in particular, on the problems of optimal density and grouping, thereby avoiding the analysis of the effective use of physical resources of the city in order to achieve strategic goals for their development. In these aspects of the development of cities, the urban planning of Ukraine faces complex theoretical and practical problems that require a revision of stereotypes and a new understanding in the light of new realities. New challenges and rethinking the usual urban planning practices should not be limited to those aspects that are aimed at solving problems of efficiency and optimality. Most of them are situational and can solve problems for a short period of time. The experience of Ivano-Frankivsk shows that the loss of form and compositional integrity leads to a violation of historical continuity, which is a critical aspect of urban development. In turn, the experience of Lviv (Ukraine) and Athens (Greece) is an example of how the cultural potential of the city and its formal representatives become an effective tool in enriching urban space.

The lack of preservation and proper management of historical heritage can lead to the loss of the city's cultural identity, reduced attractiveness for tourists, and the extinction of the urban environment. Therefore, the preservation of historical heritage and the restoration of its compositional integrity play a key role in the sustainable development of cities. Special attention should be paid to those ideas that are aimed at preserving the uniqueness of the urban environment, which is reflected in such formal characteristics as location, configuration, variability of forms and structures, etc. Consideration of these things requires a broad dialogue between researchers, professionals from various fields, investors, local authorities and the public, and various ideas that can ensure the sustainability of the urban environment and, at the same time, preserve the uniqueness and originality of each of the existing ones.

CONCLUSIONS

The study was aimed at analysing and exploring various aspects of urban form. Often its historical continuity was not consistent with modern trends, which lead to the loss of individuality of the urban environment and the acquisition of stereotypical features. Such features are manifested both at the level of the physical form of the city, expressed within its borders, and in the planning structure at the level of geometric characteristics of urban elements.

The state of formal structures of unique cities in the world was traced, and their distinctive and unique characteristics were emphasised. Special attention was paid to the variety of forms of cities, which is a key element of their identity. For example, in Neuf-Brisach (France), the traditional form characteristic of the city's founding period has been preserved. In Lviv (Ukraine), the evolution of the city's shape from geometrically correct simple to heterogeneous complex was traced. In the case of Philadelphia (USA), while the historically formed planning structure was preserved, socio-economic factors led to a complete loss of the traditional boundaries of European cities.

As part of the study, a hypothesis was put forward about the relationship between the form of a historical city and its potential. In particular, graphic comparisons were made between two cultural centres – Lviv (Ukraine) and Athens (Greece), where the inventory of the city's tangible assets was considered, a key element ensuring the integrity of the historically established urban organism. In addition to the historical, comparative, and spatial characteristics of cities, concepts were synthesised to improve living conditions and level the functional and compositional capabilities of the city to preserve the identity expressed in the form. Concepts related to the qualitative improvement of urban space and sustainable development were analysed in the context of preserving cultural values and maintaining compositional integrity. This approach expanded the understanding of factors affecting urban development and identified optimal strategies for their further improvement.

ACKNOWLEDGEMENTS

None.

CONFLICT OF INTEREST

None.

REFERENCES

[1] "Blog 360" Youtube Channel. (2017). *Districts of Lviv. Sykhiv. Blog 360*. Retrieved from https://www.youtube.com/watch?v=Pexd2wKwEEk.

[2] Balliet, J.M. (2008). Water and fortifications using the example of Strasbourg and Neu-Breisach. In C. Ohlig (Ed.), *Publications of the German Water History Society (DWhG) e.V.* (pp. 279-303). Siegburg: German Water History Society.

[3] Begley, J., Donnelly, T., Jarvis, D., & Sissons, P. (Eds.). (2019). *Revival of a city: Coventry in a globalising world*. Cham: Palgrave Macmillan. doi: 10.1007/978-3-030-22822-4.

[4] Bergmann, J., & Romanyshyn, I. (2022). Rebuilding Ukraine: How the EU should support Ukraine's reconstruction and recovery. *IDOS Policy Brief*, 6/2022. doi: 10.23661/ipb6.2022.

[5] Bibri, S.E., Krogstie, J., & Kärrholm, M. (2020). Compact city planning and development: Emerging practices and strategies for achieving the goals of sustainable development. *Developments in the Built Environment*, 4(1), article number 100021. doi: 10.1016/j.dibe.2020.100021.

[6] Böhme, K., & Martin, D. (2019). *Territorial fragmentation: A major European challenge*. Luxembourg: Territorial Thinkers.
[7] Brueckner, J.K. (2000). Urban sprawl: Diagnosis and remedies. *International Regional Science Review*, 23(2), 160-171. doi: 10.1177/016001700761012710.
[8] Busà, A. (2017). *The trouble with elite cities*. Retrieved from https://blog.oup.com/2017/09/the-trouble-with-elite-cities/.
[9] Cherkes, B. (2009). Modern architecture of Lviv between historicism and restorationism. *Bulletin of Lviv Polytechnic National University*, 656, 3-4.
[10] Common core document forming part of the reports of States parties. (2018, November). Retrieved from http://surl.li/ubzbq.
[11] Curdes, G. (1996). *Urban structure and urban design*. Stuttgart: Kohlhammer.
[12] Dastjerdi, H.K., & Nasrabadi, N.H. (2022). Interrelationships between urban policy and climate, with emphasis on the environment. *City, Territory and Architecture*, 9, article number 27. doi: 10.1186/s40410-022-00165-2.
[13] Davis, S.J., *et al*. (2018). Net-zero emissions energy systems. *Science*, 360(6396), article number eaas9793. doi: 10.1126/science.aas9793.
[14] Dimopoulou, E., Nikolaidou, V., & Zendelis, P. (1999). *Developing a land information system for the unification of the archaeological sites of Athens*. Retrieved from https://www.academia.edu/11844259/Developing_a_Land_Information_System_for_the_unification_of_the_Archaeological_sites_of_Athens.
[15] Dittmar, H., & Ohland, G. (2022). *The new transit town: Best practices in transit-oriented development*. Washington, Covelo, London: Island Press.
[16] Duany, A., Speck, J., & Lydon, M. (2010). *The smart growth manual*. New York: Mcgraw-Hill.
[17] European Environment Agency. (2016). *Urban sprawl in Europe: Joint EEA-FOEN report*. Luxembourg: Publications Office of the European Union. doi: 10.2800/143470.
[18] Fedak, A., & Linda, S. (2022). The concept of sustainability of the urban realm and community as the key feature of the utopia. *IOP Conference Series: Earth and Environmental Science*, 1049, article number 012081. doi: 10.1088/1755-1315/1049/1/012081.
[19] General plan of Ivano-Frankivsk city. (2001). Retrieved from http://www.mvk.if.ua/gplm.
[20] Google My Maps. (2023). Retrieved from http://surl.li/ubzcw.
[21] Habrel, M. (2021). Geometric problems in urbanism: Array. *Municipal Economy of Cities*, 1(161), 58-68.
[22] Hall, T. (2003). *Planning Europe's capital cities*. London: Routledge.
[23] Historical Society of Pennsylvania. (n.d.). *A map of the original city of Philadelphia*. Retrieved from https://hsp.org/education/primary-sources/a-map-of-the-original-city-of-philadelphia.
[24] History of Lviv Historical Museum. (n.d.). Retrieved from https://www.lhm.lviv.ua/hystory.html.
[25] Idak, Yu. (2020). *Bases of the theory of morphology of the city*. (Doctoral dissertation, Lviv Polytechnic National University, Lviv, Ukraine).
[26] Idak, Yu., & Frankiv, R. (2022). Gated communities in Lviv: Between social demand and spatial limitation. *Spatium*, 48, 22-29. doi: 10.2298/SPAT220703011I.
[27] Jabareen, Y.R. (2006). Sustainable urban forms: Their typologies, models, and concepts. *Journal of Planning Education and Research*, 26(1), 38-52. doi: 10.1177/0739456X05285119.
[28] Kantor, P., & Savitch, H. (2010). The politics of city regions in comparative perspective. *Pôle Sud*, 32, 119-136. doi: 10.3917/psud.032.0119.
[29] Kenny, N., & Madgin, R. (2017). *Cities beyond borders. Comparative and transnational approaches to urban history*. London: Routledge.
[30] Knupfer, S.M., Pokotilo, V., & Woetzel, J. (2018). *Elements of success: Urban transportation systems of 24 global cities*. Retrieved from http://surl.li/ubzdp.
[31] Kostof, S. (2005). *The city assembled: The elements of urban form through history*. London: Thames & Hudson.
[32] Kristjánsdóttir, S. (2019). Roots of urban morphology. *ICONARP International Journal of Architecture & Planning*, 7, 15-36. doi: 10.15320/ICONARP.2019.79.
[33] Kropf, K. (2017). *The handbook of urban morphology*. UK: John Wiley & Sons. doi: 10.1002/9781118747711.
[34] Leach, N. (2010). *Rethinking architecture: A reader in cultural theory*. London: Routledge.
[35] Liubytskyi, R. (2017). The growth of motorisation as a manifestation of anthropogenic pressure on the environment of historical cities. *Urban Planning and Territorial Planning*, 64, 183-192.
[36] Lviv City Council. (2023). *List of sights*. Retrieved from https://city-adm.lviv.ua/public-information/monuments/perelik-pamiatok.
[37] Lviv City Council. (n.d.). *Shevchenko Avenue*. Retrieved from https://city-adm.lviv.ua/portal/history-of-lviv/austrian-lviv/5565-prospekt-shevchenka-.
[38] Main Museums in the centre of Athens. (n.d.). Retrieved from https://www.athens-today.com/en/e-musei.php.

[39] Map of Stanislow in 1800. (n.d.). Retrieved from https://uma.lvivcenter.org/uk/maps/34453.
[40] Marmo, R., Pascale, F., Coday, A., & Polverino, F. (2018). The conservation of historic built heritage in Europe: Regulations and guidelines in Italy and England. In *Construction pathology, rehabilitation technology and heritage management*. Caceres, Spain: REHABEND Congress.
[41] Marshall, S. (2012). Planning, design and the complexity of cities. In J. Portugali, H. Meyer, E. Stolk & E. Tan (Eds.), *Complexity theories of cities have come of age* (pp. 191-205). Berlin, Heidelberg: Springer. doi: 10.1007/978-3-642-24544-2_11.
[42] Medeiros, E. (2019). Debating the urban dimension of territorial cohesion. In E. Medeiros (Ed.), *Territorial cohesion. The urban book series* (pp. 3-22). Cham: Springer. doi: 10.1007/978-3-030-03386-6_1.
[43] Metelsky, R. (2015). *What can be seen from Lviv City Hall?* Retrieved from https://photo-lviv.in.ua/scho-mozhna-pobachyty-z-lvivskoji-ratushi/.
[44] Moudon, A.V. (1997). Urban morphology as an emerging interdisciplinary field. *Urban Morphology*, 1(1), 3-10. doi: 10.51347/jum.v1i1.3860.
[45] Mouratidis, K. (2018). Is compact city livable? The impact of compact versus sprawled neighbourhoods on neighbourhood satisfaction. *Urban Studies*, 55(11), 2408-2430. doi: 10.1177/0042098017729109.
[46] Mumford, E. (1992). CIAM urbanism after the Athens charter. *Planning Perspectives*, 7(4), 391-417. doi: 10.1080/02665439208725757.
[47] Musiyezdov, O., & Maryniak, K. (2020). Urban identity in (post)modern cities: A case study of Kharkiv and Lviv. *East/West: Journal of Ukrainian Studies*, 7(1), 197-217. doi: 10.21226/ewjus573.
[48] Neuman, M. (2005). The compact city fallacy. *Journal of Planning Education and Research*, 25(1), 11-26. doi: 10.1177/0739456X04270466.
[49] Nientied, P., Aliaj, B., & Stachowiak-Bongwa, K. (2022). Social urban identity formation and local government. *Current Urban Studies*, 10(3), 361-380. doi: 10.4236/cus.2022.103022.
[50] Oliveira, V. (2016). *Urban morphology: An introduction to the study of the physical form of cities*. Cham: Springer. doi: 10.1007/978-3-319-32083-0.
[51] Pink, S. (2009). Urban social movements and small places. *City*, 13(4), 451-465. doi: 10.1080/13604810903298557.
[52] Piracha, A., & Chaudhary, M.T. (2022). Urban air pollution, urban heat island and human health: A review of the literature. *Sustainability*, 14(15), article number 9234. doi: 10.3390/su14159234.
[53] Posatskyi, B. (2007). *The urban space and urban culture (at the turn of the 20th-21st centuries)*. Lviv: Lviv Polytechnic Publishing House.
[54] Poundbury – design and community code. (2019). Retrieved from https://poundbury.co.uk/wp-content/uploads/2019/08/Poundbury-Design-and-Community-Code-2019.pdf.
[55] Sassen, S. (2001). *The global city: New York, London, Tokyo (REV-Revised)*. Princeton: Princeton University Press. doi: 10.2307/j.ctt2jc93q.
[56] Siláči, I., & Ebringerova, P. (2019). New interpretation of public visual art in urban space. *IOP Conference Series: Materials Science and Engineering*, 471(9), article number 092038. doi: 10.1088/1757-899X/471/9/092038.
[57] Spink, J., Pearce, A., & Thomas, M. (2022). *Managing complexity to deliver transport systems in urban environments*. Retrieved from https://www.wsp.com/en-th/insights/managing-complexity-to-deliver-transport-systems-in-urban-environments.
[58] Tranter, P., & Tolley, R. (2020). Chapter 6 – Advancing environmental health in future 'slow cities'. In P. Tranter & R. Tolley (Eds.), *Slow cities: Conquering our speed addiction for health and sustainability* (pp. 169-198). Amsterdam: Elsevier. doi: 10.1016/B978-0-12-815316-1.00006-X.
[59] Treffers, F. (2023). People, participation and processes in rebuilding Ukraine at a crossroads. In A. Rubbo, J. Du, M.R. Thomsen & M. Tamke (Eds.), *Design for resilient communities* (pp. 177-189). Cham: Springer. doi: 10.1007/978-3-031-36640-6_13.
[60] Understanding traffic & air quality: How does urban mobility affect air pollution? (2023). Retrieved from https://www.modeshift.com/understanding-traffic-air-quality-how-does-urban-mobility-affect-air-pollution/.
[61] Vanderhaegen, S., & Canters, F. (2017). Mapping urban form and function at city block level using spatial metrics. *Landscape and Urban Planning*, 167, 399-409. doi: 10.1016/j.landurbplan.2017.05.023.
[62] Vis, B.N. (2018). Introduction to cities made of boundaries. In *Cities made of boundaries: Mapping social life in urban form* (pp. 1-11). London: UCL Press. doi: 10.2307/j.ctv513drk.6.

Юлія Ідак

Доктор архітектури, професор
Національний університет «Львівська політехніка»
79000, вул. Степана Бандери, 12, м. Львів, Україна
https://orcid.org/0000-0002-1123-5759

Ольга Лисенко

Кандидат архітектури, доцент
Національний університет «Львівська політехніка»
79000, вул. Степана Бандери, 12, м. Львів, Україна
https://orcid.org/0000-0001-6230-5350

Збереження міської форми: критичний аналіз сучасних стратегій розвитку та важливість композиційної цілісності

Анотація. Актуальність дослідження випливає з потреби аналізу сучасних стратегій міського розвитку, з особливим акцентом на необхідності збереження форми міста в контексті його унікальних візуальних характеристик та подолання просторового хаосу у густонаселених житлових районах. Мета статті полягала у виявленні специфічних ознак та властивостей, які проявляються на рівні впровадження конкретних цілей у відношенні до розвитку міста на макрорівні. Методика дослідження ґрунтується на історико-типологічному, структурно-функціональному та історико-порівняльному аналізах історично сформованих складових таких міст як Львів та Івано-Франківськ (Україна), Афіни (Греція), Неф-Бризак (Франція), Філадельфія (США) та Берлін (Німеччина). Авторами підкреслено важливість забезпечення композиційної цілісності та єдності міського простору, особливо у взаємозв'язку між його формою та функцією. Зосереджуючись на таких взаємозв'язках, особливу увагу звернуто на контекстуальність історичних міст та матеріальне його наповнення через призму культурного потенціалу. У графічний спосіб визначено основні напрямки розвитку формальних структур, наголошуючи на їхньому зв'язку із культурною функцією. Зазначено, що культурний кластер як складова багатьох значущих міст є не тільки місцем збереження та розвитку духовних цінностей, але і засобом вираження своєрідності та забезпечення цілісності його зовнішнього вигляду. Зауважено, що впровадження новітніх концепцій призводить до втрати унікальності історично-сформованих структур та хаосу в модерністських районах великих міст. Зазначено, що причиною цього є акцент на позбавленні індивідуальності через впровадження типових естетичних контентів із акцентом на функціональній вираженості та економічній доцільності. Висновки статті вказують на значимість інтеграції культурного потенціалу в стратегію міського розвитку, забезпечуючи життєздатність та унікальність міст в глобальному контексті. Розуміння цих результатів допоможе зорієнтуватися в потребах та підвищити ефективність заходів, спрямованих на підтримку культурної різноманітності, соціальної інклюзії та загального благополуччя мешканців та гостей міста

Ключові слова: історичне місто; теорія містобудування; зростання; спадщина

Architectural Studies
International Journal about Architecture

Volume 10, No. 1

UDC 725.94
DOI: 10.56318/as/1.2024.104

Dzhumamedel Imankulov*
Doctor of Architecture, Professor
Kyrgyz State Technical University named after I. Razzakov
720044, 66 Ch. Aitmatov Ave., Bishkek, Kyrgyz Republic
https://orcid.org/0009-0007-9256-0134

He Feng
Doctoral Student
Kyrgyz State Technical University named after I. Razzakov
720044, 66 Ch. Aitmatov Ave., Bishkek, Kyrgyz Republic
https://orcid.org/0009-0007-9093-1480

Tian Jing
Doctoral Student
Kyrgyz State Technical University named after I. Razzakov
720044, 66 Ch. Aitmatov Ave., Bishkek, Kyrgyz Republic
https://orcid.org/0009-0003-4139-0957

Tatyana Filatova
PhD in Architecture, Associate Professor
Kyrgyz State Technical University named after I. Razzakov
720044, 66 Ch. Aitmatov Ave., Bishkek, Kyrgyz Republic
https://orcid.org/0009-0001-1333-2560

Aigerim Akmatova
Student
Kyrgyz National University named after J. Balasagyn
720033, 547 Frunze Str., Bishkek, Kyrgyz Republic
https://orcid.org/0000-0001-5019-6679

Buran Minaret as a symbol of the Chui Valley of Kyrgyzstan

Abstract. The research relevance is determined by the study of the architectural features of the Buran Minaret and its role in preserving the region's identity is key to the preservation of historical and cultural heritage in today's global cultural dynamics. The study aims to analyse the architectural significance of the Buran Minaret in the context of the cultural heritage of the Chui Valley and its influence on the formation of the region's history. The research involved a comprehensive methodological approach combining archaeological, historical, cultural and sociological methods. The results obtained have shown the uniqueness of the architectural solutions used in the construction of the Buran Minaret. The ornamental relief belts that adorn the minaret's trunk are technically complex structures of a high level of craftsmanship. The meticulous attention to detail and sophistication of the ornamental motifs emphasise that each element of the minaret's architecture was created with refinement and care for detail, reflecting the high level of skill and dedication of the ancient builders. The arched niches of the octagonal plinth, decorated with relief brick ornamentation, are also a visual expression of the minaret's artistic beauty. The preservation of the ornaments on the three belts demonstrates their significance as a historical and cultural heritage. The use of a variety of materials and masonry techniques, including

Suggested Citation:
Imankulov, D., Feng, H., Jing, T., Filatova, T., & Akmatova, A. (2024). Buran Minaret as a symbol of the Chui Valley of Kyrgyzstan. *Architectural Studies*, 10(1), 104-114. doi: 10.56318/as/1.2024.104.

Journal homepage: https://arch-studies.com.ua/en#
Architectural Studies, 10(1), 104-114
Received: 15.02.2024 Revised: 29.05.2024 Accepted: 20.06.2024

*Corresponding author

ordinary building bricks, adds authenticity and uniqueness to this architectural monument. The findings also confirmed that the Buran Minaret plays a key role in the Chui Valley on the historical, cultural, religious and tourist levels. Its historical significance is expressed through its connection to different periods of the region, as well as its symbolic significance for culture and religion, attracting thousands of tourists for its historical and architectural significance. The findings have important practical implications for the preservation of the historical and cultural heritage of the region. They broaden the understanding of the architectural and technical achievements of ancient masters, emphasising the need to preserve and restore unique architectural structures such as the Buran Minaret

Keywords: cultural heritage; architectural structures; historical site; Islamic identity; Muslim monument

INTRODUCTION

In an environment where cultural diversity and interaction play an increasingly important role, there is a growing need to understand and preserve cultural heritage. The Buran Minaret, with its rich history and symbolic significance, acts as a key element of this heritage for Kyrgyzstan. Its ancient walls and architectural details are a testimony to the past and cultural traditions that have developed over many centuries. However, in a changing world, when globalisation and technological breakthroughs lead to rapid changes in the socio-cultural environment, the preservation and study of cultural monuments such as the Minaret of Buran becomes more relevant. This site is a source of historical information and serves as a "key" to understanding the cultural evolution and collective identity of the people living in each region. Considering these changes, it is important to conduct more in-depth research to uncover all aspects of the significance of the Buran Minaret for the cultural heritage of the Chui Valley.

Research on the symbolic significance of the minaret can help to improve the quality of understanding and preservation of cultural heritage. It can shed light on the historical and cultural contexts in which the monument emerged and developed. Uncovering these aspects will create a more complete picture of the cultural wealth of the Chui Valley and its contribution to the overall history of the region. It may also help to identify the changes that have occurred over time in the perception and use of the Buran Minaret and allow an assessment of its contemporary role and significance in the cultural and social life of the community. Understanding how these changes have affected the perception of the minaret and its role in people's minds can offer valuable lessons for the future conservation and utilisation of cultural heritage.

Architectural structures, in particular minarets, are key elements in shaping the cultural and historical image of the region. The study by A. Hadrovic (2024) notes that such structures not only preserve the heritage of the past but also become symbols of identity and pride for the local population. They attract the attention of tourists, which contributes to the development of cultural tourism and enhances the attractiveness of the region as a historical and cultural centre. S. Amrane & B. Khalfallah (2023) noted that minarets serve as a testimony of architectural excellence and an important symbol of cultural wealth and heritage. Y. ALMagraby & R. El Attar (2021) emphasise that they also represent the spiritual and religious aspects of society, maintaining a link with historical traditions and religious practices. However, despite the significance of such architectural structures, many questions regarding their social role and impact on contemporary society remain open and require further research.

M.A. Kamal (2021) emphasises that minarets play an important role as architectural symbols as well as essential elements of urban space. N. Kulözü (2021) points out that they can define the image of a city, giving it a unique style and atmosphere. At the same time, A. İbrahimgil & L. Kudumovic (2023) showed that these structures act as an important element of the urban landscape, becoming its characteristic features, which often become key architectural objects and landmarks for locals and visitors. The interaction of minarets with the surrounding buildings, natural environment and socio-cultural environment creates a unique space, which is a relevant factor in attracting tourists and strengthening the cultural image of the city and may require further study and standardisation of architectural solutions.

Moreover, minarets become an integral part of public space where not only believers but also representatives of different socio-cultural groups converge. E.M. Farrag (2023) analyses in detail the socio-cultural significance of minarets, highlighting their role as symbols of religious identity, as well as centres of social and cultural life. S. Nasim (2021) also notes that they serve as venues for social activities, ceremonies, cultural festivals and other events, facilitating communication and interaction between different segments of society. Furthermore, the study by H. Abo-Egila (2021) emphasises that the structures play an active role in shaping the public environment by inspiring social and cultural initiatives as well as strengthening ties within the community. This renders minarets important architectural and religious symbols, as well as socio-cultural nodes that contribute to enriching the region's cultural heritage and strengthening its social fabric. However, issues relating to the preservation of minarets as public spaces, as well as their accessibility to different groups of people, require the development of appropriate strategies.

The study aimed to identify the architectural significance of the Buran Minaret for the people of Kyrgyzstan and its role in shaping the general cultural identity of the region. The main objectives of the study included: analysing the architectural features of the Buran Minaret to identify the methods and context of its construction,

studying the cultural and religious aspects of the minaret and assessing measures for the preservation and restoration of this historical site.

MATERIALS AND METHODS

At the beginning of the research, an extensive study of the available data on the history of the minaret's construction and existence was carried out. For this purpose, sources concerning the Buran Minaret and its role in the history of the region were studied (Archaeological-architectural complex..., n.d.). This enabled the identification of the main themes and areas of research, which included its cultural significance, religious and symbolic role, as well as its impact on the life of the local population and the tourism potential of the region.

To investigate the construction technology of the Buran Minaret, the archives of archaeological finds at the site of the construction, available in the National Historical Museum of the Kyrgyz Republic, were studied. The study examined the remains of the building structures, paying special attention to the construction materials used and the methods of their processing. Fragments of architectural details such as brickwork, decorations and brick carvings were analysed to understand the techniques used in the construction of the minaret. To gain a deeper understanding of the construction process and the engineering solutions used, the surviving documents, drawings and blueprints, as well as historical descriptions available in the Central State Archive of the Kyrgyz Republic (CSA KR) were studied. This made it possible to reconstruct an idea of how the various stages of the minaret's construction could have been carried out.

Archaeological information was also used to analyse the cultural contexts associated with the Minaret of Buran, allowing the history of the minaret to be reconstructed based on the artefacts and architectural features found. This made it possible to trace the history of the minaret since its construction and to assess its significance in the culture and history of the region. The analysis of cultural aspects was aimed at identifying the symbolic significance of the minaret for the local population and its religious role in society. The analysis was based on mythological perceptions, customs and traditions associated with the minaret, as well as its influence on the cultural life of the region.

An important aspect of the study of the Buran Minaret was the study of similar architectural structures and the comparison of their construction techniques. This made it possible to identify typical techniques and methods of construction of minarets of that time. By analysing comparable objects of architectural heritage, such as the Kalyan Minaret in Bukhara and the Surkh Minar Minaret in Termez, the study was able to identify common features and peculiarities characteristic of the construction of minarets in Central Asia in the 11th-12th centuries. By comparing the design solutions, materials, masonry, decoration and other elements of the Buran Minaret with similar elements of other minarets, conclusions were drawn about similarities and differences, as well as the degree of uniqueness and innovation of solutions used in its construction. Also, the comparison of the Buran Minaret with dated minarets of similar architecture allowed to clarify its dating and context of construction. The study of similar minarets in different regions of Central Asia made it possible to identify regional peculiarities of construction characteristics of this or that area. Employment of these materials and methods has thus resulted in an extensive collection of data that has served as a basis for analysing and drawing conclusions about the role of the Buran Minaret in the history, culture, religion and tourism of the region.

RESULTS

The Chui Valley of Kyrgyzstan, located in the northern part of the republic at an altitude of 800 to 1200 m above sea level, is a unique corner of Central Asia. This valley is the most developed and populated region in Kyrgyzstan and carries a rich heritage of ancient eras. In the Middle Ages, especially in the period from the 10th to the 13th century, the Chui Valley played a strategic role not only in Kyrgyzstan but also in the whole of Central Asia. Its importance was closely linked to the Great Silk Road that ran through the region, leaving its imprint in the form of prosperity and urbanisation (The statesman's yearbook..., 2020). However, the valley's even older past, dating back to much earlier times, testifies to its pivotal role due to its geographical location, unique climate, and wealth of water and other natural resources. The region has been a crossroads of various cultural and trade flows, making it an integral part of humanity's historical heritage. The traces of the Great Silk Road, permeating the history of this valley, have established its status as one of the most significant urbanised areas in Central Asia.

During the period of prosperity, the Chui Valley acted as an important centre on the trade route stretching from the Boom Gorge to the western tip of the region, on which the cities were located. Medieval sources provide extensive data on the demographic composition, urban infrastructure, trade and cultural interactions in the valley. These sources enabled researchers to analyse the historical names of towns and villages, establishing a link between ancient settlements and their modern counterparts (Zhylankozova, 2018; Chotaeva, 2021). The Buran Minaret becomes a unique bridge linking two epochal periods in the history of Kyrgyzstan, which are separated by millennia and belong to different economic formations. This architectural masterpiece materially embodies the historical layers and symbolically transfers this from the past time to the present, emphasising the continuity of cultural, historical and spiritual values of the state. Bearing the traces of thousands of years of art and building culture, the Minaret of Buran is the oldest monument of Islamic architecture in Central Asia. Its architectural appearance reflects the aesthetic and technical achievements of the past, embodying the symbolism and spirit of the time in which it was erected. This minaret has become an important architectural structure and a model of cult typology that is an icon of

religious and cultural identity in the open space of Muslim countries. Its symbolic significance extends beyond time, recalling the richness and versatility of the Islamic and cultural tradition (Engvall, 2020).

The Buran Minaret bears a rich historical heritage that encompasses various aspects of cultural and religious significance. First, it is the first example of Islamic architecture in the expanse of modern Kyrgyzstan, which emerged in the late 10th century. This indicates a key stage in the evolution of religious architecture in the region. Being the oldest surviving minaret in Central Asia, it is a unique artefact of antiquity, revealing the distant past and the lessons of history. The minaret's architectural style and structural features reflect the Karakhanid typology of minarets in the region, leaving a legacy of the culture and religious traditions of that era. The Buran Minaret has become a sacred place of worship for the people of Kyrgyzstan, fitting into their spiritual and cultural identity. It is also surrounded by numerous legends and tales, giving it a mystical aura and attracting the attention of explorers and travellers. The minaret has become an object of pride for Kyrgyzstan, attracting the attention of many tourists wishing to experience its uniqueness and grandeur. It has also become a venue for various festive and celebratory events for residents, strengthening ties in the community. In 2014, the inscription of the minaret on the UNESCO World Heritage List of Cultural Monuments emphasised its uniqueness and importance for all humanity (Archaeological-architectural complex…, n.d.).

Together, all the mentioned factors of the significance of the Buran Minaret have created an image and symbol of a particularly famous and respected object of antiquity, turning it into a legendary symbol extending far beyond the borders of Kyrgyzstan. The name "Buran" has become not only a designation for this historic structure but has also become established in the names of the neighbouring village, local authorities and even the river. It is present in the names of various companies, commercial establishments and hotels, creating close links between these objects and the rich history of the minaret. The public memory and society have established a deep connection with the ancient structure, which has become a symbol of the unity of different sociocultural social and economic formations in the history of Kyrgyzstan. Considering the architecture of the monument in more detail, it should be noted that at the time of its inception, the earliest minarets in Central Asia were made of raw material and crowned with wooden arbours. However, by the 10th century, the crude structures began to be covered with burnt bricks on the outside (Massoud, 2020). The Buran Minaret inherits these traditions, noticeably imitating its predecessors built of raw material. It has radial arched timbers at its base, to reinforce the raw masonry plinth under the weight of the shaft. Although this technique has lost its relevance in brick architecture, its use in the Minaret of Buran indicates that it was one of the first experiments with the use of burnt bricks in construction, and builders had not yet completely abandoned earlier methods.

The Buran Minaret has unique structural features that reveal its uniqueness. The monument's foundation, made of large cobblestones on loess mortar, is deeply embedded in the excavation, providing a solid base for the entire structure. A 4.3 metre-high "buttress" adjoined the southern side of the foundation, providing additional support and stability. The Minaret's podium, which has a square shape with steps and an octagonal plinth, is an architectural element that emphasises its grandeur. The lower ledge of the podium was 10 cm and the upper one was 69 cm, which gave the structure a harmonious ratio of proportions. The facets of the minaret's plinth, designed as arched niches and framed with rectangular ornamental frames, are decorated with masterfully executed patterns based on a diagonal square grid. These ornaments, including the openwork frame of the plinth, form a tympanum which, encircled by a thin band of brick ends, gives the structure an aesthetic grace and appeal. Moreover, the Buran Minaret is distinguished not only by its unique foundation but also by its perfectly preserved architectural details, which give it a special character. The arched niches of the octagonal plinth are decorated with relief brick ornamentation, which has been partially preserved, testifying to the skill of the ancient builders.

The trunk of the minaret, which has a conical shape, inspires majesty and power: at the level of the plinth its diameter is 8.85 m and at the top it is 5.9 m. The entire height of the minaret is covered with 11 entire belts and one fragmentary belt at the top, which alternate smooth brick surfaces with ornamental motifs. Despite the time trials leading to the destruction of some parts, at the time of restoration, the ornaments on three belts were preserved, continuing to amaze and inspire with their refinement. It is especially important to pay attention to the unique details of the ornamental relief belts of the minaret (Fig. 1). An interesting fact is the use of ordinary building bricks in the laying out of ornamental motifs, which gives these details a special character and authenticity. This technique, which distinguishes the early minarets from their later analogues, such as the Uzgen and Kalyan minarets, where special patterned and polished bricks are used for ornaments, allows to better understand the technical and artistic skills of the ancient masters, as well as their creative approach to creating unique architectural works.

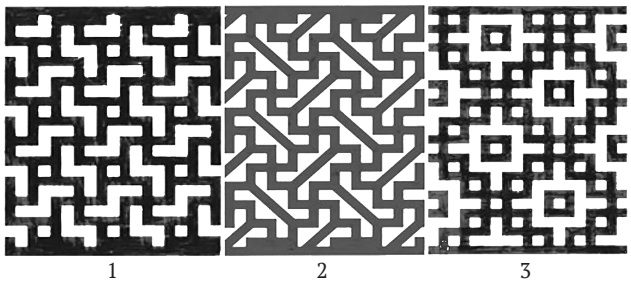


Figure 1. Ornamental relief belts
Source: compiled by the authors

The development of geometric ornaments of the Buran Minaret represents a significant achievement in the architecture of this era. These ornaments, created at the junction of 10th-11th centuries, became the progenitors of more complex and refined variants of cladding, characteristic of Central Asian architecture. The method of building various motifs on the three best-preserved belts of the minaret deserves special attention. Here the ornaments are not simply built on a static square grid, as is often the case, but are created by shifting the centres and axes, which gives them a special dynamism and elegance. The result of this approach is the unique "vertushki" – rotating figures that give the Minaret of Buran a unique character and appeal to researchers and connoisseurs of ancient architecture (Hillenbrand, 2021).

At the stage above the first smooth belt of the Buran minaret, the first ornamental relief belt begins, characterised by complex compositions of intersecting brick bands. These ribbons create unique figures in the form of swastikas, arranged along the diagonals of the square grid. The background of the ornament is filled with complex cross-shaped figures with inserts in the centre consisting of square bricks measuring 4×4 cm. The next, second ornamental relief belt is represented by intersecting brick bands forming rows of figures of "vertushki" and broken crosses. In this belt, the "twirls" are placed along the diagonals of the square grid, giving the composition a special dynamic. The third ornamental belt, separated from the second one by a simple brickwork, is also represented by the motif of "twirls" on the intersecting diagonals of the square. Here each "twirl" is inserted into the frame, which makes their contour clearer and more expressive. This belt is characterised by sparser ornamentation, where the mass of the pattern is about 30% of the background, which provides ease of perception and understanding of the ornamental motifs. The fourth ornamental belt, separated from the third by 21 rows of simple brickwork, has a particularly complex and interesting relief ornament. In this belt, the brick bands intersect to form endless swastikas with displaced axes of construction. Across the entire width of this belt, which is 190 cm, there are five rows of intersecting ribbons, 38 cm high, connected by 4×4 cm bricks. This ornamentation gives the impression of joined swastikas on a diagonal grid of squares. The fifth ornamental relief belt is narrow and is only 54 cm wide. The ornamental pattern of this belt, consisting of two rows of zigzag pairs of bricks, stands out with its large division against the background of a freer space. Perhaps this belt carries some symbolic meaning that divides the conical body of the minaret according to some principle. Nevertheless, it represents a contrasting element that probably interacted with the narrow belt of the epigraphic inscription or with the lantern cornices in the form of stalactites in the upper part of the minaret, which are lost. The sixth ornamental belt, the simplest in pattern, consists of five rows of figures in the form of squares, connected horizontally by 12×4 cm bricks on the front side and vertically by 4×4 cm bricks. This belt adds textural variety to the overall design of the minaret, presenting a calmer and more orderly pattern compared to the more complex ornaments on the previous belts.

The construction of the minaret was carried out using loess and ganache mortar for masonry. The ornamental layer of the outer masonry was created exclusively on ganache mortar, providing additional stability and aesthetic design. The bricks used for the construction of the minaret are not uniform in size, with sides varying between 23.5-25 cm. The brick has a square shape, and its thickness is 4-4.5 cm. This variety of bricks and the differences in size may have presented some challenges during the construction process but were successfully accommodated in the creation of this architectural composition. The architectural heritage of Central Asia, infiltrated by Islam, became one of the most important aspects of Islamic architecture, ranked among the world's achievements (Prychepii, 2022). From that time, beginning in the 9th century, Islam took firm root in the region, becoming the dominant religion and global ideology. Magnificent examples of Muslim architecture, including the Minaret of Buran, rise among the architectural masterpieces of Central Asia. Minarets, along with mosques, have become an integral part of urban and rural settlements, reflecting the greatness of Islamic culture and spirituality. In the modern context, with the growing interest and mass construction of minarets around the world, the study of ancient minarets of Central Asia and other countries becomes an urgent task. Answers to questions about the genesis of architecture, semantics of motifs and symbolic meanings of these structures are inextricably linked to the historical context of their creation and development.

The Buran Minaret occupies a special place in the architectural history of Central Asia. While Islam was spreading to the western areas of the region before reaching Semirechye under the Karakhanids, other minarets were encountered. One such case refers to the discovery of the remains of a 10th-century minaret at the site of Afrasiab in Samarkand. Historical sources also mention a minaret in Gireng, in Turkmenistan (Arslan, 2022). However, the Minaret of Buran deserves special attention and recognition because of several factors. Firstly, it is the only surviving late 10th-century minaret in the region. Secondly, it represents the first example of a new typology of conical minarets with an overhanging brick lantern, which became characteristic of the Karakhanid Kaganate. Together with minarets such as the Burani, Uzgen, Kalyan in Bukhara and Vabkent minarets, it became a model for imitation, standing out for its shape, architectural decoration and unique proportional relationships. As a symbol of Islamic architecture, minarets represent a diversity of styles and forms, depending on the historical and cultural context in which they were built. Despite their common functions and importance in urban planning, they differ in their origins and influences. Types of minarets such as Arab, Iranian, Turkish, Central Asian, Indian, Moorish and others are characterised by their unique architecture, decoration and location in space. All these architectural monuments attract

the attention of modern architects who strive to creatively exploit this rich heritage. The study of various forms and styles of minarets inspires architects to create new projects that embody historical heritage and modern trends.

The architecture of minarets is going through a period of creative research, where the main endeavour is to reconsider the form, image and urban planning significance of these structures. The location of the minaret in urban space is becoming increasingly important as the symbolic significance of minarets in modern architecture increases, taking precedence over their original function of proclaiming the azan (Kerimkhulle *et al*., 2023). There is also disagreement among architects about the loss of relevance and unnecessary of minarets in modern mosques. The study of Central Asian minaret building traditions becomes particularly relevant both in architectural practice and in cultural aspects. A deep understanding of the historical roots and evolution of these structures becomes a necessity for contemporary practitioners. Therefore, the architecture of the Buran Minaret, as the oldest object of Islamic architecture, acquires special significance for both theoretical analysis and practical application in modern minaret construction (Fig. 2).

Figure 2. View of the minaret before the reconstruction (1927)
Source: Buran Tower minaret (2019)

From a practical point of view, the minaret plays an important role in transmitting the call to prayer, as the voice of the muezzin can be heard further and more clearly from its height. However, from a spiritual point of view, the minister of the mosque seeks not only to communicate with the believers but also to establish a close connection with God. In the Christian tradition, high bell towers were built for this purpose, and the ringing of bells was heard over considerable distances (Bardik, 2023). In medieval cities and towns with low houses, minarets made a strong impression and served as a symbol of the greatness of God. Nevertheless, the minaret is not only a symbol of divine power but also a reflection of the power and wealth of earthly rulers. History testifies to the aspiration of rulers of Muslim states to erect majestic mosques and impressive minarets in their possessions. This tendency was vividly manifested during the Karakhanid era, who particularly valued spiritual significance and patronised the development of the religious sphere. Therefore, every dimension of divinity and sacredness of the Minaret of Buran, which has its roots in the Karakhanid era, continues to live on (Rashid, 2020).

Modern cultural and mass events, as well as family and social gatherings, are often accompanied by prayer rituals in the square near the minaret. This demonstrates the deep embeddedness of this architectural masterpiece in the cultural heritage and religious practices of contemporary society. The inhabitants of the Chui Valley perceive the Buran Minaret as something much deeper than just an architectural structure. It is a kind of symbol of historical memory associated with the ancestors and traditions of the region. Each of its contours and brickwork reminds of a long past, of the days when this land was the centre of cultural and religious development. With the national independence, interest in Islam became much more prominent and many mosques were erected in a short period. However, this quest for spirituality and religious practice often misses an important aspect – the quality of architectural solutions. Many new constructions do not meet modern safety standards and aesthetic requirements. That is why it became necessary to introduce Construction norms and rules of the Kyrgyz Republic (2017). These norms regulate the architectural aspects as well as the safety of structures so that new mosques not only serve as places of worship but also meet modern requirements and become the pride of the region. It is worth noting that, considered in comparison with the Kalyan Minaret in Bukhara, the Buran Minaret is a more modest architectural structure. The height of Buran Minaret is about 24 m, which is several times lower than the height of Kalyan Minaret, which exceeds 45 m. Likewise, the Minaret of Buran is characterised by a simpler form and minimal decoration, indicating the modesty of its design compared to the more elaborate and luxurious decoration of Kalyan (Roshdy, 2018).

While the Kalyan Minaret served not only as a call to prayer but also as a symbol of the power and authority of the Islamic state, the Buran Minaret fulfilled a more modest function within its historical context. Its simplicity and modesty may have reflected the less developed socio-political environment in which it was built, compared to the more monumental and majestic Kalyan Minaret. Nevertheless, both sites are important architectural monuments reflecting the cultural and religious heritage of their regions. The Buran Minaret, in comparison to the Surkh Minar Minaret in Termez, also has a more restrained appearance and smaller dimensions. While the Minaret of Buran is about 24 m high, the Minaret of Surkh Minar stands more than 50 m high. The Surkh Minar Minaret was erected using more sophisticated engineering techniques to create a taller and tiered structure (Xasan, 2023). The overall composition of the Buran Minaret, while bearing some similarities to the

Termez Minaret, stands out for its unique architectural sophistication. In particular, the similarity in the vertical structure, including the podium, octagonal plinth and shaft, emphasises the general direction in architectural design. However, in the Buran Minaret, the ornamental relief belts use the same brick used for the masonry of the minaret's body, creating a harmonious unity in the visual experience. While the Termez minaret also demonstrates a similar use of bricks for ornamental belts, including Kufic inscriptions on the cylindrical body, its architectural style is characterised by specific details, such as narrow belts made of end-stacked bricks, creating a spectacular "dandana". Thus, although similarities can be traced, each of these minarets has its own unique character and architectural identity.

Minarets in the East are not just architectural structures; they are symbolic monuments intertwined with ancient myths, cosmogonic visions and historical events (Osievska, 2022). One outstanding example of this is the tall minaret at Jama in northern Afghanistan. This minaret, erected on an important mountain pass, far from populated areas and without a mosque, symbolised the victory of Sultan Ghiyas al-Din's warriors over the Ghaznavids in 1192. Its presence commemorates this historical event and also embodies the spirit of victory and grandeur associated with that time (Lali & Arefi, 2020). Since the beginning of the second half of the 20th century, the Minaret of Buran has taken on a new dimension, becoming part of an open-air museum. Excavations carried out in the early 1970s as part of the restoration works led to the discovery of many new archaeological findings confirming the cultic and sacred significance of the central part of the capital city of Balasagyn. The three impressive monumental mausoleums uncovered by the excavations near the minaret provided clear examples of the portal-dome and tower type of mausoleum architecture. These architectural findings shed light on the rich history and cultural heritage of the region, making the Buran Minaret even more significant for the study and understanding of Kyrgyz history and culture (Benjamin, 2018).

On the eastern slope of the hill located towards the centre of the settlement, the ruins of a one-chamber mosque were discovered in 1981, which is an important archaeological discovery. Earlier, as early as 1971, the remains of a monumental bathhouse, as well as traces of a water pipe and sewage system from it, were discovered in the south-eastern corner of the settlement. These artefacts are valuable finds awaiting conservation and museumization. The minaret and the ruins of other discovered monuments, including the central ramparts around the centre of Balasagyn, are the main exhibits of the open-air museum, important testimonies of the rich history and culture of the region. The particular importance and popularity of the minaret are revealed in the context of tourist use. Tourist travelling routes in northern Kyrgyzstan invariably include a visit to the Burani settlement and the Historical and Architectural Museum-Reserve. These places have become an integral part of the cultural heritage of the region, attracting the attention of tourists from all over the world.

With the inclusion of the Buran site in the UNESCO Cultural Heritage List in 2014, the flow of tourists has increased significantly. This event has attracted increased attention from both residents and foreign visitors. Visiting the minaret has become a tourist route and an opportunity to immerse oneself in the history and culture of the Kyrgyz people. Foreign tourists visiting the minaret admire its ancient architecture and symbolic significance, feeling a deep respect for this historical monument. For them, the site is a cultural heritage site where they can touch the rich history and culture of Kyrgyzstan (Wang, 2021). The preservation and restoration of minarets also have social significance as they are important symbols for the local population. They have a deep and symbolic meaning for the inhabitants, being the site of various rituals, ceremonies and traditional festivals. Moreover, minarets often play a religious role, serving as places for prayer and spiritual education. They are sacred sites for Muslims and other religious communities, the preservation of which maintains spiritual and cultural traditions. Historical structures such as minarets attract a large number of tourists, which contributes to the development of the tourism industry and the economy of the region. The tourist potential of the Buran Minaret attracts international attention and raises the prestige of the region. For this reason, preserving minarets, including the Buran Minaret, is integral to preserving cultural heritage, developing the tourism industry, enhancing social stability and continuing religious traditions (Lee & Jayakumar, 2021).

The Buran Minaret and similar structures play an important role in urban development, even though their original purpose may seem to have been lost. These structures are key elements of the architectural landscape, giving the city a unique and distinctive appearance. Their elevated forms serve as landmarks in the urban space and create recognisable silhouettes that can become symbols of the city. Moreover, historical structures, including minarets, play a significant role in maintaining a link with the city's past and cultural heritage. They embody the architectural excellence of past eras and are important symbols of the history and culture of the people. The towering shapes of the minarets recall the grandeur and glory of past times, and their sturdy walls preserve the many historical events and figures associated with the place. As architectural artefacts, they carry valuable information about the traditions and customs of previous generations, helping people today to better understand their history and identity. Thus, the Buran Minaret is an important historical and architectural artefact, as well as a living symbol of Kyrgyzstan's rich cultural and religious history. Its significance goes far beyond architectural heritage, encompassing cultural, religious and social spheres. The minaret stands as a reminder of the richness and diversity of cultural heritage, as well as the importance of preserving and transmitting this heritage to future generations. The preservation and protection of such structures support historical memory and cultural heritage and contribute to the identity and pride of a people.

DISCUSSION

Architectural symbols like the Minaret of Buran carry great historical and cultural significance for the region. They are not just pillars of the past but also represent important aspects of cultural identity and heritage. The study of such architectural symbols allows for a deeper understanding of their role in shaping the collective memory of a society, including through strong cultural ties and traditions. Such architectural symbols are "living witnesses" of the past, which embody historical events and cultural traditions, carrying them through time and space. Their study becomes an important step in understanding the social life and cultural development of the region. Such structures are firmly embedded in the cultural landscape of the region, adorning it with their presence and defining its uniqueness and character. They become a visual expression of the rich history and cultural heritage of the area. Studies focusing on these structures play a key role in enhancing knowledge of the past. They act as an important source of information about the cultural and historical context of a society, helping to better understand and appreciate the value of these architectural symbols. The results of such studies provide unique insights into the traditions, customs and beliefs that have shaped the cultural essence of a region. They provide a deeper insight into the essence of the local society and a better appreciation of its contribution to world culture and history.

This study of the Buran Minaret emphasised its unique architectural designs and its multifaceted significance for the local population and tourists. Alternately, M. Alajmi & Y. Al-Haroun (2022), conducting an architectural analytical study of modern minaret design, emphasised the importance of aesthetic and functional aspects in the creation of such architectural structures. M. Bakri & M. Rahmi (2023) also analysed not only the external appearance of minarets but also their practical application, relationship with the environment and impact on the socio-cultural life of society. Evaluating the results of the mentioned works, it should be emphasised that they could complement this study by enriching the analysis of architectural structures. The mentioned works, which analyse modern minarets, could complement the study of the Buran Minaret by providing new information regarding innovative design approaches and technologies that could be applied to the preservation and restoration of this historic site. Furthermore, the use of innovative approaches in design and materials would help to preserve its historical authenticity while providing a more durable and sustainable structure. Thus, this research could mutually inspire and enrich methodologies and practical approaches to the conservation and development of architectural heritage.

The study of ornamental relief belts, as on the Minaret of Buran, was also addressed in a study by A. Al-Omari & S.I.A. Khattab (2020), in which the subject of analysis was the Minaret of Al-Hadba, a famous architectural landmark. The focus of the work was the contribution of this minaret to the development of the architectural style and the technology of the bricks used in its construction. The study by K. Al-Ghazali & S. Al-Wazni (2023) also conducted a detailed study of the quality of the brick used in the construction of the minaret, its structure and characteristics, and the technology used in its manufacture. The results of the study provided a further understanding of its role in the architectural culture of the region and its influence on the development of local construction. When comparing these results with those of the Buran Minaret study, it is significant that they all examine the architectural features and historical significance of minarets, but from different perspectives. This study takes a broader look at the significance of the Buran Minaret in the context of the history, culture and life of the Chui Valley population. It highlights the unique structural and design methods used in its construction and ornamental solutions and draws attention to its significance in various spheres, including religion and tourism. Thus, all these studies provide valuable information for a fuller understanding of the role and significance of minarets in the architectural and cultural history of the region.

W. Astrini *et al*. (2020) focused on analysing the preferences of the community in shaping the composition of mosque architecture, and particularly the minaret. The study investigated which features and designs of the minaret were favoured by the local community and how they relate to traditional architectural styles and cultural norms. Furthermore, H. Hagras (2023) identified, by analysing the architectural features and design elements of the minaret, the main preferences and values that determine the choice of minaret design in the context of the mosque and its role in the architectural landscape of the region. It is noted that the results of the work provided a better understanding of the relationship between architecture and culture in the context of minaret design and its perception by the community. However, unlike the results of the studies mentioned above, the results of this study on the Minaret of Buran are more focused on the technical and design aspects of the structure. This study revealed the unique construction and design methods used in the construction of the minaret, which emphasises the technical prowess and creativity of the ancient builders. The study also revealed the peculiarities of the ornamental relief belts, revealing their important role in shaping the architectural appearance of the structure and its historical value. At the same time, the approach to analysing the preferences and values of certain regions applied in the mentioned works could complement this study, enriching its understanding of the perception of the structure in the context of cultural and social significance.

Architectural and structural features of minarets, as well as methods of erecting structures like the Minaret of Buran, were partially analysed in the study of A. Aymelek *et al*. (2023). The study analysed full-scale structural evaluations of the Iskenderpaş Minaret. The findings provided important information for the preservation and restoration of the minaret, as well as for the development of measures to strengthen and protect it in the future. M. Pouraminian (2022) also evaluated the durability of historic brick

minarets under different hazards, which allowed for a better understanding of their stability and the development of effective methods for their preservation. In comparing the mentioned works with this study, it is worth mentioning that all of them have their importance. A detailed study of the architectural and historical features of the Buran Minaret has shown its uniqueness and importance as a cultural symbol. However, at the same time, the mentioned study provides valuable information for the conservation and restoration of minarets as well as similar structures. Applying such analyses in the context of the study of the Buran Minaret could allow for a more comprehensive assessment of its current condition and the development of effective conservation and restoration measures, which in turn would contribute to the preservation of its cultural heritage and historical value for the local community and tourists.

Thus, research on architectural structures like minarets is crucial to the preservation of the historical and cultural heritage of the region. Such studies not only enhance knowledge of the past but also understand the significance of these structures for contemporary society. They reveal the architectural, historical, cultural and religious aspects associated with minarets, preserving and transmitting their value to future generations. Moreover, such studies promote tourism, cultural exchange and intercultural understanding, making them essential for the preservation of cultural diversity and the heritage of humanity.

CONCLUSIONS

This study revealed that the Buran Minaret plays a significant role in the history, culture and life of the local population of the Chui Valley in Kyrgyzstan. The study of the architectural features of the minaret highlighted the unique construction and design methods used in its construction. Thus, the ornamental relief belts decorating the trunk of the minaret are technically complex designs of aesthetically attractive elements reflecting the high level of skill of the ancient builders. The elegance and careful elaboration of ornamental motifs testify to the fact that the creation of each element of the minaret's architecture was carried out with great care and attention to detail.

The arched niches of the octagonal plinth, decorated with relief brick ornaments, are also one of the visual expressions of the artistic beauty of the minaret. Although time and some natural factors have led to the destruction of some of the details, the preservation of the ornaments on the three belts demonstrates their significance as historical and cultural heritage. These ornaments add to the beauty and attractiveness of the minaret and are an important source for studying the technology of ancient builders in the region. Meanwhile, the variety of materials used, including loess and ganache mortar, as well as different types of bricks, is evidence that craftsmen were skilled in a wide range of construction techniques and technologies. The use of ordinary building bricks in the ornamental masonry adds to the authenticity and uniqueness of this architectural monument, distinguishing it from its later counterparts.

From a historical perspective, the Buran Minaret is an ancient architectural structure that goes back in time and is associated with different historical periods of the region. It is not only an architectural monument, but also a symbol of spirituality, history and culture of the people of Kyrgyzstan. The minaret is associated with important historical events of the religious life of the society. It attracts thousands of tourists from different countries with its historical significance, architecture and atmosphere. The study noted the need to preserve such historical structures as an important element of cultural heritage. Their role in urban planning confirms that they symbolise the historical past, influencing the formation of urban space and its identity.

One of the limitations of the study was the limited access to some sources and archival materials, which may have affected the completeness of the analysis of architectural and historical data about the minaret. Directions for further research in this area could include a more in-depth analysis of the architectural and engineering features of the Buran Minaret and an investigation of its impact on the urban environment and cultural identity. It is also essential to explore methods of conservation and restoration of such historic structures to ensure their preservation for future generations.

ACKNOWLEDGEMENTS

None.

CONFLICT OF INTEREST

None.

REFERENCES

[1] Abo-Egila, H. (2021). The remaining minarets of the remains in the city of Cairo. *Journal of Association of Arab Universities for Tourism and Hospitality*, 21(4), 194-211. doi: 10.21608/jaauth.2021.97904.1244.

[2] Alajmi, M., & Al-Haroun, Y. (2022). An architectural analytical study of contemporary minaret design in Kuwait. *Journal of Engineering Research*, 10(1A), 48-66. doi: 10.36909/jer.14523.

[3] Al-Ghazali, K., & Al-Wazni, S. (2023). Investigation and parametric study of a masonry bricks minaret structure under vibration. *AIP Conference Proceedings*, 2775(1), article number 020017. doi: 10.1063/5.0140864.

[4] ALMagraby, Y., & El Attar, R. (2021). The symbolism of contemporary mosques minarets between the content and the heritage. *Mansoura Engineering Journal*, 46(4), article number 11. doi: 10.21608/bfemu.2021.209664.

[5] Al-Omari, A., & Khattab, S.I.A. (2020). Al-Hadba Minaret, a contribution in characterizing of its brick. *Key Engineering Materials*, 857, 48-55. doi: 10.4028/www.scientific.net/KEM.857.48.

[6] Amrane, S., & Khalfallah, B. (2023). The minaret: Between the constancy of the element and the change of use. *International Journal of Architecture, Arts and Applications*, 9(3), 93-104. doi: 10.11648/j.ijaaa.20230903.14.

[7] Archaeological-architectural complex "Buran Tower". (n.d.). Retrieved from http://www.kyrnatcom.unesco.kz/culture/burana.htm.

[8] Arslan, H. (2022). Samarkand: Cultural and scientific center of Central Asia. *Afro Eurasian Studies*, 8(2), 186-198. doi: 10.33722/afes.1095356.
[9] Astrini, W., Santosa, H., & Martiningrum, I. (2020). The characteristic of minaret based on community preference for the composition of mosque architecture in Malang city. In *Proceedings of the international conference of heritage & culture in integrated rural-urban context (HUNIAN 2019)* (pp. 112-118). London: Atlantis Press. doi: 10.2991/aer.k.200729.018.
[10] Aymelek, A., Yanik, Yu., Demirtaş, B., Yildirim, Ö., Çalik, İ., & Türker, T. (2023). Full-scale structural evaluations of İskenderpaşa minaret. *Structures*, 55, 1028-1044. doi: 10.1016/j.istruc.2023.06.055.
[11] Bakri, M., & Rahmi, M. (2023). Student's perception towards the mosque's physical identity in Banda Aceh. *Bayt ElHikmah: Journal of Islamic Architecture and Locality*, 1(2), 92-99.
[12] Bardik, M. (2023). Variations in the Byzantine artistic tradition in Kyiv-Pechersk Lavra churches' painting in 1890-1910s. *Notes on Art Criticism*, 43, 26-32. doi: 10.32461/2226-2180.43.2023.286831.
[13] Benjamin, C. (2018). Soviet Central Asia and the preservation of history. *Humanities*, 7(3), article number 73. doi: 10.3390/h7030073.
[14] Buran Tower minaret. (2019). Retrieved from https://silkadv.com/en/content/burana-tower-minaret.
[15] Chotaeva, Ch. (2021). *Geography of Kyrgyzstan: Lectures for students of undergraduate educational programs*. Bishkek: Neo Print.
[16] Construction norms and rules of the Kyrgyz Republic. (2017). Retrieved from http://www.giss.kg/files/SNiP%20KR%2012-02-17.%20Organization%20of%20building.pdf.
[17] Engvall, J. (2020). *Religion and the secular state in Kyrgyzstan*. Washington: American Foreign Policy Council.
[18] Farrag, E.M. (2023). Changes in mosques' architecture design between functionalism and symbolism. In M. Fekry, M.A. Mohamed, A. Visvizi, A. Ibrahim & L.F. Ghamri (Eds.), *Mosque architecture: A transdisciplinary debate. Advances in science, technology & innovation* (pp. 63-72). Cham: Springer. doi: 10.1007/978-3-031-24751-4_8.
[19] Hadrovic, A. (2024). The symbolism of the minaret designed by the architect Ahmet Hadrovic. *International Journal of Multidisciplinary Research and Publications*, 6(8), 105-115.
[20] Hagras, H. (2023). The initial architectural shape of the Guangta minaret: Textual and architectural study. *Shedet*, 10(10), 207-226.
[21] Hillenbrand, R. (2021). The multiple faces of restoration in the medieval Islamic architecture of Central Asia. In *The making of Islamic art* (pp. 71-116). Edinburgh: Edinburgh University Press. doi: 10.1515/9781474434300-010.
[22] İbrahimgil, A., & Kudumovic, L. (2023). Architectural peculiarities of the wooden minarets in Balkans region: Examples of Montenegro. *Gazi University Journal of Science Part B: Art Humanities Design and Planning*, 11(2), 283-296.
[23] Kamal, M.A. (2021). Minarets as a vital element of Indo-Islamic architecture: Evolution and morphology. *Journal of Islamic Architecture*, 6(3), 203-209. doi: 10.18860/jia.v6i3.7711.
[24] Kerimkhulle, S., Koishybayeva, M., Slanbekova, A., Alimova, Zh., Baizakov, N., & Azieva, G. (2023). Created and realization of a demographic population model for a small city. *Proceedings on Engineering Sciences*, 5(3), 383-390. doi: 10.24874/PES05.03.003.
[25] Kulözü, N. (2021). Determining urban identity of a historical city from inhabitants' perspective: Erzurum, a case from Asia minor. *Asian Research Journal of Arts & Social Sciences*, 13(2), 46-63. doi: 10.9734/ARJASS/2021/v13i230213.
[26] Lali, M., & Arefi, R. (2020). Danger of falling "Minaret of Jam" in Ghur Province of Afghanistan and overview of Jam-Minaret. *American Journal of Humanities and Social Sciences Research*, 4(4), 238-243.
[27] Lee, Y., & Jayakumar, R. (2021). Economic impact of UNESCO Global Geoparks on local communities: Comparative analysis of three UNESCO Global Geoparks in Asia. *International Journal of Geoheritage and Parks*, 9(2), 189-198. doi: 10.1016/j.ijgeop.2021.02.002.
[28] Massoud, H.M. (2020). The minaret: A reassessment of architectural function and religious value, in light of modern technology. *Journal of Engineering Sciences*, 48(3), 406-420. doi: 10.21608/JESAUN.2020.107708.
[29] Nasim, S. (2021). Abstraction and symbolism in Faisal Mosque: As unusual architectural decoration in South Asia. *Journal of the Research Society of Pakistan*, 58(4), 1-7.
[30] Osievska, Yu. (2022). Cultural heritage as a driver of social-cultural development on the modern stage: Regional model effectiveness. *Culture and Contemporaneity*, 1, 99-105. doi: 10.32461/2226-0285.1.2022.262578.
[31] Pouraminian, M. (2022). Multi-hazard reliability assessment of historical brick minarets. *Journal of Building Pathology and Rehabilitation*, 7(1), article number 10. doi: 10.1007/s41024-021-00148-9.
[32] Prychepii, Ye. (2022). Structures of the cosmos and sacred sets on the artefact of the paleolithic. *Interdisciplinary Cultural and Humanities Review*, 1(1), 30-39.
[33] Rashid, M. (2020). *Islamic architecture: An architecture of the ephemeral*. Retrieved from https://kuscholarworks.ku.edu/handle/1808/30156.
[34] Roshdy, M. (2018). The complex of Chor Bakr in Bukhara: An archeological and architectural study. *Egyptian Journal of Archaeological and Restoration Studies*, 8(1), 53-58. doi: 10.21608/ejars.2018.13909.
[35] The statesman's yearbook: Kyrgyzstan. (2020). London: Palgrave Macmillan. doi: 10.1057/978-1-349-95940-2_108.
[36] Wang, S. (2021). *The Silk Roads: A case study in serial transboundary protection and management of cultural heritage*. (Doctoral thesis, University College London, London, England).

[37] Xasan, A.S. (2023). Conservation and use of memorial monuments of Surkhondarya region. *Journal of New Century Innovations*, 22(4), 86-88.
[38] Zhylankozova, A. (2018). Towards the Silk Road economic zone initiative: Historical perspective. *Entrepreneurship and Sustainability Issues*, 6(2), 548-557. doi: 10.9770/jesi.2018.6.2(6).

Джумамедель Іманкулов
Доктор архітектури, професор
Киргизький державний технічний університет ім. І. Раззакова
720044, просп. Ч. Айтматова, 66, м. Бішкек, Киргизька Республіка
https://orcid.org/0009-0007-9256-0134
Хе Фенг
Докторант
Киргизький державний технічний університет ім. І. Раззакова
720044, просп. Ч. Айтматова, 66, м. Бішкек, Киргизька Республіка
https://orcid.org/0009-0007-9093-1480
Тянь Цзин
Докторант
Киргизький державний технічний університет ім. І. Раззакова
720044, просп. Ч. Айтматова, 66, м. Бішкек, Киргизька Республіка
https://orcid.org/0009-0003-4139-0957
Тетяна Філатова
Кандидат архітектури, доцент
Киргизький державний технічний університет ім. І. Раззакова
720044, просп. Ч. Айтматова, 66, м. Бішкек, Киргизька Республіка
https://orcid.org/0009-0001-1333-2560
Айгерім Акматова
Студент
Киргизький національний університет ім. Ж. Баласагина
720033, вул. Фрунзе, 547, м. Бішкек, Киргизька Республіка
https://orcid.org/0000-0001-5019-6679

Мінарет Бурана як символ Чуйської долини Киргизстану

Анотація. Це дослідження має актуальність, оскільки вивчення архітектурних особливостей Мінарету Бурана та його ролі у збереженні ідентичності регіону є ключовим для збереження історичної та культурної спадщини в умовах сучасної глобальної культурної динаміки. Метою даного дослідження було провести аналіз архітектурної значущості Мінарету Бурана в контексті культурної спадщини Чуйської долини та його впливу на формування історії регіону. Дослідження включало комплексний методологічний підхід, що поєднує археологічні, історичні, культурологічні та соціологічні методи. Отримані результати засвідчили унікальність архітектурних рішень, застосованих при зведенні Мінарету Бурана. Орнаментальні рельєфні пояси, що прикрашають стовбур мінарету, являють собою технічно складні конструкції, що відрізняються високим рівнем майстерності. Ретельна увага до деталей і вишуканість орнаментальних мотивів підкреслюють, що кожен елемент архітектури мінарету був створений з вишуканістю і турботою про деталі, відображаючи високий рівень навичок і відданість древніх будівельників. Арочні ніші восьмигранного цоколя, декоровані рельєфним цегляним орнаментом, також є візуальним вираженням художньої краси мінарету. Збереження орнаментів на трьох поясах демонструє їхню значущість як історичної та культурної спадщини. Використання різноманітних матеріалів і технік кладки, включно зі звичайною будівельною цеглою, надає автентичності та унікальності цій архітектурній пам'ятці. Також, отримані результати підтвердили, що Мінарет Бурана відіграє ключову роль для Чуйської долини на історичному, культурному, релігійному та туристичному рівнях. Його історичне значення виражається через зв'язок з різними періодами регіону, а також його символічну значущість для культури та релігії, приваблюючи тисячі туристів своєю історичною та архітектурною значущістю. Отримані висновки мають важливе практичне значення для збереження історичної та культурної спадщини регіону. Вони розширюють розуміння архітектурних і технічних здобутків стародавніх майстрів, наголошуючи на необхідності збереження та реставрації унікальних архітектурних споруд, таких як Мінарет Бурана

Ключові слова: культурна спадщина; архітектурні споруди; історичний об'єкт; ісламська ідентичність; пам'ятка мусульман

Architectural Studies
International Journal about Architecture

Volume 10, No. 1

UDC 94:725
DOI: 10.56318/as/1.2024.115

Oleksii Korotkyi*
Postgraduate Student
Berdyansk State Pedagogical University
71100, 4 Schmidt Str., Berdyansk, Ukraine
https://orcid.org/0000-0001-6267-3321

Compositional and stylistic features of the Northern Black Sea region's detention facilities of the first third of the 19th century

Abstract. The investigation of the history of prison infrastructure development is being updated by the ongoing (2024) penitentiary reform in Ukraine. The planning and development of a new network of penitentiary institutions that will meet modern standards and goals of imprisonment requires attention to similar processes of rethinking prison architecture that took place in the first third of the 19th century. In this regard, the purpose of the study was to explore the transformation of the structural and spatial organisation of detention facilities during the active prison construction of the 19th century based on published and archival materials. This led to the use of historical, historical and comparative, compositional, grapho-analytical analysis, which were applied in the context of structural-functional and sociological approaches to the study of architecture. The application of this methodology helped to establish the origins and historical prerequisites for the expansion of new detention facilities during the study period. Based on the analysis of the structural and spatial construction of detention facilities, conclusions are drawn about the main goals that architects and authorities pursued when reforming prisons. By comparing the layout of different prisons, the regional specificity of different prison castles in the Kherson province was investigated. The study of the composition and structural-functional organisation of prison castles allowed tracing how the ideas about disciplinary space were embodied in the empire. Based on the analysis, the conclusions about the palliative nature of prison reform in the first third of the 19th century are clarified. The analysis of the implementation of the system of power relations in the architecture of detention facilities revealed that certain pre-reform elements have been preserved in prison castles. The study of the organisation of prison space allowed creating a periodisation of the development of architecture. It was concluded that typical places of detention of the pre-reform period were designed to solve pressing problems of functioning of detention facilities, and not to consistently implement certain penitentiary ideas in architecture. The prison reform of 1819 brought a neo-Gothic style and more complex composition to prison architecture. The results of the study can be used by researchers of other architectural experiments of the 19th century on the organisation of disciplinary spaces and serve as source material for educational and local history organisations

Keywords: prison castle; stockade; neo-Gothic; neoclassical; isolation; supervision; discipline

INTRODUCTION

The ecological theory of crime, which proclaims urban space to be not only a place but also a factor in the emergence of criminal actors, points to the significant role of architecture in shaping social space, the impact of certain architectural solutions on the future fate of buildings, streets, and districts as loci of social reality. This understanding of architecture as a way of organising society, differentiating and structuring it, however, has a much longer history, which goes back to the Age of Enlightenment and fully conscious attempts by educators, politicians, and

Suggested Citation:
Korotkyi, O. (2024). Compositional and stylistic features of the Northern Black Sea region's detention facilities of the first third of the 19th century. *Architectural Studies*, 10(1), 115-124. doi: 10.56318/as/1.2024.115.

Journal homepage: https://arch-studies.com.ua/en#
Architectural Studies, 10(1), 115-124
Received: 05.02.2024 Revised: 22.05.2024 Accepted: 20.06.2024

*Corresponding author

architects to rebuild society on a rational basis. The results of these ambitious projects were, in particular, detention facilities, which were in the centre of public attention since the last quarter of the 18th century, first in England, and later in continental Europe. The result of these attempts to solve social problems with compositional innovations was new prisons in their structure and functions, which replaced arbitrary institutions in random houses and castle dungeons, and in Eastern Europe – wooden stockades. However, the gradual disappointment with the institutional approach to solving social problems contributed to the transformation and reorganisation of these new structures. Modern reforms, particularly in Ukraine, call into question imprisonment as the main and most effective method of punishment. The closure of old prison facilities built in the 19th century (many of which still function as prisons) began before the full-scale Russian invasion of Ukraine in 2022 and was intended to contribute to the creation of a new prison experience, including a new prison architecture (Ministry of Justice plans..., 2019). These plans of the Ministry of Justice update the study of the history of past attempts to introduce modern architectural solutions for detention facilities in Ukraine.

It should be noted that a significant number of studies have been developed on this topic, which, however, only indirectly relate to it, or do not aim at a comprehensive analysis, focusing on individual institutions of the 19th century. Thus, among the latest research, it is necessary to mention O. Korotkyi (2023), who investigated the history of the construction of the first Odesa prison castle in the period 1823-1826 and the process of its further development, which was associated with the construction of a separate wing for debtors on the territory of the prison. In this study, based on the archival materials of the Odesa State Archive, the characteristic organisational and financial problems that occurred during the construction of such institutions were highlighted. Considering the place of construction of the castle, the researcher concluded that its removal to the outskirts of the city was a sign of the embodiment of modern ideas about punishment by imprisonment. Construction of a new prison in Odesa at the end of the 19th century was studied in the dissertation by Ye. Yurash (2021), who concluded that during this period, the construction of the prison took place quite quickly and did not meet significant obstacles. The main reason for its construction was the increase in the constant number of prisoners in Odesa to 900 people, while the previous prison was designed for only 400. The study by K. Kuzina (2019) traced the impact that the prison had on the surrounding urban environment of Vinnytsia in the 19th century. The researcher recorded the fact that during the construction of prison castles in the 1820s, new facilities were located outside the city, in this case – beyond the Southern Bug River. At the end of the century, when the area was already built up with residential buildings with an increase in population, the prison was again moved to the outskirts of the city. Thus, the prison was isolated from urban space and this principle required constant reproduction.

Questions of the history of 19th-century prisons, their condition and compliance with the modern paradigm of incarceration, in connection with the subsequent use of 32 Victorian buildings in England and Wales, were studied by D. Moran *et al*. (2022). This study raises an important issue of using outdated detention facilities, which were built under certain historical circumstances and became the embodiment of very specific systems of power and paradigms of punishment. The study points out the important detail that the inherently static architecture is less plastic in relation to the goals and models of incarceration. This remark is important because in such institutions as prisons, where the structural and spatial organisation has disciplinary, police and pedagogical functions, the inviolability of the composition becomes not only a "reflection" of the past, but also represents a material dimension of the phenomenon of institutional memory. The impact of preserving outdated forms of space organisation on the experience of incarceration remains a poorly investigated aspect in historical and architectural studies of penitentiary institutions.

The way the ideology of prison reforms, religious, moral and disciplinary ideas that established the basis of prison theories of the 18th-early 19th centuries were implemented in specific architectural solutions was illustrated by A.T. Rubin (2021) and J.A. Flores (2021). Both studies focus on how moral and religious beliefs prevailing in various communities in the United States influenced the structural and spatial organisation of Philadelphia and Auburn prisons. It is worth mentioning the critical article by M.R. Nadel & D.P. Mears (2018), which points out that the changes that were implemented in the prison architecture had minimal impact on prisoners and did not help in achieving the goals of punishment. Thus, these changes were caused more by theoretical transformations than by the real moral or disciplinary impact that certain compositional decisions provided. The researchers were among the first to criticise the penitentiary capabilities of prison architecture from a scientific standpoint, so their empirical conclusions need further verification.

Considering current state and trends in the study of the history and theoretical foundation of the idea of prison architecture, the following research goal was formulated: to investigate the transformation of prison architecture in Eastern Europe during the prison construction of the first third of the 19th century on the example of the Northern Black Sea region. To achieve this goal, it was necessary to perform the following research tasks: to investigate the structural and spatial organisation of prison castles designed or built in the first third of the 19th century; to consider the composition of detention facilities and their stylistic features in the context of the penitentiary paradigm proclaimed in the empire.

MATERIALS AND METHODS

The object of research was the places of detention of the Northern Black Sea region of the 19th century. The subject of the research was their style, composition, structural and

spatial organisation. The theoretical framework was based on the approaches to the analysis of prison architecture developed in classical studies on the history of imprisonment in the modern era (Evans, 1982; Foucault, 2023). Thus, the analysis of the structural and spatial organisation of detention facilities involved establishing how specific architectural decisions were influenced by the distribution of power within the institution, the type of control and supervision that prevailed at a particular time and was envisaged by the objectives of the prison sentence. This also involved reverse analysis – the study of those relationships that were generated by a particular architecture.

Historical, historical and comparative, and grapho-analytic methods were used in the context of the outlined theoretical framework. The historical method traced the changes in the architecture of prisons in the Russian Empire and, in particular, in the Northern Black Sea region in chronological order. This allowed proposing a periodisation of the development of prison architecture in this period. The historical and comparative method was applied in its two variations – synchronous and asynchronous. This helped to establish structural and stylistic differences between prisons built in different periods and differences between different prison institutions that emerged at the same time. The key method of research was grapho-analytic, which was used to consider the composition and stylistic features of detention facilities based on drawings stored in historical archives, monuments of graphics of the 18th century, paintings and photographs of the 19th century.

The materials for this study were plans for detention facilities in the Northern Black Sea region (Novorossiysk General Governorate) and standard plans for detention facilities approved at the general imperial level. Describing the first ones, their originals were kept in the Odesa State Archives (OSA) and were located in case No. 1a of the first inventory of the collection No. 361 (Odessa State Archive..., 2012). The plans of the prison castles of the Kherson province and the prison building in Mariupol, analysed in this study, were submitted to the Odesa Committee of Trustees over prisons in 1830 in response to a request from the committee to the Governor-General regarding the state of prisons in the region. These plans were copied in 1829-1830 by local surveyors and architects based on the original plans used to build prisons. The study presented copies of these plans made during archival work in the OSA. At the same time, plans of other prison castles and places of detention were analysed for comparison, copies of which were presented in other studies on the topic (Kravchuk & Karpenko, 2010; Gubar, 2015). In addition to this graphic material, there were other archival primary sources, in particular, cases from the funds of the OSA and the state archive of the Russian Federation. These documents represent cases that illustrate the processes of drawing up estimates for the construction of certain detention facilities, choosing a place for construction, bidding for contracts, building various structures on the territory of the prison, and other issues related to the process of their creation. To investigate the style of provincial castles, photographs of these structures of the late 19th century and the "Odesa album" by Carlo Bossoli (1835) (Odessa history, n. d.), which for the first time recorded the appearance of the Odesa prison castle, destroyed after the construction of a new prison in the late 19th century. The materials of the Complete code of laws of the Russian Empire were used to highlight the process of official approval of certain plans and implementation of new principles of penitentiary policy.

RESULTS

Practice and places of detention as of the beginning of the 19th century. In the period before the prison reforms, the traditional detention facilities on the territory of the empire were wooden stockades, the name and structure of which was borrowed from the corresponding medieval fortification structure. Stockades were built in the form of a square, the sides of which represented a high wooden fence with one gate, often bound with iron. The premises for prisoners had the appearance of separate wooden buildings inside the fence – "huts". Guard rooms were located at the entrance to the prison. Most often, it was one building, but large prisons could have two of them. A. Sapronov (2018) suggests that it was in the guardhouses that particularly dangerous criminals were held. The guard was led by a guard "ataman", or ward.

Such a structural and spatial organisation of detention facilities, with some exceptions, was typical for the entire territory of the empire and took place throughout the 18th century. The biggest problem for prisoners was undoubtedly the difficult conditions of detention. With the formalisation of the trial, a reduction in the number of corporal sentences, and for other reasons disclosed by O. Korotkyi (2022), the total number of prisoners gradually increased. Overcrowding in the prisons led to a number of problems: famine, escape, epidemics. The combination of these problems, including the influence of the ideas of the English prison reformers on the need to differentiate prisoners, led to the first attempts to abandon the traditional construction of prisons. Differentiation of prisoners became the main idea of Governor-General Alexey Kurakin. In 1802, he reported to Emperor Alexander I that in Chernihiv and other prisons in the region, casual prisoners were held together with repeat offenders, which led to the moral "corruption" of the former. After reading the report, which actually illustrated the state of incarceration in all the prisons of the empire, the emperor granted permission to develop new prisons in the province, which were soon built. Each category of prisoners had to have its own building, each of which had to have a small department for women. The creation of such prisons throughout the empire was provided for by decree of April 14, 1808 (The Approved Report of the Minister..., 1808). The architect who designed typical prison castles was a well-known representative of the neoclassical style, Adrian Zakharov.

These projects were used to build prison castles, including in the Northern Black Sea region. Thus, analysing

the plans and facade of the prison castles of the Novorossiysk General Governorate, it can be seen that the plan of 1808 (Russian State Historical Archive, 2009), according to which the prison was built in Kherson, was an adaptation of a typical county prison (Kravchuk & Karpenko, 2010), while in Taganrog, in which the prison castle was built in 1806, had recognisable features a typical provincial prison castle: four rectangular towers (alcoves) at the corners of the fence surrounding the main building of the prison (Fig. 1). A new stage of prison construction began in the 1820s, due to the influence of two factors: increased crime and the proclamation of prison reform in 1819.

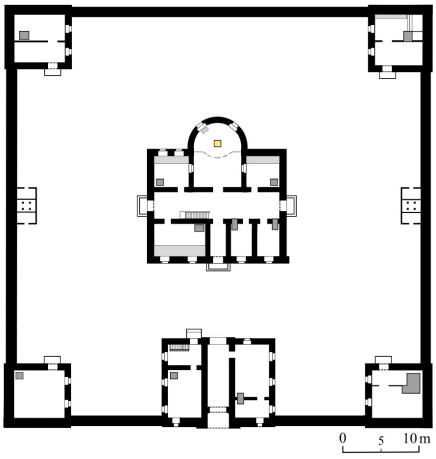


Figure 1. Plan of the Taganrog prison castle
Source: copied by the author from archival materials stored in the Odesa State Archive... (2012)

Thus, in the architecture of the empire's prisons in the first third of the 19th century, three successive stages can be traced, the chronological boundaries between which are somewhat arbitrary due to the fact that the construction of new prisons was uneven in different regions and even within individual provinces. In addition, even if funds were allocated for the creation of new detention facilities, their construction could be delayed for many years. At the beginning of the century, the traditional architecture of the wooden stockade prevailed. In the period 1808-1820, the construction of stone stockades and provincial prisons with corner towers was carried out according to the model plans of Adrian Zakharov. In the 1820s, these stone stockades replaced prison castles.

Stone stockades of the Kherson province as an architectural bricolage. In the Kherson province at the time of 1830, there were six stone prisons, of which four were built according to the same plan – in Kherson, Tiraspol, Yelisavetgrad, Olviopol (Odessa State Archive..., 2012). Analysing the plans of these prison castles (Fig. 2), first of all, it is necessary to note their metro-rhythmic simplicity, mirror symmetry and rectilinear ornament, characteristic of neoclassical architecture. The prison castle is largely characterised by a frontal composition, the centre of which was the entrance to the castle territory, the so-called front wing. The main facade of the prison barracks, which housed all the entrances to the premises, also faced the single entrance. The side and rear facades of the barracks, and the prison wall, were devoid of any other functional significance other than isolation of prisoners, were impenetrable to both the prison contingent and visitors. Thus, the entire life of the prison depended on the main entrance, which housed the prison warden's storeroom. His placement on the periphery of the prison, precisely in the place of its interface with the outside world, made the warden a key figure for the institution, but in a completely different sense than required by disciplinary motives. The warden's control and supervision was not intended to enter the barracks, but instead focused on the only possible transit point between it and the city from which the prison received food, visitors, in particular vendors and benefactors, newly arrived prisoners, etc. This organisation of space was also traced in the standard plan of Adrian Zakharov county prisons in 1811 (Kravchuk & Karpenko, 2010).

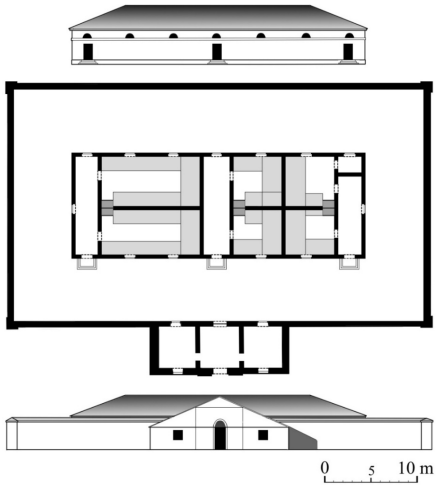


Figure 2. Plan of the Kherson prison of 1808
Source: copied by the author from archival materials stored in the Odesa State Archive... (2012)

As indicated by R. Evans (1982), this localisation of the caretaker was also characteristic of a pre-reform English prison, since the control of entry and exit from the prison established a monopoly over the flow of goods and services that came to it from the city: alms, alcohol, food, and entertainment that prisoners could afford. Thus, the maintenance of the prison, which was entirely entrusted to the warden, depended on the effective establishment of this enterprise. This was the reason for placing the warden at the only gate.

The plan of prison castles of the Kherson province (Fig. 2) has another similarity of new buildings to prisons – the organisation of internal space according to the traditional model of a peasant hut: hall ("siny"), hut ("khata") with a stove, storage room. Thus, the modern institution and its large barracks for 200 people, in its structure, were trivial three separate and impenetrable huts from the inside, the entrance to each of which began from the entrance

hall. In this case, there is nothing more than an attempt to adapt traditional residential solutions to the new needs of penitentiary theory – differentiation of prisoners by gender, state of health (patients had to be kept in a separate room), crimes committed (Name decree given to..., 1802). A similar structural and spatial organisation can be observed on a smaller scale on the example of a prison building in Mariupol (Fig. 3).

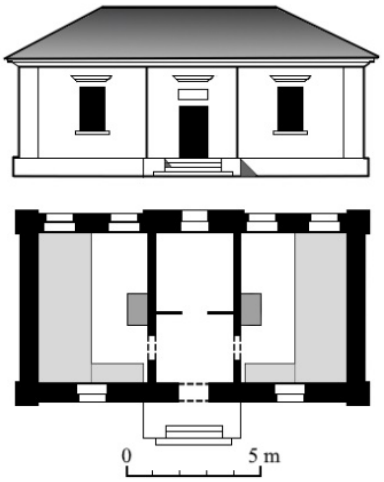


Figure 3. Plan of the prison premises in Mariupol (1830)
Source: copied by the author from archival materials stored in the Odesa State Archive... (2012)

Thus, it can be argued that the stone prisons built in the first quarter of the 19th century became an adaptation of the structure of the traditional wooden prison and peasant hut to the need to differentiate prisoners into several large groups, as was first done in Chernihiv province by Governor Alexey Kurakin (Korotkyi, 2023). Such buildings, built on the basis of standard plans of the 1810s, did not bring significant changes to the structural and spatial organisation of the prison. Their simplicity and the neoclassical style typical of all state buildings suggested that detention facilities continued to be treated as ordinary "places of presence" (administrative buildings / authorities). The proclamation of new principles of incarceration (permanent supervision, differentiation of prisoners, religious training and moral improvement, labour discipline, separate detention) in 1819 (The Approved Report of the Minister..., 1819) will change the image of the provincial prisons of the empire.

Origins of the monumentality of provincial prison castles. According to other plans, the Odesa prison castle was built in 1823-1826 and the Kherson prison was rebuilt in 1826-1831. Although these castles were the result of an adaptation and reinterpretation of the exemplary plan for the provincial prisons of Adrian Zakharov, developed in 1803, however, in practice they had significant differences, which consisted in their monumentality and neo-Gothic style. The first prison buildings in the empire, which had romantic forms inspired by medieval walls, were prison castles in Nizhny Novgorod, Astrakhan, and Kharkiv (Fig. 4), built according to the project of the imperial architect Joseph Charlemagne. One of the main changes made by this designer made to his predecessor's designs was to move the rectangular towers from the corners of the prison wall to the corners of the main prison building and give them monumental, medieval rounded shapes, which created a contrast, made them stand out among the two-dimensional space, and was immediately intended to attract the attention of the townspeople. Thus, the building, according to the name, was now supposed to resemble not the historical stockade – a fortification of medieval Rus and the Moscow State, but the historical "castle" of the Western European model.

Figure 4. Kharkiv prison, built according to the project of Y. Charlemagne in the 1820s
Notes: photo of the end of the 19th century
Source: Prison castle (2018)

The monumentality of the empire's prisons of the 1820s and 1830s thus owes a great deal to Joseph Charlemagne and the trend for the romantic, neo-Gothic style of architecture, or, in its Eastern European version, "Nicholas Gothic", named after Emperor Nicholas I, or "pseudo-Gothic". Looking for the origins of the appearance of towers on prison castles in the empire, it is worth noting that during this period a number of other buildings of this historical style appear. However, to see in the spread of Gothic elements in prison architecture exclusively the influence of metropolitan fashion is somewhat limited and does not exhaust the breadth of the problem. As noted by R. Evans (1982), the inspiration for medieval buildings was part of a broader and pan-European trend in art, which was to place imprisoned characters in the historical context of the Middle Ages. Thus, according to the researcher, the prison became a cultural reminiscence. Given the novelty of these institutions, which came to the attention of the educated public only at the end of the 18th century, this stylisation of medieval Gothic was a search for a visual style to a form that was supposed to provide new and previously unknown goals – strict isolation and strict regulation. For example, the imaginary dungeons and towers of Giovanni Piranesi's paper architecture (Fig. 5), created in 1749-1750, 1761, were partially implemented in the development of the modern prison at the turn of the 18th and 19th centuries in England and in the first third of the 19th century in the

Russian Empire and the Northern Black Sea region. An interesting fact that illustrates not the direct inheritance of images, but rather the fact that all the above-mentioned architects were in a single intellectual space: Joseph Charlemagne was a student of Charles Cameron, who, in turn, was familiar to Giovanni Piranesi and inspired by his work.

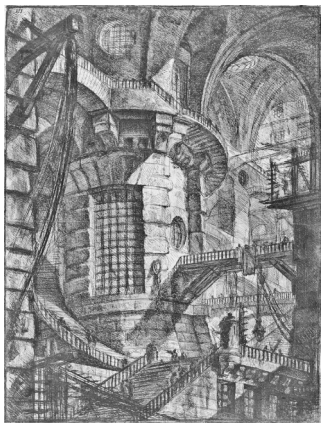


Figure 5. "Round Tower" from the series "Dungeons" by Giovanni Piranesi (1761)
Source: Imaginary prisons: Giovanni Battista Piranesi prints (2015)

It is quite possible that the clear rectangular "fortification towers" on the plans of Adrian Zakharov and the prison built on this model turned into "gloomy" and monumental medieval towers in the interpretation of Joseph Charlemagne due to the above indirect influences. Another source of the appearance of corner towers on the plans of prison castles of this architect could be the composition of the Lithuanian Castle in the capital of the Empire, on the project of reconstruction of which the master worked in 1820-1823 (Architectural monuments destroyed..., 2018). As a result, of the seven round towers designed by architect Ivan Starov in 1787, only four were left, which were eventually recreated in other prisons according to the plans of Joseph Charlemagne.

Odesa prison castle, designed and built in 1823-1826 by two Italians – Francesco Boffo (architect) and Simone Tomasini – contractor) – was also an adaptation of the best practices of Joseph Charlemagne. Adjacent to the main building were four large-scale towers topped with crenellated parapets, which housed spiral staircases connecting the prison floors (Fig. 6). In this case, despite the fact that similar stylistic neo-Gothic elements were inherent in other works of Francesco Boffo in Odesa (Pismak, 2018), it is worth talking about more global trends in the development of the style of prison architecture in the empire. According to a plan similar to the Odesa castle, the Kherson prison castle was also built, which is also characterised by the neo-Gothic style (Sukhoparov, 2002). Even more expressive monumentality was characteristic of the prison castle in Chisinau, which was designed by Odesa resident Giorgio Torricelli in 1834 (Chastina, 2020).

Figure 6. Odesa prison castle, depicted by Karlo Bossoli in 1830
Source: Odessa history (n.d.)

On a copy of the plan made in 1861 (Gubar, 2015), unlike the "stone stockades" in other cities of the province, the composition of the prison castle gets more depth, because from now on the main building is structurally connected not only with the main wing, but also with courtyards for walking and a bathhouse for women, which are adjacent to the rear facade of the building (Fig. 7). At the same time, the four symmetrically arranged corner towers add volume to the building. Consequently, it can be observed how the intensification of control over prisoners and their stricter differentiation (separation of the sick from the healthy, separation of debtors) led to a more efficient use of the prison castle space and complicated the composition and structure. Thus, the prison wards and vestibules were supplemented with a room for work, a church, a hospital, a department for minors, and later – those sentenced to imprisonment (Russian State Historical Archive, n.d.), which became relevant after the reform of the criminal legislation of 1845. The spatial composition served to better differentiate prisoners, because the four "medieval" towers were not only intended to connect the two floors of the prison and serve as a cultural reminder, but also allowed prisoners of different departments to be moved to courtyards for walking outside the central corridor of the prison. Thus, the prisoners of different departments did not have any contact with each other. These courtyards of the Odesa prison were an innovation on the territory of Southern Ukraine and quickly began to be used in other prisons. Thus, during the construction of the Kherson prison castle, when the question of arranging such courtyards arose, the city architect insisted on their construction exactly on the model of Odesa (Odessa State Archive..., 1984).

Despite these innovations, the placement of the castle warden in the main wing was a legacy of the archaic composition of the wooden prison. In conditions where the state and legislation did not put forward ideas of moral influence on prisoners, the placement of a warden inside the prison space, deep in the architectural composition, was not necessary. The situation described above was quite acceptable for a pre-reform prison, but it had neither symbolic nor

functional significance in the 1820s. In this regard, several factors for preserving this element of the wooden prison structure during the construction of new prison castles can be distinguished. The first is the preservation of imprisonment, mainly as part of the justice infrastructure: the vast majority of prisoners were in prison awaiting a court verdict, and not as a punishment, which did not involve attention to their behaviour and did not require special control. The second – the transition of providing prisoners to public funds and the organisation of cooking in prisons was delayed, so the central gate continued to play an important economic role: through them, prisoners bought goods from citizens, received alms.

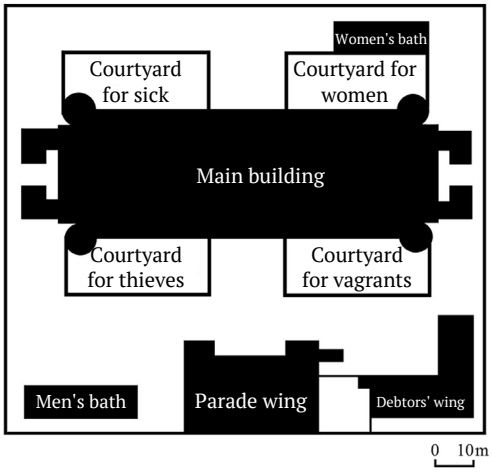


Figure 7. Plan of the Odesa prison castle
Source: designed by the author based on the material posted in the study by O. Gubar (2015)

This created a contradiction between spatial organisation and power relations in institutions. According to the materials on the history of the Kharkiv prison castle (1823) considered by R. Kravchenko (2012a), a prison guard gradually lost his power due to competition with internal security. Attention should be paid to the fact that the space for which the disputes were held was not accidental, because this was exactly the main gate of the castle, through which the guard did not allow the warden's family to pass. Considering this case, there is a certain inertia of the structural and spatial organisation of prison castles in relation to the ongoing reform and its innovations in the prison administration system, because it reproduced the pre-reform principles laid down in the plans of Adrian Zakharov. In the new conditions, under which the warden was no longer the full owner of the prison, his monopoly on "entry and exit" from the castle was called into question, but its placement not in the middle of the composition, as it happened in prisons with a radial spatial organisation, but at its intersection with the outside world, testified to the continuity of the architectural tradition despite the ongoing paradigm changes in understanding the meaning of imprisonment.

Thus, it was in the provincial prison castles that the design most consistently tried to embody the principles on which the prison reform was organised. The reason for this should be considered the better integration of large cities into the leading socio-cultural and social trends in the empire. These monumental structures were intended not only to accommodate more prisoners, but also, through more efficient use of space, to make contact between different groups of prisoners impossible, and to promote a new paradigm of imprisonment.

DISCUSSION

A long tradition that dates from the era of prison reforms at the turn of the 18th-19th centuries to modern institutions of deprivation of liberty, draws a direct link between the composition, structural and spatial organisation of detention facilities, and their impact (in a broad sense) on prisoners. Starting with John Howard and his travels in Europe, prison planning depended on specific prison theories, the implementation of which involved organising disciplinary space in one way or another. If John Howard insisted mainly on stricter differentiation of prisoners and better ventilation of prison premises, then further compositional innovations (William Blackburn's radial composition, Jeremy Bentham's panopticon, solitary confinement under the Philadelphia system) provided for the implementation through architecture of the idea of continuous supervision and moral healing through solitude and associated introspection. Thus, from the very beginning of the reforms, architecture was seen as one of the key elements of the organisation of the discipline. Critical approach of M.R. Nadel & D.P. Mears (2018) questions the penitentiary significance of a particular architecture, preferring the prison regime. Without resorting to a discussion about modern institutions, it is worth noting that the conclusions of researchers do not consider the radical changes in architecture that took place in the late 18th-first half of the 19th century both in Western Europe and in the Russian Empire. Two key changes – differentiating prisoners by gender, crime, and health status – would not have been possible without new architectural solutions. The very establishment of the prison regime begins already in reformed prisons, where differentiation and control based on certain principles were embodied in specific architectural forms and romantic images.

Given the latter, further research requires considering the origins of this monumental style. The study by A. Brodie (2019) notes that during the prison reform of the late 18th century in England, some counties abandoned the construction of new prisons and only rebuilt historic castle complexes, despite the lack of space in them, possible safety risks, and hygiene problems caused by stampede and poor ventilation. Although, as the researcher points out, the main factor in this decision was probably finances, but the reason could also be the desire to preserve the traditional connection between administrative buildings. The study did not analyse the impact of preserving the castle's architectural composition on the prison regime, but a similar dimension of institutional memory may be the subject of future research in this area.

The architecture of prisons in Eastern Europe almost does not attract the attention of researchers, and therefore, some conclusions about the features of the development of incarceration in the Russian Empire need to be clarified. Consideration of context of the space in which the prison reform was supposed to take place allows supplementing the conclusions about the reasons for the slow establishment of Committee of Trustees over prisons made by O. Tsereniuk (2002) and R. Kravchenko (2012b). Along with the rather insignificant interest in the case of custody of prisoners on the part of the local nobility, it can also be highlighted the lack of modern, reformed prisons in the counties, following the example of those that were built in Kharkiv or Odesa. Thus, there was a tendency that prison committees mainly appeared on the basis of newly built prison castles, due to the architecture of which it was possible to achieve differentiation of prisoners, organisation of their work, treatment, and religious instructions. In other prisons, in particular due to the impossibility of the distribution of prisoners and their significant accumulation, it was impossible to eliminate the traditional prison subculture, prison artels, which called into question the possibility of moral influence on prisoners, as it was assumed in prisons based on the principles of individualisation, for example, panopticon prisons, which will be created in the empire only at the end of the 19th century (Lazarenko, 2019).

The above observation confirms the conceptual generalisations of O. Etkind (2013) on the strategy of indirect population management in the empire. Due to the rather undifferentiated internal space of prison castles, which reproduced the construction of a traditional hut, the administration did not deal with individual prisoners, but with the prisoner community, united in the crowded rooms of the prison around the unwritten rules and traditions of prisoner life. The study also complements previous studies on the history of imprisonment in the Kherson province (Korotkyi, 2022; 2023), in particular, allows making certain clarifications in understanding the transformation of the prison experience of prisoners of the Kherson province of the first third of the 19th century. Thus, the analysis of the prison castles of the Kherson province indicates that the reason for the delay in the progress of reforms should be called not only "misunderstanding by the administrative elite of the new paradigm of the system of correctional punishment", but also the development of prison castles in the province, the structural and spatial organisation of which, with the exception of the Odesa and newly built Kherson prison castles, was inherited from the pre-reform period. within which prison premises were located. The need to expand prisons to solve the problem of overcrowding led to the construction of new stone prisons, which were supposed to ensure minimal differentiation of prisoners by gender and isolate them from the outside world. The lack of paradigmatic changes in the understanding of the goals of the conclusion led to its stylistic and structural-spatial characteristics. Thus, the prisons built in the Kherson province had neoclassical features typical of other administrative buildings, and the organisation of the internal space was enlarged in scale and combined under one roof of the main building of the prison houses.

The beginning of prison transformations after the foundation of the Committee of Trustees over prisons in 1819 contributed to the creation of new prison institutions in provincial cities. The main changes between pre-reform and new castles designed by Joseph Charlemagne were the necessity to move the towers from the corners of the wall to the corners of the main building of the prison and give them romantic shapes. The general stylisation of these new buildings under the medieval Gothic style had in its origins both a pan-European fashion for Gothic elements in architecture, and a specific trend of prison architecture, which was supposed to serve as a cultural reminder and evoke images of medieval dungeons. However, the monumental towers of the Odesa and Kherson prisons made the architectural composition more voluminous and complex in contrast to the simplicity and two-dimensional nature of the prisons. This was caused by the need to use space more effectively to achieve the goals of strict differentiation of prisoners. However, both in the prisons built in 1806-1820 and in the provincial prison castles, the construction of which took place in the 1820s and 1830s, such an archaic element of the structural and spatial organisation of the prisons as the placement of administrative premises at the entrance to the castle has been preserved.

The new principles of incarceration, which consisted in differentiating prisoners, improving their conditions of detention, moral correction and more consistent control, were embodied in a new structural and spatial organisation and new stylistic solutions. The prison architecture of the empire evolved from simple forms, structure, and neoclassical stylistics to monumentality, volume, and neo-Gothic style. Further research on these transformations may be aimed at studying the use of these structures after the new prison reform of the 1860s and 1870s, investigating the differences between the architecture of detention facilities of the 19th century in different regions of Europe.

CONCLUSIONS

In the architecture of the places of detention of the empire of the first half of the 19th century, three consecutive periods can be distinguished: the period of wooden stockades, stone stockades or the first prison castles built according to the plans of Adrian Zakharov, and the period of neo-Gothic prison castles. The changes were based on a gradual departure from the traditional model of a wooden stockade,

ACKNOWLEDGEMENTS

The author expresses gratitude to the administration and employees of the Odesa State Archive for the opportunity to conduct archival and search work in the institution and help in its implementation.

CONFLICT OF INTEREST

None.

REFERENCES

[1] Architectural monuments destroyed by the Soviet authorities. (2018). Retrieved from https://www.skyscrapercity.com/threads/architectural-monuments-destroyed-by-the-soviet-authorities.2104981/page-2.

[2] Brodie, A. (2019). The Castle or the Green Field: Dilemmas and solutions in English prison planning, 1780-1850. *Prison Service Journal*, 246, 4-9.

[3] Chastina, A. (2020). The creativity of architects Francesco Boffo and Ippolit vander-Schkruf in Bessarabia for the first half of the 19th century. (On the 160th anniversary of the construction of the monument in the memory of the Battle of Cahul). *Arta*, 1, 30-36. doi: 10.5281/senodo.3938159.

[4] Etkind, O. (2013). *Internal colonization: Russia's imperial experience*. Cambridge: Polity Press.

[5] Evans, R. (1982). *The fabrication of virtue: English prison architecture, 1750-1840*. Cambridge, New York: Cambridge University Press.

[6] Flores, J.A. (2021). Controlling wickedness: The journey to penal reform and the first prison systems in New York and Pennsylvania from 1820-1840. *UReCA: The NCHC Undergraduate Journal of Research and Creative Activity*, 85, 79-100.

[7] Foucault, M. (2023). *Discipline and punish. The birth of the prison*. Kyiv: Komubook.

[8] Gubar, O. (2015). *The history of urban planning in Odesa and functions of the Odesa Construction Committee*. Odesa: TES.

[9] Imaginary prisons: Giovanni Battista Piranesi prints. (2015). Retrieved from https://artimage.princeton.edu/files/ProductionJpegs/piranesi.pdf.

[10] Korotkyi, O. (2022). Transformation of the prison experience in the Russian Empire in the first third of the 19th century on the example of the Kherson province. *Zaporizhzhia Historical Review*, 6(58), 84-96. doi: 10.26661/zhv-2022-6-58-08.

[11] Korotkyi, O. (2023). Odesa prison castle in the context of the development of the network of prison places in Ukrainian provinces in the first half of the 19th century. *Knowledge, Education, Law, Management*, 2(54), 54-59. doi: 10.51647/kelm.2023.2.8.

[12] Kravchenko, R. (2012a). Kharkiv prison castle – the first stone prison in the city. *Collection of Scientific Works of H.S. Skovoroda Kharkiv National Pedagogical University. Series: "History and Geography"*, 44, 163-167.

[13] Kravchenko, R. (2012b). The Kharkiv province comitee of the Prisons' guardianship society. *Gurzhiyev Historical Readings*, 5, 159-161.

[14] Kravchuk, P., & Karpenko, V. (2010). *From the history of detention centres in Zaporizhzhia Region*. Zaporizhzhia: Department of the State Department of Ukraine for the Execution of Sentences in Zaporizhzhia region.

[15] Kuzina, K. (2019). Prison in urban space of Vinnytsia (end of the 19th – beginning of the 20th century): Location and internal structure. *Bulletin of the Penitentiary Association of Ukraine*, 3(9), 59-80. doi: 10.34015/2523-4552.2019.3.05.

[16] Lazarenko, L. (2019). Looking for the "ideal" prison (from the idea to its implementation). *Bulletin of the Penitentiary Association of Ukraine*, 2(8), 125-133. doi: 10.34015/2523-4552.2019.2.12.

[17] Ministry of Justice plans to close up to a third of prisons and build new ones. (2019). Retrieved from https://www.radiosvoboda.org/a/news-maluska-pro-tiurmy/30211378.html.

[18] Moran, D., Houlbrook, M., & Jewkes, Y. (2022). The persistence of the Victorian prison: Alteration, inhabitation, obsolescence, and affirmative design. *Space and Culture*, 25(3), 364-378. doi: 10.1177/12063312211057036.

[19] Nadel, M.R., & Mears, D.P. (2018). Building with no end in sight: The theory and effects of prison architecture. *Corrections*, 5(3), 188-205. doi: 10.1080/23774657.2018.1461036.

[20] Name decree given to the Malorosian Governor-General Duke Kurakin No. 20465 "On the Rules of Keeping Well-Dwellers According to the Type of Offence". (1802, October). Retrieved from http://morris.law.yale.edu/record=b439947~S1.

[21] Odessa history. (n.d.). Albook of Carlo Bossoli's Odessis. Retrieved from https://odessahistory.net/ua/long-story/albom-s-vidami-odessy-karlo-bossoli.

[22] Odessa State Archive of the Odessa region. (1984). *Archival fund 1, Inventory No. 190, cases of the "Building of the stone prison in Kherson, 1826-1841"*. Odesa: Odessa State Archive of the Odessa Region.

[23] Odessa State Archive of the Odessa region. (2012). *Archival fund 361, Inventory No. 1 cases of the "Odessa Prison Trusteeship Committee for the years 1836-1900"*. Odesa: Odessa State Archive of the Odessa region.

[24] Pismak, Yu. (2018). The influence of english "New-Gothic style" upon Odesa's architecture in 19th-early 20th centuries. *Problems of Theory and History of Architecture in Ukraine*, 1(18), 120-128.

[25] Prison castle. (2018). Retrieved from https://myhome.kh.ua/photos/149-tyuremnyi-zamok.html.

[26] Rubin, A.T. (2021). *The deviant prison: Philadelphia's Eastern State Penitentiary and the origins of America's modern penal systems, 1829-1913*. Cambridge, New York: Cambridge University Press.

[27] Russian State Historical Archive. (2009). *Archive fund 1488, Inventory 4, case of the "Stone prison in the city of Kherson, 1808-1819"*. St. Petersburg: Russian State Historical Archive.

[28] Russian State Historical Archive. (n.d.). *Archive fund 877, Inventory 11, case of the "On the decree of the Governing Senate on the establishment of special departments at the prisons of Kherson province for the accommodation of criminals sentenced to imprisonment, 1848".* St. Petersburg: Russian State Historical Archive.
[29] Sapronov, A. (2018). Regimental prison in Hetmanate: Appearance and condition of buildingin the middle of the 18th century. *The City: History, Culture, Society*, 1(5), 31-45.
[30] Sukhoparov, S. (2002). *Streets of Kherson*. Kherson: Publishing House "SLAJ".
[31] The Approved Report of the Minister of Home Affairs No. 22963 "On the Construction of Prison Locks in All Provinces According to the Plans Approved by the Highest Authority for the Provinces of Malorossiya". (1808, April). Retrieved from http://morris.law.yale.edu/record=b439947%7ES1.
[32] The Approved Report of the Minister of Religious Affairs and Public Enlightenment No. 27895 "On the Establishment in Russia of a Prison Guardianship Society". (1819, July). Retrieved from http://morris.law.yale.edu/record=b439947%7ES1.
[33] Tsereniuk, O. (2002). The role of the committees of the Society of Prison Trustees in the development of the penitentiary system of the 19th century Upper Dnipro Ukraine. *Problems of the History of Ukraine in the 19th and Early 20th Centuries*, 5, 169-183.
[34] Yurash, Ye. (2021). *Odesa board of the Prisons's trustee institution: Organisation, structure, activity*. (PhD dissertation, Odesa I.I. Mechnikov National University, Odesa, Ukraine).

Олексій Короткий
Аспірант
Бердянський державний педагогічний університет
71100, вул. Шмідта, 4, м. Бердянськ, Україна
https://orcid.org/0000-0001-6267-3321

Композиційні та стилістичні особливості місць ув'язнення Північного Причорномор'я першої третини XIX ст.

Анотація. Вивчення історії розбудови тюремної інфраструктури актуалізується триваючою (2024 р.) в Україні пенітенціарною реформою. Планування та розбудова нової мережі пенітенціарних закладів, які будуть відповідати сучасним стандартам та цілям ув'язнення, вимагає звернути увагу на подібні процеси переосмислення тюремної архітектури, які відбувались в першій третині XIX ст. В зв'язку з цим, метою дослідження стало вивчення, на основі опублікованих та архівних матеріалів, трансформації структурно-просторової організації місць ув'язнення в період активного тюремного будівництва XIX ст. Це обумовило використання історичного, історико-порівняльного, композиційного, графоаналітичного аналізу, які застосовувались у контексті структурно-функціонального та соціологічного підходів до вивчення архітектури. Застосування вказаної методології допомогло встановити витоки та історичні передумови розбудови нових місць ув'язнення в досліджуваний період. На основі аналізу структурно-просторової побудови місць ув'язнення зроблено висновки про головні цілі, які переслідували архітектори та влада, реформуючи тюрми. Порівнюючи планування різних в'язниць, було досліджено регіональну специфіку різних тюремних замків Херсонської губернії. Дослідження композиції та структурно-функціональної організації тюремних замків дозволило простежити яким чином в імперії втілювались уявлення про дисциплінарний простір. На основі проведеного аналізу уточнено висновки про паліативний характер тюремної реформи в першій третині XIX ст. Аналіз втілення системи владних відносин в архітектурі місць ув'язнення дозволив стверджувати про збереження в тюремних замках певних дореформених елементів. Дослідження організації тюремного простору дозволило створити періодизацію розвитку архітектури. Зроблено висновок, що типові місця ув'язнення дореформеного періоду були покликані вирішити нагальні проблеми функціонування місць ув'язнення, а не послідовно реалізувати в архітектурі ті чи інші пенітенціарні ідеї. Тюремна реформа 1819 р. привнесла до тюремної архітектури неоготичну стилістику та складнішу композицію. Отримані результати дослідження можуть бути використані дослідниками інших архітектурних експериментів XIX ст. з організації дисциплінарних просторів та слугувати джерелознавчим матеріалом для просвітницьких та краєзнавчих організацій

Ключові слова: тюремний замок; острог; неоготика; неокласика; ізоляція; нагляд; дисципліна

Architectural Studies
International Journal about Architecture

Volume 10, No. 1

UDC 622.7:666.94.02
DOI: 10.56318/as/1.2024.125

Akymbek Abdykalykov
Doctor of Technical Sciences, Professor
Kyrgyz State Technical University named after I. Razzakov
720044, 66 Ch. Aitmatov Ave., Bishkek, Kyrgyz Republic
https://orcid.org/0009-0006-7260-8738

Taalaibek Bolotov*
PhD in Technical Sciences, Associate Professor
Kyrgyz State Technical University named after I. Razzakov
720044, 66 Ch. Aitmatov Ave., Bishkek, Kyrgyz Republic
https://orcid.org/0009-0009-9556-8945

Alaybek Kurbanbaev
PhD in Technical Sciences, Associate Professor
Kyrgyz State Technical University named after I. Razzakov
720044, 66 Ch. Aitmatov Ave., Bishkek, Kyrgyz Republic
https://orcid.org/0009-0007-5402-8999

Akbermet Matyeva
Doctor of Technical Sciences, Professor
International University of Innovative Technologies
720048, 1/17 Ankara Str., Bishkek, Kyrgyz Republic
https://orcid.org/0000-0001-9765-1149

Ryskulbek Zhumabaev
PhD in Technical Sciences, Associate Professor
Kyrgyz State Technical University named after I. Razzakov
720044, 66 Ch. Aitmatov Ave., Bishkek, Kyrgyz Republic
https://orcid.org/0009-0005-0713-0216

Optimisation of composition and strength properties of slag-alkali binders based on fuel slags

Abstract. The study addresses ways to improve the composition and strength of slag-alkali binders derived from fuel combustion products. For this purpose, X-ray diffraction analysis, spectroscopy, microscopy, compression strength tests, and data analysis were used to activate the ash from the power plant units, evaluate the activity of the compositions, heat and moisture treatment, and determine the optimal compositions. Alumina binders have advantages over Portland cement: they are highly durable, waterproof, frost-resistant and corrosion-resistant. These materials are used in the construction of special-purpose facilities, such as motorways, airfields, bridges, transport tunnels and hydraulic structures. As part of an experimental study, optimal ash binders based on fuel slag with the required properties were developed. Analysis of the chemical composition of fuel slags revealed a high content of silicon, aluminium, iron, calcium and magnesium oxides, which makes them suitable for use as binders. Experimental data has shown that the

Suggested Citation:
Abdykalykov, A., Bolotov, T., Kurbanbaev, A., Matyeva, A., & Zhumabaev, R. (2024). Optimisation of composition and strength properties of slag-alkali binders based on fuel slags. *Architectural Studies*, 10(1), 125-135. doi: 10.56318/as/1.2024.125.

Journal homepage: https://arch-studies.com.ua/en
Architectural Studies, 10(1), 125-135
Received: 28.01.2024 Revised: 14.04.2024 Accepted: 20.06.2024

*Corresponding author

introduction of additives such as gypsum significantly improves the mechanical properties and durability of materials. The developed technological processes of mixing, moulding and curing ensure stable product quality. Tests of the samples demonstrated high compressive, tensile and flexural strengths, confirming their suitability for construction applications. The environmental assessment showed that the use of fuel slag reduces the carbon footprint and reduces the negative impact on the environment. As a result, a scalable production process has been developed that can be implemented in industry to create environmentally sustainable and highly efficient building materials. This study presents new data on the development of environmentally sustainable building materials based on fuel slag, which can reduce environmental impact and improve the sustainability of infrastructure

Keywords: man-made raw materials; fly ash; additive; composite building materials; chemical composition

INTRODUCTION

With sustainability and environmental safety becoming a priority for various industries, construction is facing the need to switch to more environmentally friendly materials. The use of slag-alkaline binders based on fuel slag is a promising area of construction materials. Fuel slag, a by-product of the combustion of coal and other fuels, has significant potential for use in construction due to its chemical composition. This composition is dominated by oxides of elements such as silicon, aluminium, iron, calcium and magnesium, which makes them attractive for use as binders. This chemical composition provides slags not only with the ability to effectively fix and bind other components in materials but also with additional useful properties such as increased strength and resistance to various influences, which makes them particularly valuable for creating modern and efficient building structures. The drive for sustainable development requires the efficient use of industrial waste, such as fuel slag, which otherwise can accumulate and pollute the environment. Existing building materials, such as Portland cement, are associated with high CO_2 emissions, which exacerbates the problem of global climate change. Slag-alkali binders based on fuel slag offer an environmentally friendly alternative, reducing the carbon footprint and improving the environment. Finally, such materials may have improved mechanical properties and durability, making them attractive to the construction industry. Thus, optimising their composition and strength characteristics not only contributes to solving environmental problems but also meets the growing demand for efficient and reliable materials in construction.

The problem of the lack of environmentally sustainable and efficient building materials capable of replacing traditional ones with high CO_2 emissions and insufficient durability has already attracted the attention of several authors. For example, M. Deepak *et al*. (2023) analysed the mechanical properties and microstructure of fuel slag-based concretes, revealing a significant improvement in the strength and durability of these materials. J. Chen *et al*. (2022) studied the chemical composition of fuel slags of various origins and their influence on the properties of the resulting binders. G.V.P.B. Singh & V.D. Prasad (2024) reviewed the environmental aspects of using fuel slags in construction, emphasising their potential to reduce the carbon footprint of the industry. The study by B. Isakulov *et al*. (2023) addressed the technological aspects of slag-alkali binder production, including mixing and curing methods. Ya. Wang *et al*. (2021) compared various slag additives to improve their strength characteristics. I. Amer *et al*. (2021) focused on the development of new methods for the environmental assessment of the production and use of slag binders. L. Holappa *et al*. (2021) investigated the prospects of using slag from various sources, including not only coal-fired power plants but also other industries. The research conducted by V. Athira *et al*. (2021) confirmed the superiority of slag-alkali binders over traditional building materials in terms of environmental safety and durability. N. Hui-Teng *et al*. (2021) employed new methods for analysing the structure and phase composition of slag materials to optimise their characteristics. J. Schupsky *et al*. (2021) identified the potential of fuel slag to create innovative composite materials with improved technical and environmental properties.

However, there are gaps in mentioned research on optimising the composition and production processes of slag-alkali binders, as well as assessing their durability and strength characteristics in real-world conditions. Further study of the effect of additives on the properties of fuel slag binders is also needed. Thus, this study aimed to address the potential and possibility of producing gold-alkali binders based on low-calcium acid ash produced at the Bishkek Thermal Power Plant (TPP). Research goals:

1. To study the influence of high-base additives and alkaline components on the activation of low-lime ash from thermal power plant units and the formation of a strong structure of gold-alkaline binders and composite materials.

2. Determine how the use of curing activators such as Na_2O $2SiO_2$ and NaOH affects the activity and strength of gold-alkali compositions compared to traditional lime binders.

3. To determining the optimal compositions of low-lime gold-alkali binders and composite building materials based on them, taking into account the influence of heat and humidity treatment on the strength of gold-alkali binders with Portland cement clinker.

MATERIALS AND METHODS

To begin the experiment, samples of low-calcium acid ash obtained from a unit at the Bishkek Thermal Power Plant were carefully prepared. This stage included several

procedures aimed at ensuring standardised and homogeneous sample characteristics for subsequent studies. The ash samples were subjected to purification and pre-treatment processes to eliminate possible distortions of the results due to the presence of impurities or irregular material structure. Thus, the preparation of ash samples was an important step in ensuring the reliability and accuracy of the results of the entire study. During the study of activation of low-lime ash from combined heat and power (CHP) units, samples were prepared and successively exposed to high alkalinity additives such as $Na_2O \cdot 2SiO_2$ and NaOH applied at certain concentrations. Further, the effect of these additives on the structure of ash and their chemical reaction with other components was studied. This included the use of various analytical techniques such as X-ray diffraction, spectroscopy and microscopy. The data obtained was used to assess changes in the structure of ash and to identify the formation of new phases. Further analysis was used to determine the optimal activation conditions to ensure the formation of a strong structure and the required properties of binders based on these ashes.

After the activation process of the CHP ash, compressive strength tests were carried out to assess the activity of the resulting ash-alkali compositions. For this purpose, compositions with different curing activators and concentrations of alkaline components were tested and the results were then compared with the strength of compositions containing traditional binders such as lime. After obtaining the test results, the data were analysed to identify the optimal combinations of activators and concentrations that provide the best strength and other required properties of the compositions. After obtaining the gold-alkali compositions, heat and humidity treatment was carried out to increase their strength. The samples were exposed to heat and moisture under controlled conditions, which contributed to deep hydration of the ash component and strengthening of the structure of the compositions. After the treatment was completed, the strength of the samples was compared with the strength of compositions that had not been subjected to heat and humidity treatment to determine the effectiveness of this method in improving material properties. To achieve the fineness of ash grinding, a grinding process was used in a ball mill of the KSV 008 brand (manufactured in Ukraine) for 30 minutes at a data rate of 1,000 rpm. The purpose of the extraction was to pass the ash through the KSV 008 sieve.

Based on the results of the study, the optimal compositions of low-lime ash-alkali binders and composite construction materials were identified. For this purpose, various formulations were tested for strength and other properties. The analysis of the results was used to select the most promising options for further use in construction and other industries, such as engineering structures, road construction and hydraulic structures. Compressive strength tests were carried out by subjecting the resulting gold-alkali compositions to compressive force using standard test methods. For this purpose, the samples of the compositions were placed in special testing devices, where they were pressurised along their axis. Then the force required to break the sample was measured, which was used to assess its strength characteristics. This test method is standard and widely used to assess the strength of various materials in construction and engineering practice (Turan *et al.*, 2022). The results obtained were used to determine the mechanical properties of the ash-alkali compositions and to assess their suitability for use in specific construction applications.

RESULTS

Fuel slags generated as a by-product of coal combustion at thermal power plants are complex multi-component systems. Determining the content and distribution of key components, such as SiO_2, Al_2O_3, Fe_2O_3, CaO, MgO and others, were used to understand their potential impact on the properties of binders and optimise their composition to achieve the required characteristics. The analysis of fuel slag composition begins with sampling and preparation of samples for laboratory testing (Lu *et al.*, 2023). Samples are taken considering the heterogeneity of slags and the different conditions of their formation. Chemical analysis is then carried out, including quantification of the main oxides. The composition of slag can vary widely depending on the type of coal, combustion conditions and ash removal technology, so it is important to obtain a representative sample for accurate analysis.

The main component of fuel slags is silicon dioxide (SiO_2), which makes up a significant part of their mass (Thomas *et al.*, 2021). The high content of SiO_2 gives slag acidic properties and affects its activation when interacting with alkalis. Aluminium oxide (Al_2O_3) and iron oxide (Fe_2O_3) are also present in significant quantities and play an important role in shaping the structure of the binder. They can form complex compounds with other components, improving the mechanical properties and resistance of the material to external influences. Calcium (CaO) and magnesium (MgO) are usually present in smaller quantities, but their role in the hydration and curing processes is no less important. Calcium helps to accelerate hydration reactions and form a strong structure, while magnesium can improve the material's resistance to chemical attack. The optimum ratio of these components is essential to achieve the required binder characteristics.

The distribution of the components in the slag is also important. The heterogeneity of slag, which is expressed in the uneven distribution of oxides over the volume, can lead to heterogeneity in the properties of the resulting binder. Therefore, an important step in the analysis is to determine the microstructure of the slag using electron microscopy and X-ray diffraction. These methods were used to identify the phase composition of slag and the distribution of components at the microscopic level. The data obtained serve as the basis for the development of binder formulations. Knowing the content and distribution of the main components were used to optimise the composition of slag binders by adding the necessary components to improve their

properties. For instance, if there is a lack of calcium in the slag, an additional source of CaO can be added to ensure the required hydration and solidification rate. The study of chemical reactions between fuel slag components and additives was used to determine the optimal proportions of components and their mixing conditions, which directly affect the final properties of the material, such as strength, resistance to external influences and durability. The selection of suitable additives can significantly improve the properties of binders. Additives can include alkaline components such as sodium hydroxide (NaOH), liquid glass ($Na_2O \cdot SiO_2$), and various mineral and chemical substances that can interact with the slag components. The choice of additives is based on their chemical composition and ability to react with the main components of slag, such as SiO_2, Al_2O_3, Fe_2O_3, CaO and MgO.

One of the key aspects of the research is the study of the hydration process, which plays a central role in the formation of the structure of the binder. During the hydration process, slag reacts chemically with water and additives to form new compounds that bind the material particles together, ensuring its strength and stability. For example, when sodium hydroxide (NaOH) is added to slags containing silica (SiO_2), a reaction occurs that results in the formation of sodium silicates, which contribute to the formation of a strong material structure (Abdul *et al.*, 2024). Heat and moisture treatment can significantly accelerate the hydration and curing processes, which is especially important when creating high-strength binders. The interaction of slag with various mineral additives, such as gypsum, lime, cement clinker and others, can significantly improve the properties of binders, such as strength, water and chemical resistance. For instance, the addition of gypsum promotes the formation of sulphoaluminate phases, which improve the strength characteristics of the material.

Based on the research results, optimal binder formulations can be developed. This includes adjusting the ratio of the main components of slag and additives, as well as the conditions for mixing and processing. Optimisation of these parameters makes it possible to create binders with specified properties that meet the requirements of building codes and standards. The industry is striving to reduce its negative environmental impact, which requires a comprehensive assessment of environmental aspects at all stages of production and use of materials (Cheng *et al.*, 2021). This is particularly important in the case of binders, such as slag binders, as the process of creating and using them can have a significant impact on ecosystems. In the case of slag-alkali binders, the main component is fuel slag, which is a by-product of coal combustion at thermal power plants. The use of slag as a raw material for binders helps to solve the problem of its disposal and reduce the amount of waste sent to landfills. Thus, reusing slag reduces the burden on the environment and improves the ecological situation.

The technological process, which includes slag grinding, the addition of chemical components and heat and humidity treatment, can be accompanied by emissions of dust, gases and other pollutants (Onaizi *et al.*, 2024). To minimise these emissions, it is necessary to use efficient cleaning and filtration systems and improve technological processes to reduce their negative impact on the environment. One of the key aspects is energy consumption in the production of binders. Energy-intensive technologies can adversely affect the environment through the emission of greenhouse gases and other pollutants (Zhumadilova *et al.*, 2023). Process optimisation and the use of renewable energy sources can significantly reduce the environmental footprint of production. For example, using solar or wind energy to power production processes can significantly reduce carbon dioxide emissions. Another important aspect is the environmental safety of the finished product. Binding materials must be safe for use and not emit harmful substances during operation. This requires thorough testing and analysis to ensure that there are no toxic components or decomposition products. The guarantee of environmental safety of the finished product contributes to its widespread use in the construction industry, reducing the risk of negative impact on human health and the environment. Recycling and disposal of waste generated during the production of binders are also important aspects of environmental assessment (Manjunatha *et al.*, 2021). Slag residues and other wastes must be recycled or disposed of in a manner that minimises their impact on the environment. This may include using waste as a secondary raw material for other industrial processes or developing safe disposal technologies.

Slag-alkaline binders are often formulated with high-calcium fly ash. These ashes, due to their high calcium oxide content, have properties that simplify the activation process and contribute to the formation of a strong structure of binders. The interaction of high-calcium ash with alkaline components is active and thus improves the strength characteristics of the resulting materials. The ash produced at the Bishkek TPP has acidic characteristics and is free of calcium oxide. For each type of binder, the optimum grinding ratio was determined, which was selected to ensure the required quality level with minimal energy consumption. The properties of slag-alkali binders depend not only on the basic composition of the slag but also on the choice of the alkaline component, which also has a significant impact on the characteristics of the binder (Bereziuk *et al.*, 2023).

The chemical composition of the ash produced at the Bishkek Thermal Power Plant is characterised by a silicon oxide content ranging from 0.04 to 0.07 wt%, aluminium oxide content from 0.3 to 0.4 wt% and calcium oxide content from 0.4 to 0.5 wt%, which indicates its low activity. To achieve the required fineness of grinding, the ash was subjected to a grinding process to pass through the KSV 008 sieve in a volume of 9 to 10%. Subsequently, aqueous solutions of caustic soda, soda and liquid glass were used as alkaline components to form gold-alkali binders. To improve the activity of the ash, lime was added to the composition in various proportions: 0.5%, 1% and 1.5%. The strength

characteristics of the obtained binders were determined after heat and humidity treatment (HCT), as shown in Figure 1, as well as after normal curing for 7, 14 and 28 days, shown in Figures 2-4, respectively.

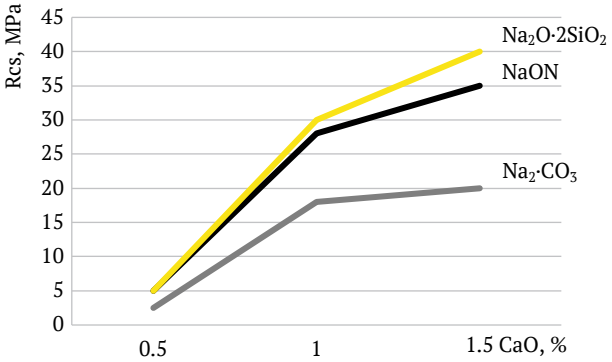


Figure 1. Dependence of compressive strength Rcs on CaO content %, after HCT after 1 day
Source: compiled by the authors

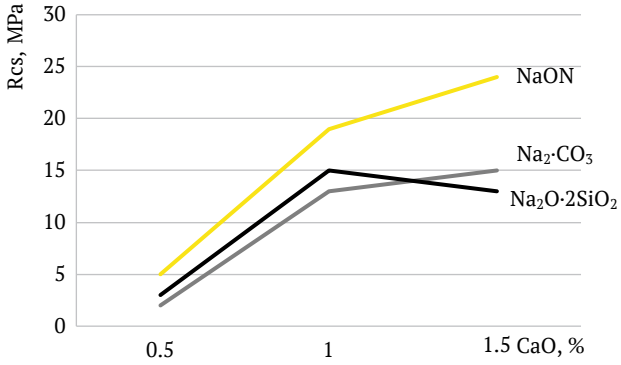


Figure 2. Dependence of compressive strength, Rcs on CaO content %, after 7 days of normal curing
Source: compiled by the authors

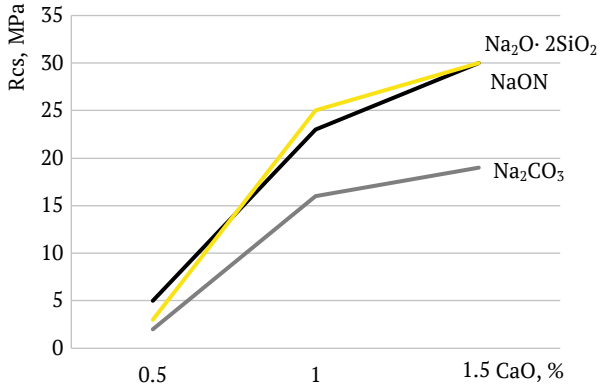


Figure 3. Dependence of compressive strength, Rcs on CaO content %, after 14 days of normal curing
Source: compiled by the authors

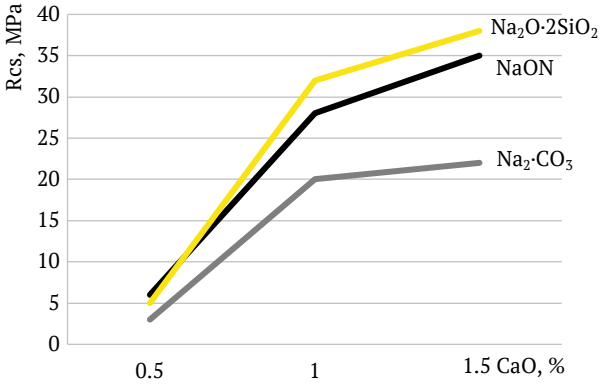


Figure 4. Dependence of compressive strength, Rcs on CaO content %, after 28 days of normal curing
Source: compiled by the authors

From the data presented, it is possible to conclude that $Na_2O \cdot 2SiO_2$ is the most effective of the alkaline components, as its use contributes to the formation of binders with high strength characteristics, which are estimated in the range from 31.9 to 37.8 MPa. Moreover, the activity of these binders during heat and humidity treatment slightly exceeds the strength values during normal curing, especially at the mature stage at the age of 28 days, reaching 39.6 MPa. Binders containing NaOH have sufficient activity, which is reflected in the strength of 34.4 MPa. An important condition for the synthesis of ash binders based on low-lime ash is the presence of CaO in the binder since composite mixtures without calcium are not capable of hardening. Lime was added in the range of 0.5 to 1.5% of the total ash weight in the preparation of composite mixtures in the study. The samples containing 1.5% lime stood out as having the highest strength compared to other variants of the compositions.

The introduction of sodium hydroxide provides a sufficient amount of Na+ ions for ion exchange of the $2Na+ \leftrightarrow Ca_2+$ type, which leads to the disruption of some bonds in the glassy phase of the -Si-O-Si- ash and the formation of shells of silicic acid gel and sodium silicate on the surface of its particles. A gel-like shell formed on the ash particles adsorbs calcium ions from the solution, gradually turning them into low-base calcium hydrosilicates such as CSH. In the process, sodium hydroxide is released in the solution. The released sodium hydroxide reacts again with the surface of the ash particles, which leads to the destruction of their structure. Excess sodium oxide in the cured mass is carbonised. Thus, the entire process of hydration and curing of the binder involves the presence of sodium ions in the curing mass. The addition of Portland cement clinker has the strongest activating effect on ash (Turkoglu *et al.*, 2023). This means that Portland cement clinker promotes a more efficient reaction of fly ash and other components, improving the properties of the binder. Therefore, it was decided to add different concentrations of Portland cement clinker (1, 2, 3, 4, 5%) to the binders. Experimental studies were carried out on mixtures with sodium hydroxide (NaOH) and $Na_2O \cdot SiO_2$ liquid glass. These components are also important for shaping the structure of

the binder and optimising its properties. The results of the study, including the effect of different concentrations of Portland cement clinker on the characteristics of binders, are shown in Figures 5-8. This data determines the optimal concentration of Portland cement clinker to achieve the desired binder properties.

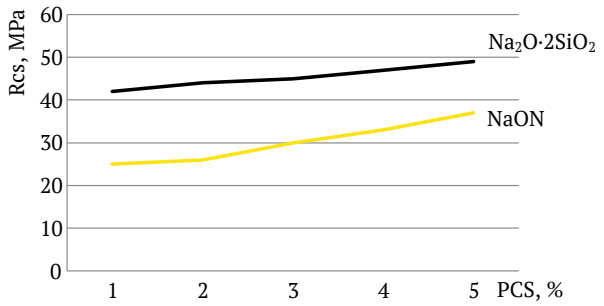


Figure 5. Dependence of compressive strength Rcs on PCS content %, after HCT after 1 day
Source: compiled by the authors

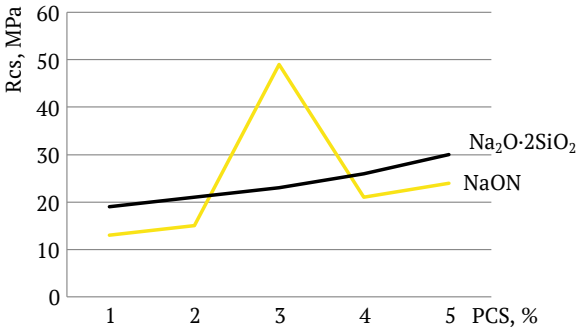


Figure 6. Dependence of compressive strength Rcs on PSC content %, after 7 days of normal curing
Source: compiled by the authors

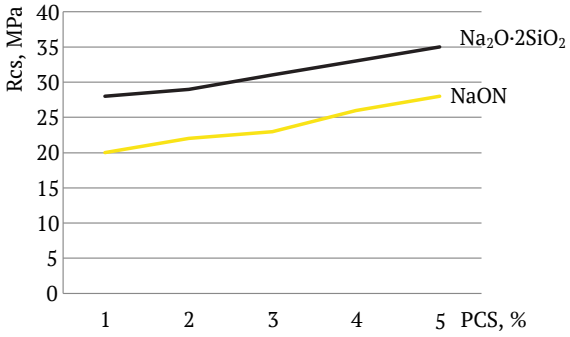


Figure 7. Dependence of compressive strength Rcs on PSC content %, after 14 days of normal curing
Source: compiled by the authors

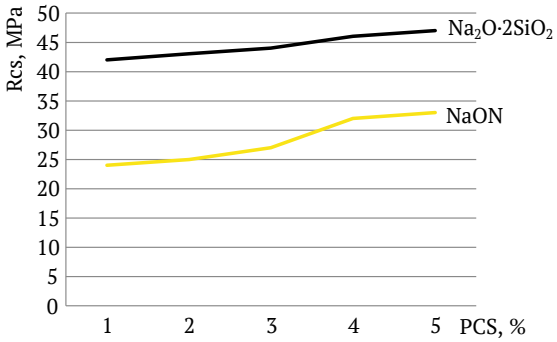


Figure 8. Dependence of compressive strength Rcs on PSC content %, after 28 days of normal curing
Source: compiled by the authors

When Portland cement clinker is added to alkaline binders, an increase in their activity is observed compared to the activation of fly ash with lime (Vázquez-Rodríguez *et al.*, 2023). The hydration process of low-lime ash produces hydrates of aluminium, iron and silicon oxides, which are then applied to the surface of the grains. At the initial stage of interaction between ash and clinker minerals, a film of $Ca(OH)_2$ crystals crystallised from aqueous solution forms on the surface of the ash particles. There is a layer of water between the film that forms and the surface of the ash particles, which remains for a long time. This layer is gradually filled with Ca_2+ reaction products that penetrate through the water layer and soluble components of the vitreous phase of the ash. First, calcium hydrosulphates are formed, followed by hydroaluminates and then calcium hydrosilicates.

The presence of alkaline components in the binder material facilitates the above-mentioned processes of ion exchange between Na+ and Ca_2+ and the strengthening of newly formed structures. The use of fly ash also accelerates the hydration of clinker minerals, in particular C_3S, and over time, the content of low-base calcium hydrosilicates such as CSH(B) increases in the composition of fly ash cement stone, which has a positive effect on the strength of the cement material. During heat and humidity treatment, the processes of structure formation and strength acquisition are faster than under conventional curing conditions. This leads to a deeper hydration of the ash components, which is determined by the higher strength of the samples after heat and moisture treatment compared to samples that are cured under normal conditions. The increase in activity is manifested by an increase in the content of PSC in the ligament. The samples with 5% PCC content have the highest strength - 32.4 MPa from NaOH and 46.8 MPa from $Na_2O{\cdot}2SiO_2$. However, it is not advisable to further increase the amount of PCC in the composition of gold-alkali knitted materials, as this affects production costs.

DISCUSSION

Optimisation of the composition and strength properties of slag-alkaline binders based on fuel slag is an important task facing the industry and the scientific community. This process involves studying and analysing the composition of fuel slag, determining the optimal proportions of binder components, and studying the impact of various additives and modifications on its strength properties. This aspect was also addressed by P. Krivenko *et al.* (2023), and they

concluded that optimising the composition of slag-alkali binders based on fuel slag is an important task for industry and science. It includes studying the composition of fuel slag, determining the optimal proportions of binder components and investigating the effect of additives on its properties. Successfully solving this problem can lead to the creation of new efficient and environmentally sustainable building materials. Furthermore, a study conducted by J. Huang *et al*. (2021) noted that the analysis of the effect of additives on the strength characteristics of slag binders is relevant for the development of materials with improved properties. Additives can improve strength and stimulate chemical reactions by promoting the formation of additional bonds in the material structure (Kombayev *et al*., 2022). However, potential negative effects, such as reduced machinability or increased porosity, must be considered. A thorough study of the effect of additives helps to optimise the material composition to achieve the desired characteristics. This is in line with the results of this study, which confirms that the optimal choice of additives can significantly improve the strength properties of slag binders. The results of the study also reveal the complex effect of additives on the structure and properties of the binder, which is key to its further improvement.

A necessary step in optimising the composition of slag-alkali binders is a detailed study of the composition of fuel slag, which is the main raw material to produce such materials. This includes analysing the content of key components such as SiO_2, Al_2O_3, Fe_2O_3, CaO, MgO and others, as well as their distribution. Studying the composition of slag allows us to determine its potential for use as a binder and select the best methods of processing and modifying it. The mentioned was also investigated by Yi. Gao *et al*. (2022), where the results showed that the study of fuel slag composition is key to optimising the production of slag binders. The analysis of the chemical composition and physical properties of slag assessed its potential as a binder and determined the best methods of processing and modifying it. X. Dai *et al*. (2022) also investigated that the analysis of fuel slag components plays a key role in the development of the optimal composition of slag binders. This analysis allows us to determine the content of key chemical components such as SiO_2, Al_2O_3, Fe_2O_3, CaO, MgO and others, as well as their distribution in the material. The study of these parameters helps to identify the potential of fuel slag for use as a binder and develop optimal methods of its processing and modification, which helps to improve the strength and other properties of slag-alkali binders. It is worth noting that the analysis of fuel slag components is an important stage in the development of slag-alkali binders. With a complete understanding of the slag composition, researchers can determine the optimal proportions and mixing conditions for the various components to achieve the desired binder properties. In addition, component analysis can identify potential obstacles or limitations that may arise when using slag as a binder. This approach contributes to the more efficient use of fuel slag as a valuable resource and the creation of higher quality and more sustainable building materials.

The study of chemical reactions between slag components and possible additives determines the optimal proportions and mixing conditions for obtaining a binder with the required strength properties. For example, the addition of gypsum can improve the strength and water resistance of the binder. Research in this area may also include the influence of various process parameters, such as temperature and processing time, on the characteristics of the binder. This aspect has attracted the attention of many scientists, including W. Guo *et al*. (2021), who emphasise that optimising slag-based binders requires studying the chemical reactions between slag components and possible additives. This determines the optimum mixing ratios and conditions to obtain a material with the desired properties. Additives such as gypsum can improve the strength and water resistance of the material. E. Khobotova & I. Kaliuzhna (2023) concluded that the study of the influence of chemical reactions on the properties of slag-alkali binders is also substantial in their optimisation. Chemical reactions between slag components and additives lead to the formation of new compounds that can significantly affect the properties of the binder. For instance, during the slag hydration process, hydrates of calcium, aluminium and other elements can be formed, which determine the strength, water resistance and other characteristics of the binder. The study of these chemical reactions makes it possible to optimise the composition of the binder and develop new production methods to improve its efficiency and environmental sustainability. These results confirm the above study, as they demonstrate which specific chemical processes and reactions lead to the improvement or change of the properties of slag binders. This is necessary for describing the mechanisms of interaction between material components and their influence on its characteristics. Determining the optimal proportions of the main components for creating a binder may involve adjusting the content of CaO, SiO_2, Al_2O_3 and other components depending on the required properties of the final product. For example, increasing the CaO content can improve the strength of a material, while increasing the SiO_2 content can increase its resistance to water (Yakovkin *et al*., 1998). CaO has an impact on strength, SiO_2 on water resistance and Al_2O_3 on stability. This creates the possibility of customising the material properties to meet specific needs.

Analysing the environmental impact of the production and use of binders selected the most environmentally sustainable options and developed strategies for their implementation. For instance, the use of fuel slag as a raw material for binders can reduce waste and reduce the environmental impact. N. Cristelo *et al*. (2021) determined that the environmental assessment of the production of slag-alkaline binders plays an important role in the modern construction materials industry. The use of fuel slag as the main raw material for binders reduces waste. The choice of environmentally sustainable production technologies and

innovations in materials reduce the negative impact on the environment. This assessment selected the most environmentally sustainable options that meet modern sustainability requirements. It is worth noting the study by B. Gao *et al*. (2021), also showed that the use of fuel slag in the production of binders has significant environmental significance. It reduces waste and minimises the consumption of natural resources, as slag is a by-product of energy production. However, their chemical composition and potential environmental risks, such as heavy metal content, must be addressed. However, the proper use of slag can reduce the negative impact on the environment and contribute to the transition to more sustainable production methods.

Comparing the data obtained in the study, it is possible to conclude that the use of fuel slag as a raw material for binders has its advantages and disadvantages. Positive aspects include reduced waste and lower consumption of natural resources, which contribute to the environmental sustainability of production. However, it is also necessary to address the negative aspects, such as the possible content of harmful substances and heavy metals in slag, which can lead to soil and water pollution if not handled properly. Therefore, it is necessary to take measures to control the quality of slag and develop technologies for its processing to minimise its negative impact on the environment. In general, optimising the composition and strength properties of fuel slag-based cementitious binders is a multi-stage process that requires joint efforts of industry, academia and environmental organisations. This creates materials that not only have the required technical characteristics but also reduce the negative impact on the environment.

CONCLUSIONS

The study considered the following aspects: the composition of fuel slag, which allowed to determine its potential for use as a binder; the content of the main components of slag, such as SiO_2, Al_2O_3, Fe_2O_3, CaO, MgO and others, which allowed to understand their impact on the properties of the binder; chemical reactions between slag components and additives, which allowed to determine the optimal proportions and mixing conditions to obtain a material with the desired properties; -adjustment of the content of CaO, SiO_2, Al_2O_3 and other components depending on the requirements for strength, water resistance and other characteristics, which allowed to highlight its key role in the process of optimising the composition of binders.

The study found that the addition of an alkaline component to low-lime ash produced at thermal power plants activates them and promotes the formation of a strong structure, which allows the production of gold-alkali binders and composite materials based on them. The use of Portland cement clinker in combination with alkaline components, such as Na_2O-$2SiO_2$ and NaOH, as curing activators, increases the activity of gold-alkali compositions, exceeding the compressive strength of gold-alkali binders with the addition of lime by 10-15%. Heat treatment of gold-alkali binders containing Portland cement clinker increases the compressive strength by 12-15% compared to conventionally cured compositions. This is determined by the deeper hydration of the ash component. Optimal compositions of binding materials based on low-lime ash and composite building materials made from them were identified. An additional area of research could be the study of the long-term impact of various operating conditions on the strength and environmental properties of slag-alkali binders to better assess their potential in construction and environmental impact.

ACKNOWLEDGEMENTS

None.

CONFLICT OF INTEREST

None.

REFERENCES

[1] Abdul, F., Adachi, K., Ho, H.-J., Iizuka, A., & Shibata, E. (2024). Magnesium recovery from ferronickel slag by reaction with sodium hydroxide. *Journal of Environmental Chemical Engineering*, 12(3), article number 112516. doi: 10.1016/j.jece.2024.112516.

[2] Amer, I., Kohail, M., El-Feky, M.S., Rashad, A., & Khalaf, M.A. (2021). A review on alkali-activated slag concrete. *Ain Shams Engineering Journal*, 12(2), 1475-1499. doi: 10.1016/j.asej.2020.12.003.

[3] Athira, V., Charitha, V., Athira, G., & Bahurudeen, A. (2021). Agro-waste ash based alkali-activated binder: Cleaner production of zero cement concrete for construction. *Journal of Cleaner Production*, 286, article number 125429. doi: 10.1016/j.jclepro.2020.125429.

[4] Bereziuk, O., Lemeshev, M., & Stadniichuk, M. (2023). Prevalence of ash processing in the manufacture of building materials. *Modern Technology, Materials and Design in Construction*, 35(2), 56-61. doi: 10.31649/2311-1429-2023-2-56-61.

[5] Chen, J., Xing, Y., Wang, Y., Zhang, W., Guo, Z., & Su, W. (2022). Application of iron and steel slags in mitigating greenhouse gas emissions: A review. *Science of the Total Environment*, 844, article number 157041. doi: 10.1016/j.scitotenv.2022.157041.

[6] Cheng, Y., Awan, U., Ahmad, Sh., & Tan, Zh. (2021). How do technological innovation and fiscal decentralization affect the environment? A story of the fourth industrial revolution and sustainable growth. *Technological Forecasting and Social Change*, 162, article number 120398. doi: 10.1016/j.techfore.2020.120398.

[7] Cristelo, N., Castro, F., Miranda, T., Abdollahnejad, Z., & Fernández-Jiménez, A. (2021). Iron and aluminium production wastes as exclusive components of alkali activated binders – towards a sustainable alternative. *Sustainability*, 13(17), article number 9938. doi: 10.3390/su13179938.

[8] Dai, X., Ren, L., Gu, X., Yilmaz, E., Fang, K., & Jiang, H. (2022). Strength analysis and optimization of alkali activated slag backfills through response surface methodology. *Frontiers in Materials*, 9, article number 844608. doi: 10.3389/fmats.2022.844608.

[9] Deepak, M., Reddy, Y.R., & Nagendra, R. (2023). Investigating the mechanical strength, durability and micro-structural properties of slag-based concrete. *Innovative Infrastructure Solutions*, 8, article number 272. doi: 10.1007/s41062-023-01234-2.

[10] Gao, B., Yang, Ch., Zou, Yi., Wang, F., Zhou, X., Barbieri, D.M., & Wu, Sh. (2021). Compaction procedures and associated environmental impacts analysis for application of steel slag in road base layer. *Sustainability*, 13(8), article number 4396. doi: 10.3390/su13084396.

[11] Gao, Yi., Zhao, W., Zhou, A.-N., Han, R., Li, Zh., Zhang, N.-N., Wang, J.-Z., & Ma, Ch. (2022). Study on the composition and structure characteristics and dry decarbonization separation of coal water slurry gasification fine slag. *Journal of Fuel Chemistry and Technology*, 50(8), 954-965. doi: 10.1016/S1872-5813(22)60007-0.

[12] Guo, W., Wang, Sh., Xu, Z., Zhang, Zh., Zhang, Ch., Bai, Ya., & Zhao, Q. (2021). Mechanical performance and microstructure improvement of soda residue-carbide slag-ground granulated blast furnace slag binder by optimizing its preparation process and curing method. *Construction and Building Materials*, 302, article number 124403. doi: 10.1016/j.conbuildmat.2021.124403.

[13] Holappa, L., Kekkonen, M., Jokilaakso, A., & Koskinen, J. (2021). A review of circular economy prospects for stainless steelmaking slags. *Journal of Sustainable Metallurgy*, 7, 806-817. doi: 10.1007/s40831-021-00392-w.

[14] Huang, J., Zou, Ch., Sun, D., Yang, B., & Yan, J. (2021). Effect of recycled fine aggregates on alkali-activated slag concrete properties. *Structures*, 30, 89-99. doi: 10.1016/j.istruc.2020.12.064.

[15] Hui-Teng, N., Cheng-Yong, H., Yun-Ming, L., Al Bakri Abdullah, M.M., Hun, K.E., Razi, H.M., & Yong-Sing, N. (2021). Formulation, mechanical properties and phase analysis of fly ash geopolymer with ladle furnace slag replacement. *Journal of Materials Research and Technology*, 12, 1212-1226. doi: 10.1016/j.jmrt.2021.03.065.

[16] Isakulov, B., Abdullaev, H., Mukasheva, A., Akishev, U., & Ordabayeva, G. (2023). Investigation of the formation of microstructure and strength characteristics of slag-alkaline arbolite. *EUREKA: Physics and Engineering*, 2, 209-221. doi: 10.21303/2461-4262.2023.002814.

[17] Khobotova, E., & Kaliuzhna, I. (2023). Waste blast-furnace slag as a resource for the production of slag-alkaline binders. *Journal of Chemistry and Technologies*, 31(3), 563-571. doi: 10.15421/jchemtech.v31i3.279211.

[18] Kombayev, K., Muzdybayev, M., Muzdybayeva, A., Myrzabekova, D., Wieleba, W., & Leśniewski, T. (2022). Functional surface layer strengthening and wear resistance increasing of a low carbon steel by electrolytic-plasma processing. *Strojniški Vestnik – Journal of Mechanical Engineering*, 68(9), 542-551. doi: 10.5545/sv-jme.2022.147.

[19] Krivenko, P., Helevera, O., Rudenko, I., & Rohozina, N. (2023). Structure formation and optimization of compositions of decorative alkali-activated slag cements. *AIP Conference Proceedings*, 2684(1), article number 040012. doi: 10.1063/5.0120046.

[20] Lu, H., Bai, J., Kong, L., Li, H., Bai, Z., & Li, W. (2023). The crystallization kinetics analysis and the new prediction index of melilite-bearing slag under solid fuel gasification condition. *Chemical Engineering Journal*, 477, article number 147089. doi: 10.1016/j.cej.2023.147089.

[21] Manjunatha, M., Preethi, S., Malingaraya, Mounika, H.G., Niveditha, K.N., & Ravi. (2021). Life cycle assessment (LCA) of concrete prepared with sustainable cement-based materials. *Materials Today: Proceedings*, 47(13), 3637-3644. doi: 10.1016/j.matpr.2021.01.248.

[22] Onaizi, A.M., Tang, W., & Liu, Ya. (2024). Co-grinding treatment for developing integrated-properties SCMs from basic oxygen furnace slag and furnace bottom ash: A step toward synthesis advanced SCMs. *Case Studies in Construction Materials*, 20, article number e03163. doi: 10.1016/j.cscm.2024.e03163.

[23] Schupsky, J.P., Netter, T., Wu, G., Spliethoff, H., & Müller, M. (2021). Crystal morphology data for viscosity modelling of fuel slags – supplementation of spinel phase and validation by crystallisation in entrained flow gasifiers. *Fuel*, 303, article number 121114. doi: 10.1016/j.fuel.2021.121114.

[24] Singh, G.V.P.B., & Prasad, V.D. (2024). Environmental impact of concrete containing high volume fly ash and ground granulated blast furnace slag. *Journal of Cleaner Production*, 448, article number 141729. doi: 10.1016/j.jclepro.2024.141729.

[25] Thomas, S., Huang, L., & Barati, M. (2021). A review of slag refining of crude silicon. *JOM*, 73, 260-281. doi: 10.1007/s11837-020-04470-4.

[26] Turan, C., Javadi, A.A., Vinai, R., & Russo, G. (2022). Effects of fly ash inclusion and alkali activation on physical, mechanical, and chemical properties of clay. *Materials*, 15(13), article number 4628. doi: 10.3390/ma15134628.

[27] Turkoglu, M., Bayraktar, O.Y., Benli, A., & Kaplan, G. (2023). Effect of cement clinker type, curing regime and activator dosage on the performance of one-part alkali-activated hybrid slag/clinker composites. *Journal of Building Engineering*, 68, article number 106164. doi: 10.1016/j.jobe.2023.106164.
[28] Vázquez-Rodríguez, F., Elizondo, N., Montes-González, M., Gómez-Rodríguez, C., González-Carranza, Ya., Guzmán, A.M., & Rodríguez, E.A. (2023). Microstructural and mechanical characteristics of alkali-activated binders composed of milled fly ash and granulated blast furnace slag with µ-limestone addition. *Materials*, 16(10), article number 3818. doi: 10.3390/ma16103818.
[29] Wang, Ya., Cao, Yu., Ma, Yu., Xiao, Sh., Hu, J., & Wang, H. (2021). Fresh and hardened properties of alkali-activated fly ash/slag binders: Effect of fly ash source, surface area, and additives. *Journal of Sustainable Cement-Based Materials*, 11(4), 239-262. doi: 10.1080/21650373.2021.1932637.
[30] Yakovkin, I.N., Katrich, G.A., Loburets, A.T., Vedula, Yu.S., & Naumovets, A.G. (1998). Alkaline-earth overlayers on furrowed transition metal surfaces: An example of tailoring the surface properties. *Progress in Surface Science*, 59(1-4), 355-365. doi: 10.1016/S0079-6816(98)00061-6.
[31] Zhumadilova, A., Zhigitova, S., & Turalina, M. (2023). The impact of greenhouse gases on climate change. *Scientific Horizons*, 26(6), 97-109. doi: 10.48077/scihor6.2023.97.

Акимбек Абдикаликов

Доктор технічних наук, професор
Киргизький державний технічний університет ім. І. Раззакова
720044, просп. Ч. Айтматова, 66, м. Бішкек, Киргизька Республіка
https://orcid.org/0009-0006-7260-8738

Таалаібек Болотов

Кандидат технічних наук, доцент
Киргизький державний технічний університет ім. І. Раззакова
720044, просп. Ч. Айтматова, 66, м. Бішкек, Киргизька Республіка
https://orcid.org/0009-0009-9556-8945

Алайбек Курбанбаєв

Кандидат технічних наук, доцент
Киргизький державний технічний університет ім. І. Раззакова
720044, просп. Ч. Айтматова, 66, м. Бішкек, Киргизька Республіка
https://orcid.org/0009-0007-5402-8999

Акбермет Матиєва

Доктор технічних наук, професор
Міжнародний університет інноваційних технологій
720048, вул. Анкара, 1/17, м. Бішкек, Киргизька Республіка
https://orcid.org/0000-0001-9765-1149

Рискулбек Жумабаєв

Кандидат технічних наук, доцент
Киргизький державний технічний університет ім. І. Раззакова
720044, просп. Ч. Айтматова, 66, м. Бішкек, Киргизька Республіка
https://orcid.org/0009-0005-0713-0216

Оптимізація складу та міцнісних властивостей шлаколужних в'яжучих на основі паливних шлаків

Анотація. У рамках цього дослідження вивчаються способи вдосконалення складу та міцності шлаколужних в'яжучих, отриманих із продуктів згоряння палива. Для цього було застосовано рентгеноструктурний аналіз, спектроскопію, мікроскопію, випробування на міцність під час стискування, та аналіз отриманих даних для активації зол блоків теплоелектроцентралі, оцінки активності композицій, тепловологісної обробки та визначення оптимальних складів. Зололужні в'яжучі матеріали мають переваги порівняно з портландцементом: вони мають високу міцність, водонепроникність, морозостійкість і корозійну стійкість. Ці матеріали застосовуються в будівництві об'єктів спеціального призначення, таких як автомобільні дороги, аеродроми, мости, транспортні тунелі та гідротехнічні споруди. У рамках експериментального дослідження було розроблено оптимальні зололужні

в'яжучі на основі паливних шлаків, що володіють необхідними властивостями. Аналіз хімічного складу паливних шлаків виявив високий вміст оксидів кремнію, алюмінію, заліза, кальцію і магнію, що робить їх придатними для використання як в'яжучих матеріалів. Експериментальні дані показали, що введення добавок, таких як гіпс, значно покращує механічні властивості та довговічність матеріалів. Розроблені технологічні процеси змішування, формування та затвердіння забезпечили стабільну якість продукції. Випробування зразків продемонстрували високі характеристики міцності на стиск, розтягнення і вигин, що підтверджує їхню придатність для будівельних застосувань. Екологічна оцінка показала, що використання паливних шлаків знижує вуглецевий слід і зменшує негативний вплив на навколишнє середовище. У результаті розроблено масштабований процес виробництва, який може бути впроваджений у промисловість для створення екологічно стійких і високоефективних будівельних матеріалів. Це дослідження представляє нові дані про розробку екологічно стійких будівельних матеріалів на основі паливних шлаків, що може знизити екологічне навантаження і поліпшити стійкість інфраструктури

Ключові слова: техногенна сировина; зола гідровіддалення; добавка; композиційні будівельні матеріали; хімічний склад

Architectural Studies
International Journal about Architecture

Volume 10, No. 1

UDC 711.1
DOI: 10.56318/as/1.2024.136

Hong Li*
Doctor of Fine Art
Krirk University
10220, 3 Soi Ramindra Rd., Bangkok, Thailand
https://orcid.org/0009-0008-4974-789X

Urban spatial evolution of Guangzhou's Xiguan historic old town: An analysis under the semantics of the Conzen School

Abstract. The analysis of urban morphology using Conzen's methods is relevant in terms of studying the historical transformation of the urban landscape and its interaction with modern urban development processes. Despite numerous studies of the general urbanization process in Guangzhou, specific aspects of the historical development of Xiguan have remained insufficiently covered. The purpose of this study is to substantiate the spatial structure and evolution of Guangzhou's Guangfu Nan District with a detailed identification, analysis of key changes in the urban organization of this historic district, and proposals for effective urban landscape management and cultural integration development. The information and methodological basis of this paper is based on historical maps, archival records, and other primary sources to restore and substantiate the evolution of the urban environment, as well as to develop modern spatial planning strategies for the historic city of Xiguan. The study analyses the key reforms of urban planning and industrialization in the People's Republic of China, determining their impact on urban morphology, economy and social structure, with a special focus on the periodization of the historical development of the Daguan River and the Xiguan Commercial District. A detailed analysis of the development of the street network, land distribution, and architectural layout was conducted using historical cartographic data and changes in land use. The results revealed how historical, cultural and economic factors have jointly influenced the shaping of Xiguan's urban landscape, highlighting its unique contribution to the larger context of Guangzhou's urbanization. This study not only enriched the understanding of the historical urbanization process in Southern China, but also provided valuable empirical data for planning the future development and conservation of historic districts in the region. The practical significance of this work is to develop proposals for strategic directions for the effective management of the urban landscape and preservation of the historical heritage of the old city of Xiguan in Guangzhou

Keywords: urban morphology; adaptation of historical areas; transformation of the urban landscape; rational land use; strategic management; protection and preservation of cultural heritage

INTRODUCTION

The problematic issue covered by the study is the identification of the driving forces of morphological evolution, taking into account the factors that contributed to the changes in the Guangzhou Nan District during different historical stages. Another equally important issue is to determine the extent to which historical changes have influenced contemporary urban planning in the context of historical transformation and current conservation and development strategies. The problem that sums up these issues is finding ways to balance the needs of modern urban development with the need to preserve China's historical and cultural heritage. Urbanization in China was particularly intense in

Suggested Citation:
Li, H. (2024). Urban spatial evolution of Guangzhou's Xiguan historic old town: An analysis under the semantics of the Conzen School. *Architectural Studies*, 10(1), 136-150. doi: 10.56318/as/1.2024.136.

Journal homepage: https://arch-studies.com.ua/en#
Architectural Studies, 10(1), 136-150
Received: 01.02.2024 Revised: 19.05.2024 Accepted: 20.06.2024
*Corresponding author

the 1980s and 1990s, when large numbers of people moved in search of better economic opportunities. Accordingly, from the early 2000s and over the next few decades, this process continued to accelerate, leading to the creation of megacities and a significant increase in infrastructure in urban areas. During these transformations, old buildings were often replaced by modernized high-rise buildings that met the needs of the modern age. However, Guangzhou's historic area has managed to retain its authentic appearance from the Ming and Qing Dynasties (Yang, 2022). In 2005, the Guangzhou Nan District was officially designated as the city's historic area, and its real estate acquired a special status, is under state protection and has a special legal regime of use. Thanks to these changes, the executive authorities and local governments of Guangzhou managed to preserve its unique architectural elements.

During the Tang Dynasty, Guangzhou was known as a leading international trading port. In 1472, the Daguan River, which ran through the centre of the district from West to East, improved logistics, which fostered entrepreneurial development. By 1686, the Thirteen Guangzhou Factories were established South of Langan Road, strengthening the district's trade potential. This made Guangfu Nan a key meeting point between Chinese and Western trade representatives and a location where mutual trade in Eastern and Western goods developed during the late Qing Dynasty (Wang *et al*., 2023). The study of the urban spatial evolution of the historic old town of Xiguan in Guangzhou using the Conzen school's semantics focuses on the analysis of transformations of the urban landscape and development of the area under the influence of various historical, social and economic factors (Whitehand, 2021). The main problematic of this work is to identify changes in the use of urban space and architectural styles, as well as to understand the interaction between historical heritage and the needs of modern urban development. An important aspect is also to study how different eras have influenced the modern appearance of the district and its socio-economic structure.

The historical development of the Xiguan District in Guangzhou has become an object of considerable interest due to its extensive cultural and architectural heritage. D. Lisaia & C. Zhang (2022) focus on the morphology and physical attributes of the Xiguan District in Guangzhou, revealing the features of its urban composition, traditional buildings and daily life of the community. The paper also discusses the historical reserve on Enning Road and the micro-renovation project in the Yongqing Fang community. B. Du *et al*. (2021) analyse the spatio-temporal aspects, formation mechanisms and barriers to integration between urban and rural areas in China from 2008 to 2018, using the concept of sustainable development. In conformity with H. Zhang *et al*. (2022), the regeneration of historical centres in Chinese cities usually takes place through the demolition of old buildings for new construction or the development of infrastructure around historical monuments. Using the example of Shanghai's Old Town, the authors applied the theory of sociological institutionalism through the interaction between the power structure, discourse, and management tools, emphasizing the need for innovative approaches.

In the context of the urban spatial evolution of the historic old town, urban cemeteries play a significant role as physical evidence of the dynamics of the perception of life and death by urban residents, as noted by H. Deng & M. Li (2023). The authors examine different types of morphological evolution of the Nanjing cemetery, highlighting not only general trends but also specific features for China. In the context of the urban spatial evolution of historic old towns, the digital twin has become a key tool for documenting and preserving cultural heritage, as detailed in the studies of X. Dang *et al*. (2023). This technology, which includes the collection, processing, and use of graphic and spatial data, is widely used for the detailed study and digitization of heritage sites in China, providing opportunities for the analysis and restoration of historical sites.

Despite several scientific studies, the issues of a comprehensive interdisciplinary approach that combines geography, history, architecture, and sociology in the context of urban planning remain insufficiently addressed. It is worth analysing in more detail the changes in functional zones in the city's historic areas, such as the transformation of residential areas into commercial or industrial ones, and what impact this had on the use of the city's architectural monuments. The aim of the study was to analyse the evolution of the urban organization of the Guangzhou Nan Historic District using the method of urban morphological analysis of the Conzen School, as well as to formulate proposals for the implementation of strategies for managing the urban landscape and preserving the historical heritage of the district.

MATERIALS AND METHODS

The basis of the methodological support for this study was the morphological approach of the Conzen school based on a detailed conceptualization of the historical development of urban areas, high terminological accuracy and analytical use of cartographic materials (Conzen, 2021). These aspects of Conzen's approach formed the basis for analysing the urban landscape of the Xiguan District in Guangzhou in terms of urban transformation, as well as structural and functional urban change over time. The methodological basis of the study includes a detailed examination of historical maps, archival documents and other sources to recreate the evolution of the urban environment and substantiate its current state, as well as the spatial planning of the historic city of Xiguan.

The archival research was conducted using government planning reports, literature, and vector map data, which provide detailed information on building types, specific building districts, and street dimensions. Visual documentation was carried out through on-site photography, which allowed to capture building characteristics, entrance locations and other important features of the urban landscape. Satellite imagery from Google Maps was used to validate the visual information, while vector maps were

obtained from the Guangzhou Urban Planning and Design Research Institute. A more detailed visualization of the spatial layout of Guangzhou's Old Town was carried out using the QGIS software of the Quick Map Service search module, Esri Word Imagery. In particular, the research was based on historical, economic and environmental theories, as well as categories and concepts. In addition, the principles of architectural composition were included. The social laws and political regularities used made it possible to identify objective and repeatable cause-and-effect relationships between social phenomena and processes that arise as a result of mass or individual actions of people. This approach provided a deep understanding of the relationships between architecture, history, and contemporary social processes in shaping the urban space of Xiguan.

The paper summarizes the key reforms of urban planning and industrialization in the People's Republic of China and substantiates their impact on urban morphology, economy and social structure with a detailed periodization of the historical development of the Daguan River and the Xiguan commercial district. The graphic materials that form the basis of this study reflect: the relationship between the Xiguan Guangfu South Historic District and Guangzhou Old Town using remote sensing tools; the geographical relationship between the study area of Guangzhou Old Town and the Xiguan and Daguan Rivers; the original texture of the Daguan River; the architectural texture reflecting the riverway lifestyle; the transformation of the Pearl River shoreline within the study area; the relationship between architecture and the original morphology of the river shoreline; typification of historic architecture; types of bamboo tube houses; geographical and functional characteristics of the designated riverside area along the Pearl River. A systematic analysis of the historical stages of commercial development of the Xiguan District and their impact on the formation of the district's street structure is carried out. The study provides a justification for a multifaceted approach to the main components of strategic urban landscape management in the historic Xiguan Old Town, Guangzhou.

RESULTS

The Conzen School, founded by the German geographer M.R.G. Conzen (2021), focuses on the analysis of the urban landscape through the study of its form, structure, and processes over time. This method includes a comprehensive approach that focuses on understanding the physical appearance of the city, its historical development and changes that have occurred in the urban environment over a certain historical period. The key features of the analysis of historic cities according to the Conzen School methodology are (Arat, 2023):

1. Morphological approach – the Conzen school pays special attention to the morphology of the city, understanding it as a structure formed by street networks, buildings, land parceling and building typology. This approach helps to identify patterns and trends in the development of urban structures.

2. Temporal depth – Conzen's methodology incorporates a historical perspective, looking at urban development as a process that unfolds over time. This includes analysing changes in the street network, land use and architectural style over different historical periods.

3. Land and land parcelisation – the study of the history of land parcelisation is central to Conzen's methodology, as it helps to understand how urban space has been organized and used by different social groups. This includes analysing the boundaries of plots, their owners, and changes in ownership.

4. Street system – a detailed analysis of the city's street system helps to understand how traffic and accessibility were organized in different periods. This allows to assess the extent to which the street network has influenced the development of urban planning and development.

5. Land use – analysis of land use provides an insight into how the functionality of different parts of the city has changed. This includes the study of commercial, residential and industrial areas and their development.

6. Data integration – Conzen's methodology includes the integration of various data sources, including historical maps, archival records, archaeological data and modern geographic information systems for a comprehensive analysis of urban development.

7. The evolution of the historic old town of Xiguan in Guangzhou, analysed through the semantics of the Conzen school, reveals interesting insights into the morphology of urban space and its historical transformations.

Located in the historic Xiguan District of Guangzhou, Guangfu Nan has a long history dating back to the Tang Dynasty and was originally zoned as a residential area. With the development of the economy and population concentration during the Ming Dynasty (1368-1644), the area developed into a densely populated commercial and residential community. The highest point of economic prosperity in the area was during the Qing Dynasty (1636-1912). During the republican period and early years of the People's Republic of China, several key urban planning and industrialization reforms had a major impact on urban morphology, economy and social structure, among other things (Fig. 1). These reforms have changed not only the physical landscape of cities, but also the lifestyles and social dynamics of their inhabitants, contributing to the transition to a more urbanized and industrialized society. Table 1 shows the characteristics of the boundary of the Guangfu Nan District with the justification of spatial planning and historical significance of roads. A more detailed visualization of the spatial layout of Guangzhou's Old Town is shown in Figure 2.

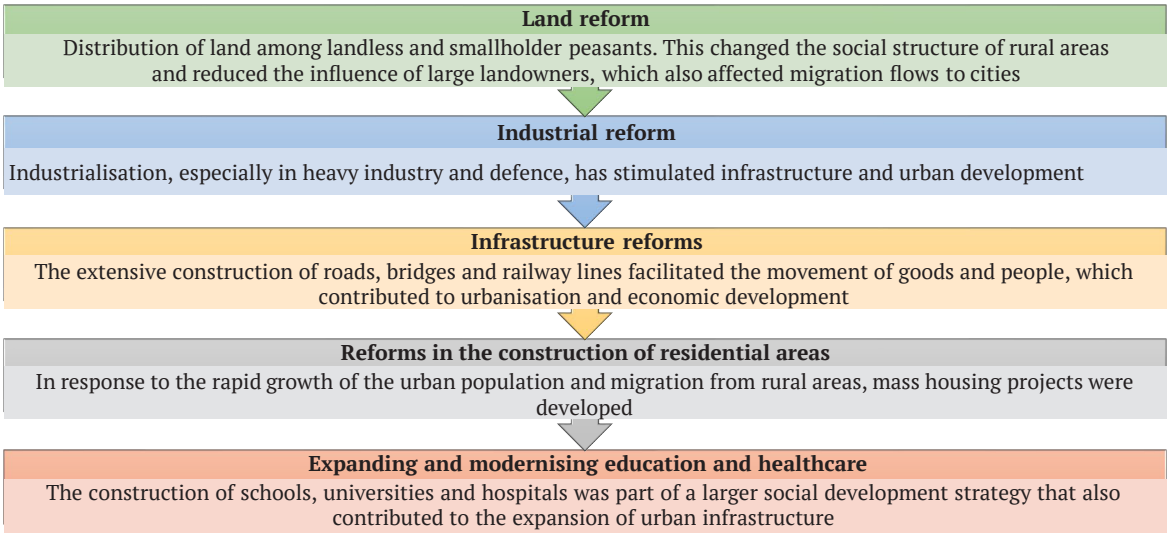


Figure 1. Key reforms of urban planning and industrialization in the People's Republic of China
Source: compiled by the author according to the B. Du *et al*. (2021)

Table 1. Characteristics of the boundary of the Guangfu Nan Historic District and its spatial layout

Boundary in terms of horizon	Name of the road	Rationale
North	Shanzhu Road	One of the few surviving ancient shopping streets from the Eighteen Piers, still an active shopping centre
South	Heping East Road	A historic transport artery that connected Xiguan to the city centre during the Ming and Qing Dynasties
East	Guanfu South Road	It was known as Datong Street during the Qing Dynasty
West	Yangxiang Road	There is no mention of this object in historical sources

Source: compiled by the author

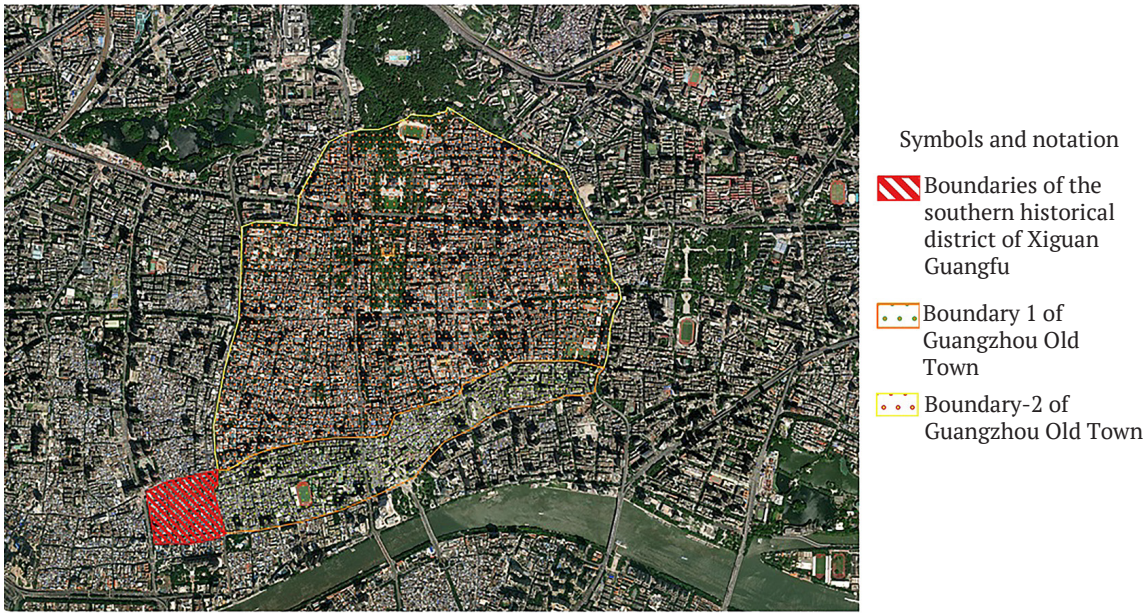


Figure 2. Mapping the connection between Xiguan Guangfu South Historic District and Guangzhou Old Town using remote sensing
Source: compiled by the author using the QGIS software of the Quick Map Service search module, Esri Word Imagery

The historical development of the Daguan River and the 18 Fu commercial district of Xiguan during the Ming Dynasty marked significant changes in urban morphology and cultural exchange (Fig. 3). The Daguan River facilitated not only local trade but also international economic ties, reinforcing Xiguan's role as a central hub in Guangzhou.

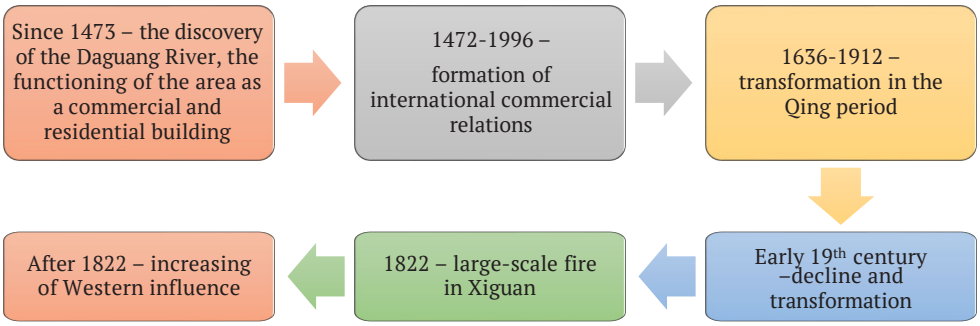


Figure 3. Periodization of the historical development of the Daguan River Valley and Xiguan Commercial District
Source: compiled by the author

The founding of the Daguan River allowed the development of a commercial district known as Xiguan 18 Fu (the name of the district's quarters). This area was built along the river banks near the West Canal and was an extension downstream of the Xiguan River. Its strategic location favoured commercial growth and connectivity. The commercial street that developed from the Sui Dynasty workshops flourished during this period. The area from the 9th to the 16th Fu around the Daguan River was particularly known for significant commercial and residential developments. The waterways around the Daguan River strengthened international trade links with more than 50 countries, making it a vital centre for trade, intercultural communication and exchange, which was key in this era.

By the middle of the Qing Dynasty, due to its proximity to the Thirteen Factories and convenient transport network, the area became a convergence point for East-West trade, increasing its economic and cultural importance. However, already in the early 19th century, the river began to dry up, which led to the filling of its channel and subsequent replacement with residential buildings. This physical and functional transformation reflects the ability to adapt to the changing conditions of the surrounding natural ecosystems in the context of rapid urbanization. In 1822, a large-scale, devastating fire struck Xiguan, destroying a significant number of residential buildings in the 15th and 16th Fu, with land in the reclaimed areas being reclassified as residential development land. This event marks a period of significant urban renewal and architectural evolution. Notably, the renovated buildings retained traditional architectural layouts but incorporated Western neoclassical styles on their facades, indicating the penetration of Western cultural influences in Guangzhou, especially in the South of Guangzhou. For example, the Guangzhou Nan District can be divided into the following urban types: riverbeds, former waterfronts, commercial streets and traditional residential areas.

Given the analysis of data from the 1860 historical map, it is shown that the Daguan River was about 15 metres wide. This river started from the West Moat at Taiping Gate, flowed through Liubo Chong and into the Xiguan, Qinyun and Deyun Li Districts, which defined its boundaries. According to historical records, the Daguan River began to silt up during the Ming Dynasty, and local people gradually began to develop the former riverbed. By 1810, the areas around Qinyun Bridge, Taosha Dang and Wanzhong Li had become significantly silted up. Historically, Guangzhou Nan was located upstream of the Daguan River. Maps from the early 19th century confirm that the Daguan River was almost completely silted up at that time (Fig. 4). This led to changes in the use of the former waterways, which were gradually replaced by buildings (Lisaia & Zhang, 2022).

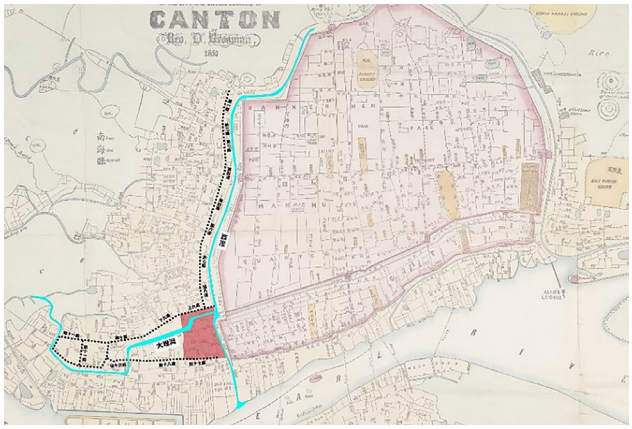


Figure 4. Geographical relationship between the study area of Guangzhou Old Town and the Xiguan and Daguan Rivers
Source: compiled by the author

As the riverbed was narrowed and filled in, new street-village developments emerged, shaped in accordance with the former direction of the river's flow. The morphology of the blocks of the 18 Fu Commercial District followed this direction, with streets organized perpendicular to the former riverbed, creating a fishbone-like structure (Fig. 5).

Figure 5. Cadastral visualization of blocks of the commercial district, 18 Fu
Notes: a – Google Maps presentation of the original texture of the Daguan River; b – architectural texture that reflects the lifestyle of the riverway
Source: compiled by the author

Over time, when the river became completely silted up, the silted-up areas were developed, including small courtyards or extensions to existing houses. The structures that occupied the former channel expanded both horizontally and vertically to adapt to the new land ownership boundaries. Modern maps still reflect the morphology of the Grand Canal, where buildings along the former channel retain narrow facades and deep layouts that reflect the historic grid of streets and alleys along the river. This type of layout, with its narrow facades and deep buildings, is characteristic of large buildings in Guangzhou's Xiguan, where the width-to-depth ratio of buildings ranges from 1:1 to 1:2, with internal layout comprising rooms and corridors.

The riparian area along the Pearl River has been designated as a riverside zone. According to the mapping data, the main street arteries of this zone run parallel to Jiang'an Avenue, which runs along the river, while secondary streets and alleys are located perpendicular to the shoreline, demonstrating the historical changes in the location of the Zhujiang River bank. The important transport artery Jianglian, located South of the Northern boundary of the study area and North of Heping Road, also runs East-West (Fig. 6; Table 2).

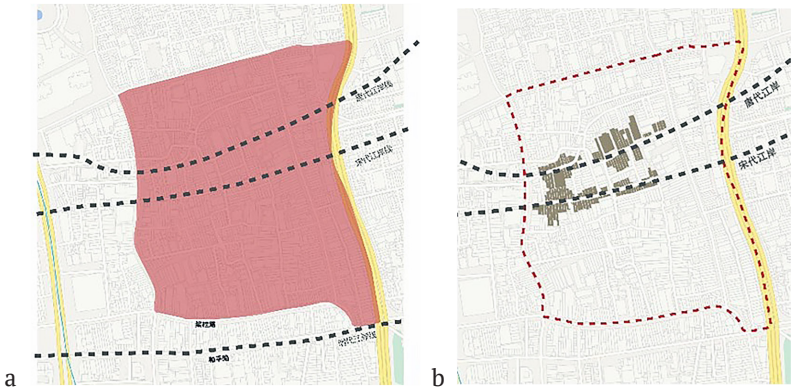


Figure 6. Spatial representation of historical changes
in the location of the Zhujiang River bank and the Jianglian transport artery
Notes: a – changes in the Pearl River shoreline within the study area; b – relationship between the architecture and the original morphology of the riverbank
Source: compiled by the author

Table 2. Textual representation of the main geographical and functional characteristics of the designated coastal zone along the Pearl River

Element	Description
Coastal zone	Located along the Pearl River
Main arteries	Run parallel to Jiang'an Avenue
Secondary streets	Located perpendicular to the coastline, demonstrating historical changes in the coastline
An important artery	Jianglian Road – runs from East to West

Table 2. Continued

Element	Description
Jianglian location	South of the Northern boundary of the zone and North of the Heping Road
Historical changes	The northern bank of the river shifted to the South during the Yuan and Ming Dynasties
North shore (up to the Qing)	From Penlai Road to Huaxi Road via Heping Road and others
Jianglian function	A centre for the trade of boat oars, which is reflected in the name "fence for oars"

Source: ompiled by the author

The formation of commercial precincts in Guangzhou's historic Xiguan Old Town is an important aspect of its urban spatial evolution, reflecting profound changes in the region's socio-economic life. These changes began during the Ming Dynasty, when the Huaiyuan Postal House was established to accommodate foreign envoys and trade delegations. This move spurred commercial development in the area, turning Xiguan into a significant trade centre. The periodization of the historical stages of commercial development in Xiguan District and the influence of geographical and historical factors on the street structure of the area is shown in Table 3.

Table 3. Historical stages of commercial development in the Xiguan District and their impact on the street structure

Period	Event	Impact	Result
1368-1644 Ming Dynasty	Founding of the Huaiyuan Post Office	Accommodation for foreign envoys and trade delegations	Stimulating the commercial development of Xiguan
1644-1912 Qing Dynasty	Lifting of the naval ban, establishment of thirteen factories. Continuation of the tribute system	Legalization of Western merchants and compradors. Regulation of foreign trade, restriction of access for non-tributary nations	Stimulation of local economy and international trade, important role in East-West trade. Maintaining control over foreign trade, influencing trade policy
1653 – reign of Emperor Shunzhi of the Qing Dynasty	Arrival of Siamese and Dutch ships	Tribute trade, limited maritime trade	Supporting the Ming Dynasty's maritime restriction policy, promoting international trade
1827 – reign of Emperor Daoguang of the Qing Dynasty	Founding of The Canton Register newspaper	Press development, new industry development in Guangzhou	Increased information flow and communications, increased public awareness and commercial activity
1860	Guild of Siamese merchants	The Chinese in Siam (and other parts of South-East Asia) were active participants in the local economy. The merchants' guilds became important institutions to support the interests of the Chinese diaspora, providing them with resources and economic protection	Facilitating trade between China and Siam, especially in the export of Chinese goods such as tea, silk and porcelain, and agricultural products. Increased cultural exchange. The influence of the guild, which was of diplomatic importance, strengthening interstate relations through the stabilization and growth of trade

Source: compiled by the author based on D. Lisaia & C. Zhang (2022)

The imposition of maritime restrictions that allowed trade only with foreign powers under the tribute system concentrated international trade in the area, giving Xiguan a crucial role in China's foreign economic relations. In subsequent periods, especially during the Qing Dynasty, the continuation of the tribute system underscored the importance of Xiguan as a key international trade hub. The development of the city was also closely linked to hydrographic changes, in particular, the siltation of the Daguan River, which led to the redesign of the street network and the use of former waterways for development. This created new commercial spaces and contributed to the concentration of commercial and industrial activities in the area (Yang *et al.*, 2019). The lifting of maritime restrictions during the reign of Emperor Kangxi (Qing Dynasty) and the establishment of thirteen factories in Guangzhou played a crucial role in legalizing trade with Western merchants, leading to further commercial expansion. These policies not only fostered local economic growth, but also ensured that Xiguan was central to international trade by the mid-19th century.

The founding of The Canton Register in 1827 reflected the growth of the information and communications industry in Guangzhou, which also signalled the significant development of commercial infrastructure in the region. The streets and alleys perpendicular to the river and the morphology of the neighbourhoods, which reflect the structure of the dense river network of past eras, are evidence of the unique history and character of the commercial development of the old city of Xiguan (Wang *et al.*, 2022). With the economic prosperity of the Guangzhou Nan District during the Ming and Qing Dynasties, there was a significant increase in the sustainable population. With limited space, where every centimetre of land was at a premium, architectural solutions that optimize the use of space became extremely important. The traditional bamboo pipe buildings in Xiguan met the functional requirements, as their narrow frontage and deep layout allowed for efficient placement of commercial spaces in the front and residential areas in the back. Narrow alleys simplified pedestrian access and facilitated ease of movement (Zhao *et al.*, 2023).

To maximize the use of space, alongside the main shopping arteries, the secondary streets in the area were extremely narrow, usually less than three metres wide, often zigzagging. Some streets were only 1-2 metres wide, and the narrowest, usually dead-end streets, allowed only pedestrian and cyclist access, being less than one metre wide. The original architectural form for housing in the area was bamboo tube houses, which were arranged back-to-back linearly. Each block of the house was measured in "bays", usually 4 metres wide and with a depth that had a ratio of 1:1 or 2:1 to the width, including patios. Over time, it became a practice to combine two or more bamboo tube houses during renovation work (Fig. 7-9).

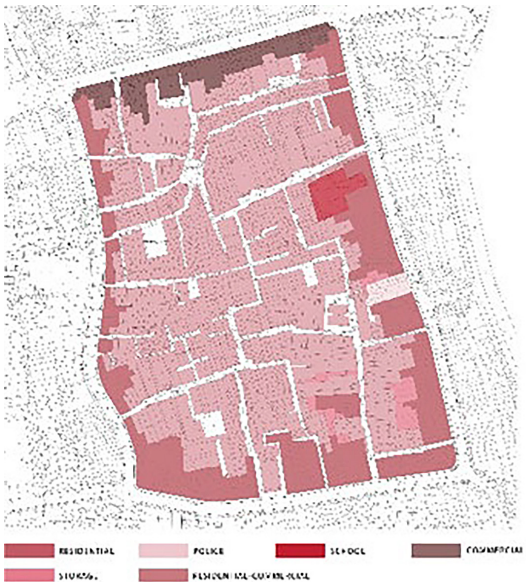


Figure 7. Typification of historical architecture
Source: compiled by the author according to H. Deng & M. Li (2023)

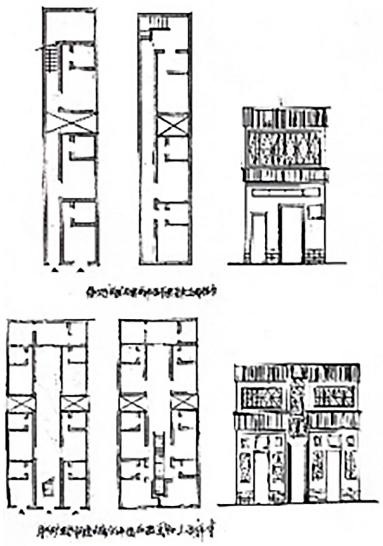


Figure 8. Double house made of bamboo pipes
Source: compiled by the author

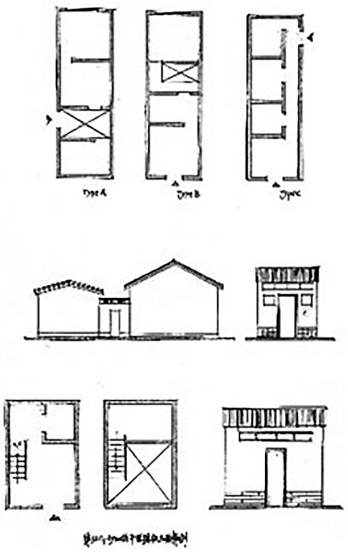


Figure 9. Types of houses made of bamboo pipes
Source: compiled by the author

Ming-style houses and large Xiguan houses also appeared in the area, which were integrated with bamboo buildings. The Ming style house was characterized by a two-tiered planning structure, symbolizing the Ming symbol from which its name was derived. Such buildings were sometimes called "second Ming houses". Large Xiguan houses usually had a three-tiered front. Many residential buildings along the streets were adapted for commercial use. Understanding the spatial evolution of Xiguan through the lens of land use allows to understand how historical patterns can influence contemporary urban planning and conservation strategies. This analysis highlights the importance of integrating historical perspectives into current urban development plans to ensure sustainable and respectful development. In traditional Xiguan, the land use pattern was distinctly characterized by narrow streets and alleys, where residential and commercial properties were combined. Among them are the iconic "Qilou" buildings, which are arcade-style buildings with commercial space on the ground floor and residential units on the second floor. This dual-use approach helped to maximize the use of limited land while accommodating a dense population (Lu *et al.*, 2022).

Land use regulations in Xiguan have changed markedly over different historical periods. For example, during the Republican era, modernization efforts led to the introduction of new zoning laws and changes in property rights, which significantly affected land use and development. These rules were intended to organize the chaotic expansion of cities and promote more structured growth (Su *et al.*, 2024). Since 2010, the preservation of historical sites in Xiguan has been a key priority. This position is characterized by the preservation of the architectural integrity of the Qilou buildings (since 2012, in accordance with the government's project for the restoration and conservation of cultural heritage sites) while adapting land use

to modern requirements. The main challenge is to balance the preservation of historical integrity with economic development and urban renewal. Measures have been taken to regulate building heights, preserve street layouts, and manage commercial and residential spaces to preserve the historic character of Xiguan (Venkatachalam *et al.*, 2022).

Current land use and development trends are to integrate the needs of the modern city with its historical structure, which is under pressure from tourism and the demand for modern infrastructure. Local governments and planners have been tasked with developing strategies that will protect Xiguan's heritage while ensuring that it meets modern urban requirements. Developing an urban landscape management and historic preservation strategy in Guangzhou's historic Xiguan Old Town, considering its morphological characteristics, requires a multifaceted approach and adaptation to the area's unique urban morphology and historic elements. The modernization aims to integrate conservation with urban planning, using sustainable practices and technological innovations to preserve the area's rich historical attributes while meeting the needs of modern cities (Abaikyzy *et al.*, 2020). The rationale for the main components of strategic urban landscape management in the historic Xiguan Old Town, Guangzhou, and the underlying approaches for their implementation are presented in Table 4.

Table 4. Components of strategic urban landscape management in the historic Xiguan Old Town, Guangzhou

Strategy component	Characteristics	Approach to implementation
Understanding urban morphology	Detailed mapping and historical research to analyse the existing urban morphology and its evolution	Comprehensive studies to create detailed territory plans. Collecting and analysing historical data to substantiate morphological changes and their socio-economic and environmental interactions
Preserving history through urban planning	Identify heritage protection zones and promote adaptive reuse of historic buildings to preserve the architectural integrity and modern function of the city	Zoning of land in the historical area of the city with the establishment of a legal regime of use. Adapting to the reuse of historic buildings for purposes that enhance local identity
Legal and regulatory framework	Developing guidelines for new reconstructions that take into account the historical urban fabric Introducing an incentive programme to support the maintenance and restoration of historical and cultural heritage sites	Enshrine legal regulations that include restrictions on building height and facade design. Introduce financial incentives, such as tax breaks and subsidies, for property owners to restore and maintain historic properties
Community engagement and education	Involve local stakeholders in the preservation process and educate the community about the benefits of cultural heritage preservation	Launching educational initiatives to raise public awareness and foster a sense of stewardship among residents
Infrastructure and environmental aspects	Integrating practices to improve the quality and balance of the environment, as well as implementing advanced infrastructure solutions to protect against environmental risks, including floods	The use of green infrastructure methods, such as green roofs. Upgrading public transport and improving public space, Development of advanced flood control and drainage systems to protect the historic district
Monitoring and continuous evaluation	Establish a framework for periodic reviews of current technology to ensure the effectiveness of strategies and adaptation to new challenges or findings	Establish regular review mechanisms to evaluate and improve strategies. Use GIS technology and 3D modelling to monitor urban change and plan more effectively

Source: compiled by the author based on Z. Wang *et al.* (2022)

Developing a strategic approach to urban landscape management and preserving the historical characteristics of the historic Xiguan Old Town, Guangzhou, is key to preserving the cultural and historical integrity of the area and protecting national heritage from the erosive effects of modern urban development and globalization.

By combining modern urban needs with the preservation of historic districts, the strategy promotes a balanced approach that ensures economic vitality without compromising cultural heritage. In particular, such development can attract tourism and improve the quality of life of residents, thereby contributing to the local economy. A multifaceted approach to strategic planning allows for the adaptive reuse of historic buildings and spaces, giving them new life and function while preserving their historic character (Subin-Kozhevnikova *et al.*, 2023). This not only prevents these buildings from falling into disrepair and neglect, but also provides the community with valuable spaces for cultural, educational and commercial activities. The strategic management of urban landscapes in historic districts, such as Siguan, involves the use of advanced technologies and methodologies such as geographic information systems (GIS) and three-dimensional modelling. These tools provide precise monitoring and control over development planning, ensuring that changes made, or restoration work carried out, are historically accurate. This approach helps to preserve the authenticity and value of cultural heritage sites. Thus, the strategic management of Xiguan's urban landscape and historic features includes not only preservation, but also the active promotion of an urban environment that harmoniously combines historic integrity, community engagement, economic development, and sustainable urban practices. This integrative approach ensures that Xiguan remains relevant and vibrant in the context of the modern world, while maintaining its unique historical narrative and cultural significance.

DISCUSSION

The study of the urban spatial evolution of the historic old town of Xiguan in Guangzhou, conducted using the methodology of the Conzen School, analyses urban transformations and their impact on the historical structure of the urban landscape. This method focuses on the morphology of Guangzhou's historic area, taking into account aspects such as the street network, coastlines, riverbeds, plots and buildings, as well as the periodization of their historical development. This approach allows to identify and analyse key stages in the development of the urban environment, changes in planning and development that have occurred under the influence of various social, economic and political factors. The results of such a study are important for understanding how historical events and decisions in urbanism have influenced the current appearance and functioning of old cities, including Xiguan. The scientific significance of the study lies in the possibility of applying the knowledge gained to develop strategies for the preservation of cultural heritage, as well as to plan the future development of urban areas, taking into account historical value and identity. This approach also helps to create a balance between the preservation of historical heritage and the need to adapt the urban environment to modern needs and challenges.

The application of the Conzenian approach to urban morphology in the context of World Heritage management can provide a systematic and objective way to assess changes in urban form and their impact on the city's outstanding universal values (OUVs). T. Venkatachalam *et al*. (2022) believe that innovative urban regeneration strategies should go beyond traditional methods of "monitoring" and "design" and instead aim to create more inclusive governance structures that set priorities and shape new discourse. It is necessary to develop a theoretical and methodological framework that contributes to a sound understanding of the complexity and institutional challenges that arise in the context of global urban regeneration and the management of creative transformations in historic district renewal projects, as noted by G.F. Hassan *et al*. (2022). This approach opens up new perspectives for the development and implementation of management strategies that are adequate to modern requirements and challenges in the context of the urban development of Shanghai's Old Town.

The application of available photogrammetry techniques to the detailed documentation of architectural entrances in historic buildings in Old Tripoli, Lebanon, has allowed the creation of accurate 3D models that reflect the physical characteristics and context of the entrances, which is especially important in light of the potential threat from armed conflict, neglect, and environmental risks that could lead to the disappearance of these monuments, as noted in research by N. Mohareb *et al*. (2023). The use of these technologies contributes not only to the preservation of information about cultural values for future generations, but also supports the awareness and appreciation of the historical and cultural importance of architectural elements, according to Sh. Zhang *et al*. (2021). The regeneration of the historic centres of Chinese cities often follows two main scenarios: "demolition-reconstruction" and "frozen protection". While these strategies have the potential to preserve cultural values, they can lead to fragmented and heterogeneous urban environments and limitations in historic preservation and infrastructure development.

The morphological transformation of the historic urban quarters near Maldah Patti in Dinajpur, according to A.T.M. Shahriar *et al*. (2023), has had a negative impact on the architectural integrity due to the low level of economic development, inefficient management sector at the local level, and monopoly of owners. In today's rapidly urbanizing world, there is a need to harmonize historical heritage and modern socio-economic needs, emphasizing the importance of design that recreates the historical context while taking into account functional and spatial requirements, as shown in the example of Guangzhou. No less crucial are the issues noted by B. Arandelovic & R. Musil (2023), these matters are the renovation, rehabilitation, and adaptation of buildings of exceptional historical value. The authors consider four important reconstructions for architectural monuments in the historic centre of Vienna. These objects are of different scale and functional purpose, belong to different historical periods, but they have in common their exceptional heritage and location in the centre of Vienna. In such circumstances, it is important to apply a comprehensive approach to the restoration of historic buildings that considers architectural, historical, social and environmental aspects.

In conformity with P. Daly *et al*. (2023), the application of an integrated approach to study the transformation of traditional housing in four historic districts of the Kathmandu Valley as a result of natural disasters is extremely effective, as it combines both quantitative and qualitative methods. The large-scale earthquake of 2015 in Nepal revealed serious shortcomings in the existing methods of protection and restoration of architectural objects, which emphasizes the need to develop more effective reconstruction strategies. In turn, F. Giuliani *et al*. (2020) focus on the role of urban configuration and morphology in ensuring the safety and resilience of historic settlements during earthquakes, using an interdisciplinary approach. The use of spatial syntax allows analysing road networks and developing scenarios to optimize evacuation routes. In studying the urban spatial evolution of the historic old town of Xiguan in Guangzhou, floods, storms, and earthquakes, among others, have had a significant impact on morphological changes. Indeed, these natural disasters have changed urban structures, forcing city administrations to redevelop and rebuild the affected areas, prompting the introduction of new building codes and standards aimed at reducing the city's vulnerability to similar events in the future (Fedoniuk *et al*., 2024).

F. Ribera *et al*. (2020) emphasize in their works the importance of preserving cultural heritage through continuous monitoring and selection of compatible uses to avoid

abandonment. The authors propose an innovative and economical valuation model to determine the highest and best use of historic buildings. The model is tested on the example of the monumental Palazzo Genovese in Salerno, demonstrating the practical utility of the protocol in making decisions on the reuse of architecture that maximizes economic benefits and ensures the preservation of cultural heritage. This model allows not only assessing the financial effectiveness of restoration interventions, but also their impact on the community, creating new functions and employment opportunities, promoting cultural development while preserving historical and architectural values (Kotkevych, 2023). S. Pavel & I.S. Jucu (2020) analyse the urban transformations and cultural evolution of Timişoara (Romania) and focus on important cultural stages that shaped the post-socialist urban identity. Spatial changes caused by different historical periods have an impact on the current challenges and opportunities arising from the city's new status as the European Capital of Culture, according to E. Elldér (2024). The above study aims to provide a scientific basis for understanding and capitalizing on the local cultural heritage, contributing to the further socio-economic development of historical and cultural centres like Timişoara and Guangzhou.

R. Caro & J.J. Sendra (2021) investigate the energy efficiency of historic buildings by conducting experimental studies through measurements of indoor air temperature, CO_2 concentration and humidity. Given the fact that it is quite difficult to improve energy efficiency in historic buildings without damaging architectural values, the results of this study can provide valuable information for developing strategies that can be easily adapted to historic properties and are efficient in terms of energy consumption. The protection of urban cultural heritage highlights the problems and challenges faced by historic suburban villages under the pressure of modern urban development, as noted in studies by B. Olczak *et al*. (2022) and A. Majewska *et al*. (2022). The study of the situation in Bronowice Małe, which is part of Kraków, highlights the conflict between the need to preserve historic architecture and the rapid expansion of urban development. This study is important from the point of view that suburban village areas are often subject to intensive development that does not take into account historical features, and the availability of strategies and methodologies that allow assessing the compliance of new development with historical standards is critical for preserving the cultural identity of these places.

According to M. Wang *et al*. (2022), one of the crucial problems of urban spatial evolution is the uncontrolled proliferation of tourism enterprises, which can lead to changes in the traditional urban landscape, destruction of architectural values and overloading of infrastructure, which threatens the preservation of cultural heritage. Thus, the use of multifactorial analysis and the creation of spatial databases to assess the impact of the tourism business allows to identify both high-risk areas and opportunities for sustainable development, ensuring a balance between economic development and the preservation of historical value. It is worth noting that the development of the tourism industry raises the importance of historical assets as a potential for economic growth, despite the pressure of urban modernization (Buil *et al*., 2016). Thus, A.S. Yawer *et al*. (2023) emphasize the need to create a strategy for the protection of historic cities on the example of Mosul (Iraq), which allows their residents to continue living in them, adapting to the principles of sustainable development. Using an inductive methodology and sustainable development concepts, the authors identify goals, strategies, and tools to ensure that historic cities can develop sustainably. Indeed, this study contributes to the development of strategies that combine the preservation of cultural heritage with the needs of modern communities, ensuring a balance between historical values and the requirements of residents.

Based on the initiative of the European Cooperation in Science and Technology (COST), which identified three main roles of culture for achieving the goals of sustainable development – "IN", "FOR", "AS", H.W. Al-Shami *et al*. (2024) developed a theoretical framework for cultural sustainability using the concept of "Third Place", which includes culture in the integrated planning of urban spaces, supporting sociability and attachment to place. Using Briggate Street in Leeds, UK, as an example, the authors used visual surveys and interviews to determine users' perceptions of the critical role of cultural resilience in cities. These approaches allowed them to formulate recommendations for improving the quality of urban areas and achieving cultural well-being while preserving the cultural heritage of these places. This approach helps to understand how historical and contemporary processes influence the formation of the urban landscape and what strategies can be used to manage future development, while preserving the historical heritage and cultural value of urban space, which is also agreed in work by N.C. Palazzi *et al*. (2023). In this study, for a more detailed visualization of the spatial layout of Guangzhou's Old Town, a map was generated using the QGIS software of the Quick Map Service search module, Esri Word Imagery, which uses remote sensing data. This method also aims to identify urban landscape transformations and their impact on the future development of the historic area. M.A. Ali & H. Abouelfadl (2022) study the peculiarities of overcoming the challenges of segregation between the viability of Kom al-Nadur as a cultural and tourist site and the local community, which largely ignores its historical significance. The site, despite its rich history spanning the Fatimid, Mamluk, Ottoman, French expedition and Muhammad Ali eras, remains inaccessible and unrecognizable to the public. As in the case of Qom a Nadur, the study of the historical site in Guangzhou highlights the need to develop strategies that would allow the archaeological site to be used to strengthen intercultural dialogue and social cohesion. In this way, it is possible to identify the links between historical sites and other material historical assets in the region, including ancient cisterns, a large memorial hall, a Taoist temple, Arab city

walls and Sufi mosques, and Buddhist temples, in order to create an integrated cultural landscape (Stoiian, 2024).

Thus, the conducted research includes some recommendations how to increase tourism potential, raise awareness of Xiguan's historical wealth, and strengthen the local economy. Stakeholders such as government agencies, NGOs, and academia can use this research to prepare grant applications, develop educational programmes, and initiatives aimed at increasing public participation in cultural heritage preservation.

CONCLUSIONS

Conzen's morphological approach allowed to substantiate the historical continuity and interconnection between urban geography, economy, culture and spatial configuration. The analysis of the urban architecture typification of Xiguan in Guangzhou has opened up new opportunities for urban landscape management and conservation planning. In particular, the study emphasizes the importance of the historical integrity of street, site and building systems in shaping the urban fabric, which affects the overall image and functionality of the city.

The recommendations of the study are aimed at preserving the traditional modules of the plots during reconstruction in order to reduce the impact on street spaces and maintain the harmonious coexistence of traditional and modern forms. It is noted that the integration of the theoretical foundations of urban morphology into practical urban planning can significantly improve the processes of renovation and preservation of historic districts, as well as contribute to the preservation of the identity of urban spaces. It is important to create strategies that take into account the links between historical and modern urban forms, which is a key factor in protecting urban heritage and effective urban development management. The result of this study is proposals for the development of strategies for the preservation of historical heritage, considering the specifics of the urban morphology and identity of Xiguan. Strategic planning is the key to implementing an effective urban landscape management policy that will maintain a balanced combination of the latest urban development and the historical value of the area.

The study of the urban spatial evolution of the historic old town of Xiguan in Guangzhou based on the methodology of the Conzen school, although significant, has several limitations that should be considered. The first and main limitation is the availability of archival data. Another important limitation is the subjectivity of the interpretation of historical materials. Individual interpretations of historical sources may differ, which affects the objectivity and universality of the study's conclusions. In addition, the use of Conzen's methodology may be difficult to adapt to local conditions in Siguan if the cultural and historical characteristics of the region are not taken into account. The methodology may require some modifications or additions to reflect the unique aspects of urban development. The study of the urban spatial evolution of the historic old town of Xiguan in Guangzhou using the methodology of the Conzen School opens up prospects for further research that could focus on a detailed analysis of the interaction between historic buildings and modern urban interventions. A relevant area of research is the analysis of socio-economic changes in the Xiguan community and their impact on urban spatial planning.

ACKNOWLEDGEMENTS

None.

CONFLICT OF INTEREST

None.

REFERENCES

[1] Abaikyzy, M., Yerkinbayeva, L., Aidarkhanova, K.N., Aigarinova, G.T., & Baimbetov, N.S. (2020). The formation of land conservation principles as the framework for the implementation of the concept of sustainable development of society. *International Journal of Sustainable Development and Planning*, 15(8), 1231-1240. doi: 10.18280/ijsdp.150809.

[2] Ali, M.A., & Abouelfadl, H. (2022). Stitching the gap between contemporary archaeology and the city through "Urban Dots": A case study of Kōm al-Nāḍūra Area, Alexandria, Egypt. *Alexandria Engineering Journal*, 61(12), 12891-12914. doi: 10.1016/j.aej.2022.06.020.

[3] Al-Shami, H.W., Al-Alwan, H.A.S., & Abdulkareem, T.A. (2024). Cultural sustainability in urban third places: Assessing the impact of 'Co-operation in Science and Technology' in cultural third places. *Ain Shams Engineering Journal*, 15(3), article number 102465. doi: 10.1016/j.asej.2023.102465.

[4] Arandelovic, B., & Musil, R. (2023) The renovation, rehabilitation and adaptation of Historical Heritage Buildings in Public Ownership. The case of historical buildings of exceptional importance in Vienna. *Building and Environment*, 246, article number 110937. doi: 10.1016/j.buildenv.2023.110937.

[5] Arat, M.A. (2023). *Morphological regionalization: Strengthening the Conzenian method*. Cham: Springer. doi: 10.1007/978-3-031-33509-9.

[6] Buil, R., Piera, M.A., & Ginters, E. (2016). Multi-agent system simulation for urban policy design: Open space land use change problem. *International Journal of Modeling, Simulation, and Scientific Computing*, 7(2), article number 1642002. doi: 10.1142/S1793962316420022.

[7] Caro, R., & Sendra, J.J. (2021). Are the dwellings of historic Mediterranean cities cold in winter? A field assessment on their indoor environment and energy performance. *Energy and Buildings*, 230, article number 110567. doi: 10.1016/j.enbuild.2020.110567.

[8] Conzen, M.R.G. (2021). *Alnwick, Northumberland: A study in town-plan analysis*. Melbourne: Hassell Street Press.
[9] Daly, P., Ninglekhu, S., Hollenbach, P., McCaughey, J.W., Lallemant, D., & Horton, B.P. (2023). Rebuilding historic urban neighbourhoods after disasters: Balancing disaster risk reduction and heritage conservation after the 2015 earthquakes in Nepal. *International Journal of Disaster Risk Reduction*, 86, article number 103564. doi: 10.1016/j.ijdrr.2023.103564.
[10] Dang, X., Liu, W., Hong, Q., Wang, Yi., & Xuemin, Ch. (2023). Digital twin applications on cultural world heritage sites in China: A state-of-the-art review. *Journal of Cultural Heritage*, 64, 228-243. doi: 10.1016/j.culher.2023.10.005.
[11] Deng, H., & Li, M. (2023). The morphological evolution of Chinese urban cemeteries from the perspective of fringe belt: A case study of Nanjing. *Frontiers of Architectural Research*, 12(6), 1065-1079. doi: 10.1016/j.foar.2023.08.005.
[12] Du, B., Wang, Yi., He, J., Li, W., & Chen, X. (2021). Spatio-temporal characteristics and obstacle factors of the urban-rural integration of China's shrinking cities in the context of sustainable development. *Sustainability*, 13(8), article number 4203. doi: 10.3390/su13084203.
[13] Elldér, E. (2024). Built environment and the evolution of the "15-minute city": A 25-year longitudinal study of 200 Swedish cities. *Cities*, 149, article number 104942. doi: 10.1016/j.cities.2024.104942.
[14] Fedoniuk, T., Pyvovar, P., Skydan, O., Melnychuk, T., & Topolnytskyi, P. (2024). Spatial structure of natural landscapes within the Chornobyl Exclusion Zone. *Journal of Water and Land Development*, 60(1-3), 79-90. doi: 10.24425/jwld.2024.149110.
[15] Giuliani, F., De Falco, A., & Cutini, V. (2020). The role of urban configuration during disasters. A scenario-based methodology for the post-earthquake emergency management of Italian historic centres. *Safety Science*, 127, article number 104700. doi: 10.1016/j.ssci.2020.104700.
[16] Hassan, G.F., Rashed, R., & Nagar, S.M.E. (2022). Regenerative urban heritage model: A scoping review of paradigms' progression. *Ain Shams Engineering Journal*, 13(4), article number 101652. doi: 10.1016/j.asej.2021.101652.
[17] Kotkevych, N. (2023). Normative legal support for the development of territorial urban communities in Ukraine. *Democratic Governance*, 31(1), 75-85. doi: 10.23939/dg2023.01.075.
[18] Lisaia, D., & Zhang, C. (2022). Morphological and physical characteristics of the historic urban fabric and traditional streets of Xiguan in Guangzhou. *Journal of Urban Design*, 27(4), 441-458. doi: 10.1080/13574809.2021.2020632.
[19] Lu, Yu., Xu, S., Liu, S., & Wu, J. (2022). An approach to urban landscape character assessment: Linking urban big data and machine learning. *Sustainable Cities and Society*, 83, article number 103983. doi: 10.1016/j.scs.2022.103983.
[20] Majewska, A., Denis, M., Krzysztofik, S., & Cysek-Pawlak, M.M. (2022). The development of small towns and towns of well-being: Current trends, 30 years after the change in the political system, based on the Warsaw suburban area. *Land Use Policy*, 115, article number 105998. doi: 10.1016/j.landusepol.2022.105998.
[21] Mohareb, N., Alsalloum, A., & Webb, N. (2023). A morphological analysis of historic buildings entries using affordable photogrammetry techniques: Old Tripoli, Lebanon. *Digital Applications in Archaeology and Cultural Heritage*, 28, article number e00261. doi: 10.1016/j.daach.2023.e00261.
[22] Olczak, B., Wilkosz-mamcarczyk, M., Prus, B., Hodor, K., & Dixon-gough, R. (2022). Application of the building cohesion method in spatial planning to shape patterns of the development in a suburban historical landscape of a 'village within Kraków'. *Land Use Policy*, 114, article number 105997. doi: 10.1016/j.landusepol.2022.105997.
[23] Palazzi, N.C., Baquedano, J.P., Ferreira, T.M., Rosas, J., Monsalve, M., & de la Llera, J.C. (2023). Fire risk assessment of historic urban aggregates: An application to the Yungay neighbourhood in Santiago, Chile. *International Journal of Disaster Risk Reduction*, 86, article number 103550. doi: 10.1016/j.ijdrr.2023.103550.
[24] Pavel, S., & Jucu, I.S. (2020). Urban transformation and cultural evolution of post-socialist European cities. The case of Timisoara (Romania): From 'Little Vienna' urban icon to European Capital of culture (ECoC 2021). *City, Culture and Society*, 20, article number 100296. doi: 10.1016/j.ccs.2019.100296.
[25] Ribera, F., Nesticò, A., Cucco, P., & Maselli, G. (2020). A multicriteria approach to identify the highest and best use for historic buildings. *Journal of Cultural Heritage*, 41, 166-177. doi: 10.1016/j.culher.2019.06.004.
[26] Shahriar, A.T.M., Mithun, S.M.N.H., Saha, D., & Ahmed, S. (2023). Designing architectural continuity in a historic urban quarter of Dinajpur, Bangladesh. *Frontiers of Architectural Research*, 12(5), 803-819. doi: 10.1016/j.foar.2023.05.001.
[27] Stoiian, T. (2024). China's experience of infrastructure megaprojects in Eurasia and Africa: Successes and contradictions. *Foreign Affairs*, 34(1), 88-97. doi: 10.46493/2663-2675.34(1).2024.88.
[28] Su, J., Wang, M., Zhang, D., Yuan, H., Zhou, S., Wang, Yu., & Razi, M.A.M. (2024). Integrating technical and societal strategies in Nature-based Solutions for urban flood mitigation in Guangzhou, a heritage city. *Ecological Indicators*, 162, article number 112030. doi: 10.1016/j.ecolind.2024.112030.
[29] Subin-Kozhevnikova, A., Khorosha, O., Sliusar, I., & Kovalchuk, M. (2023). Urban planning principles of location of modern hotel complexes. *Modern Technology, Materials and Design in Construction*, 35(2), 137-144. doi: 10.31649/2311-1429-2023-2-137-144.

[30] Venkatachalam, T., Day, J.C., & Heron, S.F. (2022). A systematic approach for defining thematic groups of World Heritage properties to support the strategic management of threats. *Environmental Challenges*, 8, article number 100538. doi: 10.1016/j.envc.2022.100538.
[31] Wang, M., Liu, J., Zhang, S., Zhu, H., & Zhang, X. (2022). Spatial pattern and micro-location rules of tourism businesses in historic towns: A case study of Pingyao, China. *Journal of Destination Marketing & Management*, 25, article number 100721. doi: 10.1016/j.jdmm.2022.100721.
[32] Wang, Ya., Matsumoto, K., Wang, R., Zhou, W., & Sawaki, M. (2023). Investigating the potential historic conservation area in China: A case study on 11 old colonial cities. *Journal of Asian Architecture and Building Engineering*, 22(6), 3718-3731. doi: 10.1080/13467581.2023.2182644.
[33] Wang, Z., Zhang, H., Yang, X., & Li, G. (2022). Neighbourhood streets as places of older adults' active travel and social interaction – a study in Daokou ancient town. *Journal of Transport & Health*, 24, article number 101309. doi: 10.1016/j.jth.2021.101309.
[34] Whitehand, J.W.R. (2021). Conzenian research in practice. In V. Oliveira (Ed.), *Morphological research in planning, urban design and architecture* (pp. 19-42). Cham: Springer. doi: 10.1007/978-3-030-66460-2_2.
[35] Yang, Yi. (2022). *The politics of urban heritage-making in the Yongqingfang redevelopment project in Guangzhou, China*. Retrieved from https://metropolitics.org/The-Politics-of-Urban-Heritage-Making-in-the-Yongqingfang-Redevelopment-Project.html.
[36] Yang, Zh., Chen, Yi., Wu, Zh., Qian, Q., Zheng, Z., & Huang, Q. (2019). Spatial heterogeneity of the thermal environment based on the urban expansion of natural cities using open data in Guangzhou, China. *Ecological Indicators*, 104, 524-534. doi: 10.1016/j.ecolind.2019.05.032.
[37] Yawer, A.S., Bakr, A.F., & Fathi A.A. (2023). Sustainable urban development of historic cities: Historic Mosul City, Iraq. *Alexandria Engineering Journal*, 67, 257-270. doi: 10.1016/j.aej.2022.12.042.
[38] Zhang, H., Cong, C., & Chakraborty, A. (2022). Exploring the institutional dilemma and governance transformation in China's urban regeneration: Based on the case of Shanghai Old Town. *Cities*, 131, article number 103915. doi: 10.1016/j.cities.2022.103915.
[39] Zhang, Sh., Liu, J., Song, C., Chan, Ch.-Sh., Pei, T., Yu, W., & Zhang, X. (2021). Spatial-temporal distribution characteristics and evolution mechanism of urban parks in Beijing, China. *Urban Forestry & Urban Greening*, 64, article number 127265. doi: 10.1016/j.ufug.2021.127265.
[40] Zhao, Y., Huang, X., Zhao, Yi., Liu, X., & Zhou, R. (2023). The application of landscape character classification for spatial zoning management in mountain protected areas – a case study of Laoshan national park, China. *Heliyon*, 9(3), article number e13996. doi: 10.1016/j.heliyon.2023.e13996.

Хонг Лі
Доктор мистецтвознавства
Університет Крірка
10220, дорога Сої Рамінтра, 3, м. Бангкок, Таїланд
https://orcid.org/0009-0008-4974-789X

Урбаністична просторова еволюція історичного старого міста Гуанчжоу Сігуань: аналіз під кутом зору семантики школи Концені

Анотація. Аналіз міської морфології з використанням методів Конзена є актуальним з точки зору вивчення історичної трансформації міського ландшафту та його взаємодії з сучасними містобудівними процесами. Незважаючи на численні дослідження загального процесу урбанізації в Гуанчжоу, специфічні аспекти історичного розвитку Сігуаня залишаються недостатньо висвітленими. Метою цього дослідження є обґрунтування просторової структури та еволюції району Гуанфу Нань у Гуанчжоу з детальною ідентифікацією, аналізом ключових змін у містобудівній організації цього історичного району та пропозиціями щодо ефективного управління міським ландшафтом і розвитку культурної інтеграції. Інформаційно-методологічною основою роботи є історичні карти, архівні матеріали та інші першоджерела, що дозволяють відновити та обґрунтувати еволюцію міського середовища, а також розробити сучасні стратегії просторового планування для історичного міста Сігуань. У дослідженні проаналізовано ключові реформи містобудування та індустріалізації в Китайській Народній Республіці, визначено їхній вплив на міську морфологію, економіку та соціальну структуру, з особливим акцентом на періодизацію історичного розвитку річки Дагуан та комерційного району Сігуань. Детальний аналіз розвитку вуличної мережі, розподілу земельних ділянок та архітектурного планування був проведений з використанням історичних картографічних даних та змін у землекористуванні. Результати показали, як історичні, культурні та економічні чинники спільно вплинули на формування міського ландшафту Сігуаня, підкресливши його унікальний внесок у ширший контекст урбанізації Гуанчжоу. Це дослідження не тільки збагатило розуміння історичного процесу урбанізації на півдні Китаю, але й надало цінні емпіричні дані для планування майбутнього розвитку та збереження історичних районів регіону. Практичне значення роботи полягає у розробці пропозицій щодо стратегічних напрямів ефективного управління міським ландшафтом та збереження історичної спадщини старого міста Сігуань у Гуанчжоу

Ключові слова: морфологія міста; адаптація історичних районів; трансформація міського ландшафту; раціональне землекористування; стратегічне управління; охорона та збереження культурної спадщини

Architectural Studies
International Journal about Architecture

Volume 10, No. 1

UDC 691.32
DOI: 10.56318/as/1.2024.151

Turatbek Kasymov*
PhD in Technical Sciences, Professor
International University of Innovative Technologies
720048, 1/17 Ankara Str., Bishkek, Kyrgyz Republic
https://orcid.org/0000-0003-3039-2001

Bakytbek Barpiev
PhD in Physical and Mathematical Sciences, Professor
Institute of Physics named after Zh. Zheenbaev of the National Academy of Sciences of Kyrgyz Republic
720071, 265A Chui Ave., Bishkek, Kyrgyz Republic
https://orcid.org/0009-0006-0369-2964

Zhanbolot Aidaraliev
Doctor of Technical Sciences, Professor
Institute of Physics named after Zh. Zheenbaev of the National Academy of Sciences of Kyrgyz Republic
720071, 265A Chui Ave., Bishkek, Kyrgyz Republic
https://orcid.org/0000-0002-1100-3237

Ulugbek Begaliev
Doctor of Technical Sciences, Professor
International University of Innovative Technologies
720048, 1/17 Ankara Str., Bishkek, Kyrgyz Republic
https://orcid.org/0000-0002-5596-5737

Islan Omurbekov
PhD in Technical Sciences, Associate Professor
Kyrgyz Civil Engineering Institute named after. N. Isanova
of the Kyrgyz State Technical University named after I. Razzakov
720000, 34B A. Maldybaev Str., Bishkek, Kyrgyz Republic
https://orcid.org/0009-0006-0841-6205

Physical and mechanical properties of light and heavyweight concretes reinforced with basalt fibre

Abstract. The purpose of this study was to investigate the effect of basalt fibres in concrete mixtures to improve their physical and mechanical properties. The study used Portland cement grade PC400 D0, granite crushed stone, perlite gravel fill, and sand coarse aggregate to create concrete mixtures of various densities. The findings of this study confirmed that the optimum dosage of basalt fibres plays a key role in achieving the best mechanical properties of concrete. Upon proper dosage of up to 3%, the fibres improve the structure of concrete, increasing its strength and crack resistance. However, when this level is exceeded up to 5%, agglomeration of fibres and lack of cement paste to bind the aggregates result in lower flexural strength of concrete. The study also revealed that the tensile strength and compressive strength of concrete varies with basalt fibre content. The tensile (flexural) strength showed an increasing trend with the addition of up to 3% fibres, with a maximum increase of 11.3% over the original sample. However,

Suggested Citation:
Kasymov, T., Barpiev, B., Aidaraliev, Zh., Begaliev, U., & Omurbekov, I. (2024). Physical and mechanical properties of light and heavyweight concretes reinforced with basalt fibre. *Architectural Studies*, 10(1), 151-162. doi: 10.56318/as/1.2024.151.

Journal homepage: https://arch-studies.com.ua/en
Architectural Studies, 10(1), 151-162
Received: 03.03.2024 Revised: 20.05.2024 Accepted: 20.06.2024

*Corresponding author

when the basalt fibre content was further increased, the strength started to decrease, emphasising the significance of maintaining the optimum dosage. Concrete shrinkage also varied with fibre content: as the basalt fibre content increased, shrinkage decreased due to the formation of an internal reinforcing structure that prevents the movement of concrete particles. In case of lightweight concrete, analogous trends were discovered: compressive strength and flexural strength increased up to a certain level of basalt fibre content, but then decreased when the optimum dosage was exceeded. The findings emphasise the significance of careful control of basalt fibre dosage in the design of concrete structures, as insufficient or excessive basalt fibre content can adversely affect the mechanical properties of concrete. Optimised use of basalt fibres can considerably improve the strength, crack resistance, and other characteristics of concrete, making it more stable and durable under various service conditions

Keywords: structure of building materials; fibre concrete; flexural strength; compression; extrusion; tensile breaking strength; tear strength

INTRODUCTION

With the ever-increasing need for innovative materials to build sustainable and durable structures, attention to innovative approaches to concrete reinforcement becomes inevitable. This is particularly important for improving material performance in the face of various construction requirements, including mechanical resistance, durability, and environmental friendliness. One of the key factors that motivates research in this area is the search for alternative materials that can improve the strength and stability of concrete without increasing its mass or degrading its environmental performance. Notably, conventional concrete reinforcement methods may have disadvantages, including insufficient resistance to various mechanical stresses, as well as other factors. In this context, the emergence of basalt fibre represents a promising solution because of its high strength, corrosion resistance, and chemical inertness. A detailed investigation of the properties of basalt fibre reinforced concretes may offer an improved understanding of the effect of this material on various characteristics of concrete structures. These studies will not only help to determine the optimum dosages of basalt fibre to achieve the desired mechanical properties of concrete but will also help to identify potential problems or limitations that may arise during the use of this material in construction. All this can significantly contribute to the development of more efficient and sustainable building materials, helping to improve the quality and durability of concrete structures.

Basalt fibre, due to its high strength as well as other properties, is a promising solution for reinforcing both light and heavyweight concretes. I. Tashpolotov and E. Mamatov (2022) investigated the chemical composition of basalt rocks in Kyrgyzstan and found that the addition of basalt fibre significantly increases the strength of concrete, and this is due to the improvement of the internal structure of the material and more uniform distribution of loads. A. Sagyndykov *et al*. (2023) focused on studying the effect of basalt fibre on the durability of concrete structures in different climatic conditions, showing that concrete with fibre addition shows better resistance to cyclic loads and aggressive media compared to conventional concrete. However, despite the findings, questions regarding the durability and performance of basalt fibres are still open and require further investigation to fully understand and effectively apply this material in the construction industry.

An essential feature of basalt fibre is also its ability to improve adhesion between cement paste and aggregate, creating additional bonding points and increasing the density of the material. Y. Zheng *et al*. (2022) found that the use of basalt fibre in concrete composition helps to considerably reduce shrinkage and increase compressive strength, which is particularly important for structures subjected to high loads. Y. Li *et al*. (2022) focused on the durability evaluation of basalt fibre concrete and showed that such concrete exhibits increased resistance to aggressive chemical media and moisture, which makes it more durable under extreme service conditions. At the same time, Z. Li *et al*. (2022) found that basalt fibre can reduce the permeability of concrete to water and gases, which further improves its performance, reducing the risk of reinforcement corrosion and increasing the service life of structures. Thus, this confirms the need for more detailed studies for the application of this material in the construction of diverse types of structures, including those operating in harsh environments.

It should also be considered that the use of basalt fibre in concrete can have an impact on its mechanical and performance characteristics. M. Khan *et al.* (2022) found that the addition of basalt fibre can substantially increase the strength of concrete, which confirms its effectiveness in improving the crack resistance of the material. H. Zhou *et al*. (2020) also showed that basalt fibre helps to improve the frost resistance of concrete, making the material more resistant to cyclic freezing and thawing, which is particularly important for regions with harsh climates. M. Elshazli *et al*. (2022) showed that the use of basalt fibre can reduce the overall weight of structures without sacrificing their strength and durability. However, to better understand all aspects of basalt fibre use in concrete, further research is needed to determine the optimum proportions and mixing methods, and to investigate the long-term effects and interactions of fibre with the various components of the concrete mix.

The purpose of this study was to investigate the effect of basalt fibre on the physical and mechanical properties of light and heavyweight concrete. For this, the respective

objectives were set, which included determining the optimum dosage of basalt fibre to increase the flexural and tensile strength of concrete, as well as investigating the variation in compressive strength and shrinkage of concrete as a function of basalt fibre content.

MATERIALS AND METHODS

Portland cement of PC400 D0 grade manufactured at "Kant Cement Plant" (Kyrgyzstan) was used in this study. Its properties and characteristics are summarised in greater detail in Table 1.

Table 1. Characteristics of Portland cement PC400 D0

Characteristics	Indicator value
Compressive strength after 28 days, MPa	44.5
Initiation/completion of the setting process, min	300/420
Specific surface area, cm^2/g	2,850
Thickness of cement mortar, %	26

Source: developed by the authors of this study

Granite crushed stone of medium size fractions of 5-20 mm was also used in the study. The density of the material was 1,650 kg/m^3. The true density of this crushed stone was 2,700 kg/m^3. Crushed stone had a crushing capacity of – 12.5%, and the hollowness of the material was 39%. Perlite gravel fill was selected as the coarse lightweight aggregate. Its bulk density was 220 kg/m^3, but its true density was at 360 kg/m^3. The hollowness of the perlite gravel fill was up to 75%. Sand coarse aggregate was used as fine aggregate with a fraction size of 0.1-5 mm and a bulk density of 1,400-1,600 kg/m^3. The material also had a low content of organic impurities and particles. Basalt fibre in the role of dispersed reinforcement was used to reinforce the materials. The detailed characteristics of this fibre are summarised in Table 2.

Table 2. Characteristics of basalt fibre

Characteristics	Indicator value
Basalt fibre	
Tensile strength, MPa	2,800
Fibre thickness, m	$14 \cdot 10^{-6}$
Length of fibres, mm	10
Elasticity coefficient, GPa	75
Bulk density, kg/m^3	2,450

Source: developed by the authors of this study

The superplasticiser Sika ViscoCrete-20 HE (Switzerland) was used to control the mobility of concrete mortars. A hydraulic press UMM-5 (Russia) was used for compression tests. The NMP-2 instrument (Russia) was used to determine the deviations from the plane. To measure deviations from perpendicularity, the NP-3 instrument (Russia) was used in the study. Sartorius laboratory scales (Germany) were also used. The characteristics of the concrete mix composition used to create the heavyweight concrete are detailed in Table 3.

Table 3. Characteristics of concrete mix composition

Characteristics	Indicator value
Water-cement ratio	0.59
Cement, kg/m^3	369
Water, kg/m^3	199
Crushed stone, kg/m^3	1,151
Sand, kg/m^3	695
Concrete mix density (ρ), kg/m^3	2,470

Source: developed by the authors of this study

In creating lightweight concrete, 25% of the dense aggregate was replaced by porous material, keeping the cement consumption and sand to crushed stone ratio the same. The mobility of the concrete mix was controlled by adjusting the water flow rate. The concrete samples used in the study included different basalt fibre contents: A0 (no fibres), A1 (0.5%), A2 (1.5%), A3 (3%), and A4 (5%). To determine the compressive strength, the concrete samples were held in the tank for 24 hours and then placed in the testing machine. The load on the 250×250×250 mm cubes was increased at a rate of 289 kN per minute until failure. Strength was determined as the average of all samples. A hydraulic device was used to gradually increase the force at a variable rate from 0.05 to 0.15 mm per minute. The peak load (P) was calculated considering the instantaneous and residual strains of a 250×250×800 mm sample. The loading rate for the bending test was 3,745 kN per minute until the sample failed. Equation (1) is the fracture factor used to calculate the strength of a material:

$$f = PL/Bd^2, \quad (1)$$

where: L – the length of the sample; d – the depth of the sample; P – the load leading to failure; f – the flexural strength of the material.

To evaluate the flexural strength of concrete, tests were carried out on five samples of each type of mix, using universal equipment with a capacity of 350 kN and a load of 9 MPa per minute. The 200×450 mm samples contained 60 cylinders of basalt fibres in various proportions. The tensile breaking strength test was carried out at varying load rates from 0.5 to 1.5 MPa per minute until complete failure of the sample. To determine the tensile strength of concrete at splitting, the average value for three samples was taken according to the following equation (2):

$$f_p = 2P/\pi DL, \quad (2)$$

where: D – the sample diameter; f_p – the tensile strength of the material.

RESULTS

Figure 1 shows the results of the study demonstrating that an increase in the percentage of fibre volume leads to a decrease in concrete shrinkage.

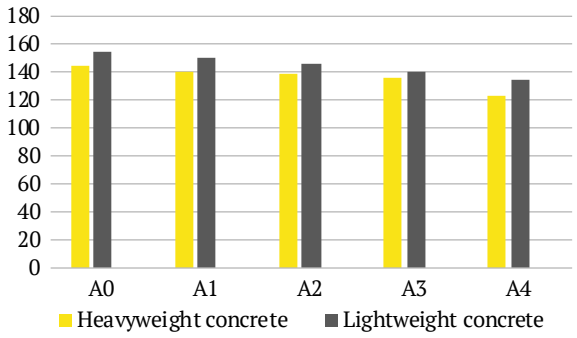


Figure 1. Results of subsidence tests on heavyweight and lightweight concrete, mm
Source: developed by the authors of this study

When adding chopped basalt fibres to concrete, a decrease in subsidence with increasing percentage of fibre content is observed and this trend is maintained throughout the experiment. For instance, for the A0 heavyweight concrete mix without chopped basalt fibres, the shrinkage value was 145 mm. In turn, for A1 concrete mix in which the basalt fibre content was 0.5%, the value of subsidence decreased to 141 mm and for the subsequent mixes, a further decrease in this value was observed to 139 mm, 136 mm, and 123 mm, respectively.

The effect of reducing concrete shrinkage by adding basalt fibres is based on a complex of physical processes occurring inside the concrete matrix. When basalt fibres are introduced into the mix, they form an internal structure resembling a reinforcing network that actively interacts with the concrete particles. This mechanism effectively restrains particle movement, preventing disintegration, and reducing water and binder seepage through the concrete matrix. As a result, the shrinkage of concrete is reduced, which is important to ensure quality structures and durability of the material (Pastsuk *et al.*, 2020; Tahwia *et al.*, 2023). Notably, the structure of basalt fibres allows water to be retained in the mixture at the micron level. This creates additional pathways for water within the concrete, which helps it to cure more efficiently and reduce shrinkage. Improving the workability of concrete is important for construction work because it facilitates the placing and shaping of structures and improves the quality and durability of the finished product.

The surface of basalt fibres also plays a key role in their interaction with the concrete matrix. Basalt fibres have microroughnesses and irregularities on their surface, which create additional contact points and improve adhesion to a binder material such as Portland cement. This mechanism promotes a more even distribution of fibres within the concrete matrix and creates a stronger structure. Increasing the amount of basalt fibres in the mix leads to an increase in the total interaction surface between the fibres and the material, which increases the number of interaction sites. This substantially strengthens the structure of concrete, making it more resistant to various impacts (Yu *et al.*, 2022). The increased contact area between the fibres and the concrete contributes to better handling of subsidence and enhancing its mechanical performance.

An essential aspect is also that microroughnesses and irregularities on the surface of basalt fibres contribute to the creation of additional mechanical interlocks with the concrete. This gives extra support and strengthens the bond between the fibres and the material, which ultimately increases its strength and stability. Thus, the surface characteristics of basalt fibres are crucial for the formation of a high-quality and durable concrete structure with high mechanical properties and resistance to various influences. Furthermore, the workability of concrete is significantly affected by parameters such as mixing ratio and moisture content. The correct proportion of water and binder material, ensured by an optimum mixing ratio, allows achieving an optimum consistency of the mixture, which is important for the ease of placement (Zhao *et al.*, 2020). Moisture content plays an important role in the proper performance of concrete, as insufficient or excessive moisture can lead to undesirable changes in concrete properties. Examination of the data presented in Figure 2 reveals the dynamics of changes in the compressive strength of heavyweight concrete when basalt fibre is used. When analysing the results of the study, it can be observed that when 0.5% basalt fibre is added, the compressive strength of the concrete stays almost unchanged compared to the control A0 concrete, showing a stable value of 74.5 MPa in the 28-day test. This result suggests that a small amount of basalt fibre does not substantially affect the compressive strength properties of concrete. However, with further increase in fibre concentration, some decrease in compressive strength of concrete is observed. For A1 concrete

with fibre content at 0.5%, this reduction is 2.34% and for A2 concrete it is 3.01% compared to the control concrete. This indicates that an increase in basalt fibre content may adversely affect the compressive strength properties of concrete. Such changes may be related to the specific features of the interaction between basalt fibres and the concrete matrix, which may have a negative effect on the mechanical properties of the material. In turn, the results of the study using basalt fibre for lightweight concrete, are presented in Figure 3.

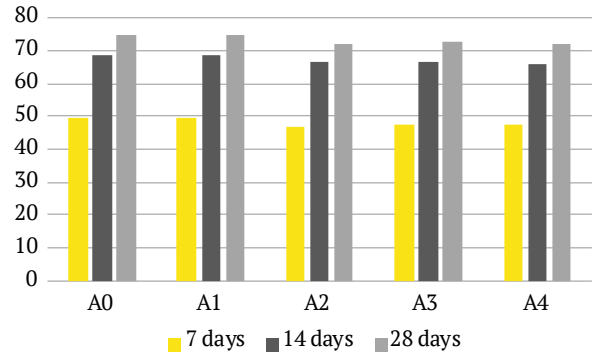


Figure 2. Results of research on compressive strength of heavyweight concretes, MPa
Source: developed by the authors of this study

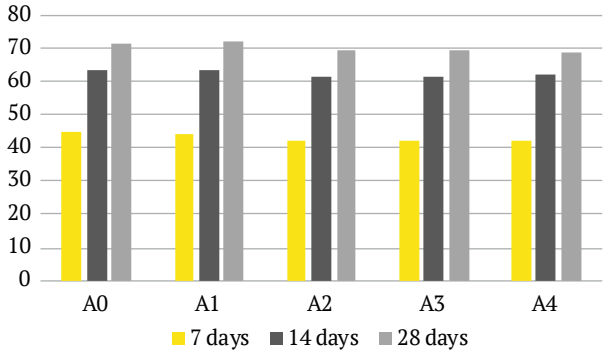


Figure 3. Results of the study on compressive strength of lightweight concretes, MPa
Source: developed by the authors of this study

Table 4. Average results of compressive strength tests

Sample No.	Solution name	Heavyweight concretes			Lightweight concretes		
		7 days	14 days	28 days	7 days	14 days	28 days
1	A0	49.8	66.4	73.4	44.3	60.3	69.7
2	A1	49.9	66.5	73.7	44.5	60.5	69.9
3	A2	47.5	64.8	71.2	42.3	58.9	68.2
4	A3	47.9	64.9	71.3	42.8	58.8	68.5
5	A4	47.6	64.3	70.8	42.5	58.2	68.1

Source: developed by the authors of this study

Notably, when lightweight concretes are considered, analogous trends in strength change with the addition of basalt fibre are observed. For instance, at a fibre concentration of 0.5%, the compressive strength of concrete can stay stable as in the case of heavyweight concrete, reaching values of about 71.5 MPa after 28 days of curing. However, when the fibre concentration is increased to 1.5% or more, a strength reduction analogous to that observed in heavyweight concrete may appear (Table 4).

These results may be conditioned by a series of factors, including the interaction features between the fibres and the concrete matrix (Zhang *et al.*, 2023). First of all, fibre concentration can play a key role in determining the strength properties of concrete. At low fibre concentrations, such as 0.5%, its effect on mechanical properties can remain negligible or even positive, as the fibres can strengthen the structure of the material without substantially affecting its mechanical properties. However, when the fibre concentration is further increased, for instance to 1.5%, 2.5%, or more, undesirable effects such as a reduction in the strength of the concrete may occur. Notably, an important aspect is the quality of basalt fibre and its dispersion in concrete. Uniform distribution of fibres in the matrix can contribute to better reinforcement of the material and increased strength. However, if the fibres are unevenly distributed or of poor quality, it may lead to the formation of weak areas in the concrete and consequently reduce its strength (Liu *et al.*, 2021).

The interaction of basalt fibres with cement paste and aggregate in concrete should also be considered. If the fibres are not sufficiently bonded to the matrix or insufficient binder is present to ensure proper adhesion, this can also reduce the strength properties of the material. Fibres, being unevenly distributed, can form clusters, which leads to local stress concentrations and development of microcracks. In turn, the lack of cement paste reduces the ability of the bonding components to effectively surround and retain aggregates, which deteriorates the overall cohesiveness and density of the concrete structure (Zajac *et al.*, 2020). These factors are particularly critical at high fibre concentrations where basalt fibres begin to compete for the limited amount of cement paste, reducing its availability to aggregates and weakening the final composite matrix. The results presented in Figures 4 and 5 provide a detailed analysis of the concrete tensile strength and related parameters.

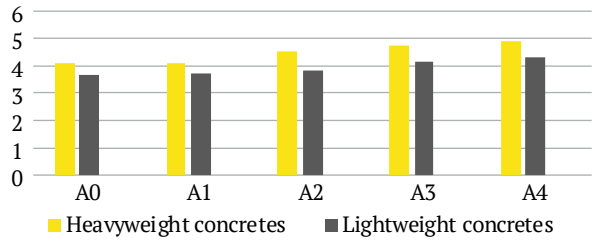


Figure 4. Tensile strength results of heavyweight and lightweight concretes, MPa
Source: developed by the authors of this study

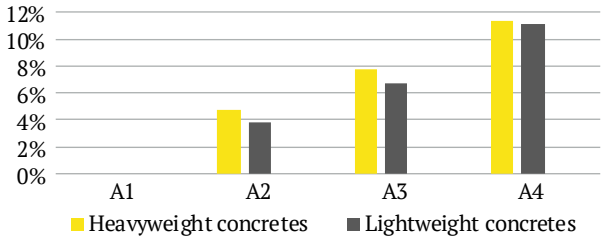


Figure 5. Dynamics of tensile strength increase of heavyweight and lightweight concrete, %
Source: developed by the authors of this study

When the mixture of heavyweight concrete without fibre addition was analysed, it was found that the breaking tensile strength was 4.1 MPa. This value stays constant when 0.5% basalt fibre is added. However, when 1.5% fibre was introduced, an increase in tensile strength of up to 4.7% was observed, which is higher than the control concrete. When the fibre content is further increased to 3%, the strength increases further, reaching an increase of 11.3%. The maximum strength is fixed at this fibre content. Increasing the proportion of basalt fibre in the concrete mixture leads to the manifestation of signs of cracking of the material, which contributes to the improvement of crack resistance of concrete. This effect can be attributed to several important processes occurring within the concrete matrix. First of all, basalt fibres distributed in the mix create an internal reinforcing network. This reinforcement prevents the propagation of micro-cracks that are caused by stresses. The fibres act as barriers, redirecting and dissipating stresses, which slows down crack development and reduces crack size (Li *et al.*, 2022a). The structure and properties of basalt fibres also contribute to a more even distribution of loads in the concrete matrix. The fibres have high tensile strength and modulus of elasticity, which allows them to effectively take up part of the load, thereby reducing stresses in the cement paste and aggregates. This even distribution of loads reduces the probability of weaknesses in the concrete and helps to improve its strength properties.

It is worth emphasising that basalt fibres play an important role in improving the adhesion between cement paste and aggregate in concrete mixes. These fibres, with their high strength and resistance to chemical attack, create additional bonding points in the concrete structure (Tamayo *et al.*, 2022). The microroughness and surface roughness of basalt fibres contribute to more effective mechanical interlocking with the cement paste, which provides better bonding of the mixture components. This improves the stress distribution within the concrete matrix, reducing the probability of micro-cracks forming and propagating under load. Additionally, basalt fibres have high surface activity, which facilitates the formation of chemical bonds between the fibres and the cement paste. These bonds strengthen the overall structure of concrete, making it denser and more resistant to various external influences. As a result, concrete mix with basalt fibre addition shows not only improved crack resistance, but also increased compressive and flexural strength. This is because the fibres effectively bind the cement matrix and aggregates, preventing them from separating under the influence of external forces.

An important aspect of using basalt fibres is their ability to be evenly distributed throughout the entire mass of the concrete mix. This ensures the creation of a homogeneous internal structure of concrete, which considerably improves its mechanical properties (Mohamed *et al.*, 2021). As a result, concrete with basalt fibres can withstand higher loads and shows a long service life without significant changes in its properties. This mix is particularly effective in applications where concrete is subjected to constant dynamic loads or extreme temperature conditions. Figures 6 and 7 show the results of the average flexural strength and the percentage increase in this strength compared to the original concrete after 28 days.

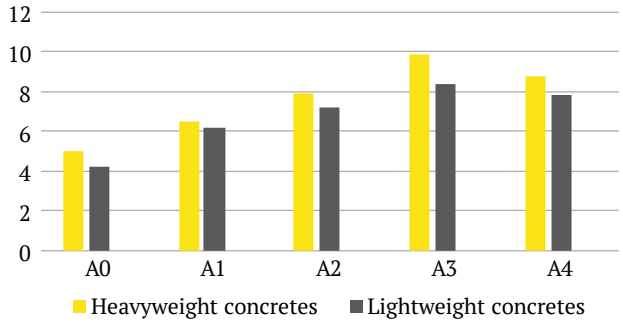


Figure 6. Average results of flexural strength tests of heavyweight and lightweight concrete, MPa
Source: developed by the authors of this study

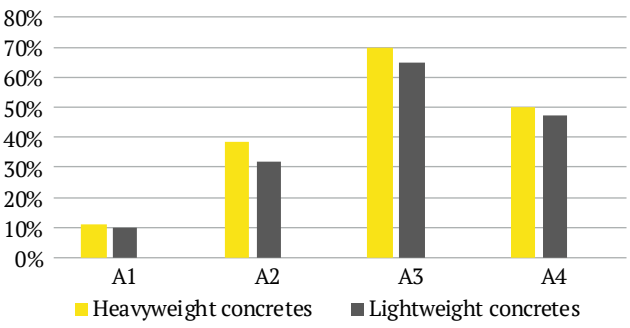


Figure 7. Dynamics of increase in average flexural strength of heavyweight and lightweight concretes
Source: developed by the authors of this study

Analysing the obtained results, it can be noted that the average flexural strength of the original concrete without fibre addition was 5.05 MPa. When 0.5% basalt fibres were added, the flexural strength increased by 11% for the A1 grade mix. This initial increase in strength is due to the fact that the basalt fibre begins to form an internal reinforcing structure that helps hold the concrete particles together, thereby preventing the development of micro-cracks and distributing loads more evenly. The fibres effectively limit crack growth and improve the overall strength of the material. A considerable improvement was observed when 1.5% fibres were added: the flexural strength increased by 38.5% compared to the original concrete. With this number of fibres, their reinforcing effect becomes more pronounced. They create multiple bonding points with the cement matrix, increasing its density and preventing the propagation of cracks. This results in a considerable increase in flexural strength, as the fibres effectively resist tensile forces and strengthen the concrete structure. When the fibre fraction was further increased to 3%, the average flexural strength reached 9.9 MPa, corresponding to an increase of 69.8%. This value was found to be the maximum for the A4 grade mix. With this fibre concentration, the fibres provide an even denser reinforcement, which considerably increases the mechanical resistance of the concrete. However, when 5% fibres were added, the flexural strength started to decrease. This is due to several factors that affect the interaction between fibres, cement paste and aggregates. First of all, the binding action of the fibres effectively limits crack growth only up to a certain limit, at which level the fibres create a sufficiently dense internal reinforcing structure that improves the ductility of the concrete and distributes loads more evenly. This helps to increase flexural strength as the fibres hold the concrete matrix together, preventing the propagation of micro-cracks and increasing the material's resistance to tensile forces.

Also importantly, when the fibre content is increased to 5% their effect on strength becomes negligible or even negative. This is due to agglomeration of the fibres as they begin to cluster or "bundle" together. These clusters of fibres create weak zones in the concrete matrix where strength is substantially lower. In these areas, the cement paste cannot effectively bond to the fibres and aggregates, resulting in a deterioration of the overall structural integrity of the concrete. Furthermore, the excessive number of fibres requires more cement paste to envelop and bind them. This reduces the amount of cement paste available to bind the aggregates, which impairs the overall cohesion and strength of the concrete. As a result, the bond between aggregates and cement paste is weakened, which negatively affects the mechanical properties of the material including flexural strength (Liu *et al.*, 2020). In addition, with higher fibre concentrations there are difficulties in distributing them evenly in the mix. Improper distribution of fibres can lead to the formation of inhomogeneities in the structure of concrete, which also adversely affects its strength properties (Anas *et al.*, 2022). The fibres begin to flocculate, further exacerbating the agglomeration problem. The obtained findings confirmed that the optimum dosage of basalt fibres plays a key role in achieving the best mechanical properties of concrete. At the correct dosage (up to 3%), the fibres improve the structure of concrete, increasing its strength and crack resistance. However, when this optimum level is exceeded (5%), agglomeration of fibres and lack of cement paste to bind the aggregates result in lower flexural strength of concrete. Consequently, the balance between the number of fibres and their uniform distribution in the concrete mix is a critical factor in ensuring high performance of the material.

Thus, the use of basalt fibres in concrete, both heavyweight and lightweight, requires careful control of their concentration to achieve optimum mechanical properties. Fibres can considerably improve the tensile strength, compressive strength, and crack resistance of concretes, but exceeding the optimum concentration leads to deterioration of these characteristics. This confirms that to obtain the best performing concrete, a balance must be struck between the amount of basalt fibres and their uniform distribution in the mix.

DISCUSSION

Building materials research plays a key role in the successful development of the construction industry. They can contribute to the improvement of existing materials and the development of new ones with improved performance characteristics. The importance of such studies is conditioned by the need to improve the durability, strength, and stability of building structures, which is especially relevant in the conditions of increasing loads and increasingly complex operating conditions. In addition, new developments and improvements in this area contribute to the economic efficiency of construction projects. Improvement of materials and technologies makes it possible to reduce the costs of construction and operation of buildings and structures. The introduction of new materials with improved characteristics also helps to reduce construction time and improve the quality of finished projects, ultimately resulting in resource savings and longer life cycles. Additionally, the various building materials must fulfil high requirements in terms of mechanical performance as well as environmental safety. In this regard, research aimed at reducing the negative environmental impact of construction processes is becoming increasingly important. The use of green and renewable resources such as natural fibres and waste materials reduces the carbon footprint of the construction industry and promotes sustainable construction.

In this study, it was found that when chopped basalt fibres were added to the concrete, there was a decrease in shrinkage with increasing percentage of fibres, which was a characteristic throughout the entire study. For the A0 heavyweight concrete mix, which did not contain chopped basalt fibres, the value of subsidence was 145 mm. In A1 concrete mix containing 0.5% basalt fibres, the shrinkage value decreased to 141 mm. Further increases in fibre

content continued to reduce shrinkage: for A2 mix containing 1.5% fibres the shrinkage was 139 mm, for A3 mix with 3% fibres – 136 mm, and for A4 mix with 5% fibres – 123 mm. These results indicate a significant effect of basalt fibres on the rheological properties of concrete mixture. The reduction in shrinkage can be attributed to the formation of a denser and more cohesive internal structure in concrete due to the presence of fibres. Basalt fibres act as micro-reinforcing elements that prevent concrete particles from moving under their own weight and external loads. As a result, they help to improve the mixture's resistance to deformation. The observed decrease in shrinkage with increasing basalt fibre content has important practical implications for the construction industry. Lower shrinkage contributes to improved controllability and workability of the concrete mixture, which is particularly important when pouring and moulding structures. This allows for greater accuracy in the shape and size of the elements and reduces the probability of voids and defects in the finished product. B. Al-Kharabsheh *et al*. (2023) also found that the addition of basalt fibres substantially improves the mechanical properties of concrete including its resistance to cracking, especially at low fibre dosages. V. John and B. Dharmar (2021) showed that basalt fibres contribute to the durability of concrete structures by improving their resistance to freezing and thawing, as well as to the effects of aggressive chemical media. E. Al-Rousan *et al*. (2023) also showed a considerable reduction in shrinkage and cracking of concrete when basalt fibres were added, which helps to improve the overall structural integrity of the material. Nevertheless, the findings of the present study, in contrast to the cited studies, highlight the significance of proper dosing of basalt fibres to achieve optimum performance of the concrete mix. Increased crack resistance, improved structure and reduced shrinkage make concrete with basalt fibres a promising material for use in various construction applications where high mechanical and performance properties are required.

When analysing the results of the study, it is also important to note that the addition of 0.5% basalt fibre to the concrete had almost no effect on the compressive strength of the concrete compared to A0 concrete. The strength of the concrete at 28-day test stayed stable at 74.5 MPa. This result shows that a small amount of basalt fibre has no significant effect on the compressive strength properties of concrete. However, with further increase in fibre concentration, a tendency to decrease the compressive strength of concrete was observed. For instance, for A1 concrete with fibre content at 0.5%, the strength reduction was 2.34%, and for A2 concrete with 1.5-3.01% compared to A0 concrete. This indicates that negative effects on the mechanical properties of concrete may occur when the basalt fibre content is increased. This is probably caused by the specific features of interaction between basalt fibres and cement matrix, which can deteriorate the structure of the material and reduce its strength characteristics. Analogous trends are observed in lightweight concrete. When 0.5% fibre was added, the compressive strength of the concrete stayed stable, reaching values of about 71.5 MPa after 28 days of curing. However, when the fibre concentration was increased to 1.5% or more, the compressive strength of concrete started to decrease, which confirms the observations made for heavyweight concretes. These findings have important implications for the design and optimisation of concrete mixtures, especially when strength and crack resistance enhancement is required without considerably altering other mechanical properties. They point out that the amount of basalt fibre introduced into the mix needs to be carefully controlled to avoid adverse effects on the compressive strength of concrete. The findings also highlight that basalt fibre can be an effective material for improving the performance of both light and heavyweight concretes but requires optimisation of dosage to achieve maximum effect. H. Dilbas and Ö. Çakır (2020) also found that the addition of basalt fibres to concrete can improve its crack resistance and mechanical resistance, but a decrease in strength properties was observed when the optimum dosage was exceeded. C. Zhang *et al*. (2021) showed that various additives in concrete mix, including basalt fibres, contribute to the durability of concrete by improving its resistance to aggressive media and cyclic loading. Thus, the findings of this study, in conjunction with the above mentioned studies, highlight the significance of accurately determining and maintaining the optimum dosage of reinforcing fibres to achieve the best mechanical properties and durability of concrete, as well as the need for further research to better understand the interaction of such fibres with the concrete matrix.

A significant result of the study is also the finding that when the heavyweight concrete without fibre addition was analysed, the breaking tensile strength was 4.1 MPa. This value stayed unchanged when 0.5% basalt fibre was added, indicating that there was no significant effect of small amount of fibre on the tensile strength of concrete. However, when 1.5% basalt fibre was introduced, a marked increase in tensile strength up to 4.7 MPa was observed, which is significantly higher than that of the original A0 concrete. When the fibre content was further increased to 3%, the strength increased even further, reaching an increase of 11.3% over the original concrete. This result demonstrates that basalt fibre can considerably improve the tensile strength if the dosage is followed precisely. The maximum strength is recorded exactly at a fibre content of 3%, which emphasises the significance of accurate dosage selection to achieve the best results. The findings suggest that basalt fibre effectively improves the mechanical properties of concrete in tensile breaking, but only if the optimum dosage is maintained. Exceeding this level does not provide additional benefits and may even lead to reduced strength, as proved in other studies. This confirms the need to accurately determine and follow the optimum dosage of basalt fibre. This is a critical factor for improving the strength properties of concrete, which is important for its application in construction projects. L. Dvorkin *et al*. (2021)

showed that the addition of basalt fibre to concrete mixtures can considerably improve their strength characteristics at certain dosages, demonstrating that the optimum concentration of basalt fibre contributes to the strength of different types of concrete. Q. Liu *et al*. (2022) focused on the effect of carbon fibres and showed that their addition also improved the mechanical properties of concrete, but at slightly higher fibre concentrations. At the same time, when comparing the findings of the present study with those of the cited studies, it should be noted that in the former, the effect of different dosages of basalt fibre on the compressive strength of concrete was examined in greater detail. This allows drawing more comprehensive conclusions on the behaviour of concrete when the basalt fibre content is varied, highlighting the significance of precise adherence to the optimum dosage to achieve the best performance. Overall, the study complements and extends the existing data, confirming the effectiveness of reinforcing fibres in the form of basalt fibre and highlighting the need for further research to optimise its use in concrete mixtures.

One of the key findings of this study was to confirm that the addition of basalt fibres substantially affects the flexural strength properties of concrete mixtures. Starting with a small fibre content of 0.5%, a noticeable increase in flexural strength of 11% was observed for the A1 grade mix. This suggests the initial positive effect of the fibres, which form an internal reinforcing structure, inhibiting the development of micro-cracks and distributing the load evenly. Next, when 1.5% fibres were introduced, the increase in flexural strength was already 38.5%, indicating a more intensive reinforcement of their structure. The effective resistance of the fibres to tensile forces and the strengthening of the concrete results in a significant increase in its strength. On further increase in fibre content up to 3%, maximum increase in flexural strength was observed up to 69.8% for A4 grade mix. This result demonstrates that for a given fibre concentration, the optimum reinforcement of concrete is achieved to maximise its mechanical resistance. However, exceeding this dosage up to 5% begins to have a negative effect on the strength of concrete, which is probably due to the specific features of interaction of fibres with cement paste and aggregates. These results play an important role in the field of concrete structures design, especially in the context of finding effective methods to improve their mechanical properties. Understanding the effect of basalt fibre content on the flexural strength of concrete can enable the optimisation of concrete mixes to achieve maximum strength and durability of structures. L. Yang *et al*. (2021) also found that the addition of a large amount of fibre can lead to a decrease in the flexural strength of concrete, indicating insufficient binding to the concrete matrix. S. Biradar *et al*. (2020) also investigated analogous properties, but using materials with distinctive characteristics, highlighting the significance of considering the characteristics of each specific material when using it in concrete mixtures and noting the need for more research to optimise the conditions of use of such reinforcement additives. However, the findings of the present study, in contrast to the studies cited above, suggest the potential effectiveness of basalt fibre as a reinforcing admixture to improve the mechanical properties of concrete. These findings highlight the significance of research in optimising the composition of concrete mixtures considering a range of factors including the type and concentration of materials added.

Thus, the findings of all such studies may not only improve the general understanding of the effect of various reinforcing materials on concrete performance, but also emphasise the significance of further research in this area. Understanding these interrelationships will open new opportunities to develop more efficient and sustainable building materials, which contributes to infrastructure development, improved safety and durability of building structures, and reduced environmental impact. All these factors make such research necessary and relevant for the development of the construction industry and the sustainable development of society.

CONCLUSIONS

As a result of this study, it was confirmed that the optimum dosage of basalt fibres plays a key role in achieving the best mechanical properties of concrete. Upon proper dosage (up to 3%), the fibres improve the structure of concrete, increasing its strength and crack resistance. However, when this optimum level is exceeded (5%), agglomeration of fibres and lack of cement paste to bind the aggregates result in lower flexural strength of concrete.

The study also revealed that the tensile strength and compressive strength of concrete varies with basalt fibre content. The tensile strength showed an increasing trend with the addition of up to 3% fibres, with a maximum increase of 11.3% over the original concrete sample. However, with further increase in fibre content, the tensile strength started to decrease, indicating the significance of maintaining the optimum dosage. The compressive strength with up to 0.5% fibres stayed almost unchanged compared to the control concrete sample. However, when 1.5% fibres were added, the average compressive strength decreased by 2.34% and at 3% the average compressive strength decreased by 3.01% compared to the control concrete sample. The shrinkage of concrete also showed significant variations depending on the fibre content. As the basalt fibre content increased, the shrinkage decreased due to the formation of internal reinforcing structure that prevents the movement of concrete particles and shrinkage reduction. For the heavyweight concrete mix without fibres (A0) the shrinkage was 145 mm, while for the mix with 5% fibres (A4) it decreased to 123 mm. In the case of lightweight concretes, the results showed comparable trends. The compressive strength increased up to a certain level of fibre content but then decreased when the optimum dosage was exceeded. Tensile strength and flexural strength also improved with the addition of up to 3% fibres, confirming the effectiveness of basalt fibres in improving the mechanical properties of concrete.

It is worth remembering that while the study showed considerable positive results, it also revealed some limitations. For instance, the effect of basalt fibres on the durability of concrete under different climatic conditions and over a prolonged period is still understudied. Furthermore, the optimum fibre dosage may vary depending on the type of concrete and its application conditions. Further research in this area may include a more in-depth analysis of the effect of basalt fibres on other concrete characteristics, such as cyclic load resistance, and possible changes in the microstructure of the material, to better understand the long-term effects and performance of basalt fibres under different service conditions.

ACKNOWLEDGEMENTS

None.

CONFLICT OF INTEREST

The authors of this study declare no conflict of interest.

REFERENCES

[1] Al-Kharabsheh, B.N., Arbili, M.M., Majdi, A., Alogla, S.M., Hakamy, A., Ahmad, J., & Deifalla, A.F. (2023). Basalt fiber reinforced concrete: A compressive review on durability aspects. *Materials*, 16(1), article number 429. doi: 10.3390/ma16010429.

[2] Al-Rousan, E.T., Khalid, H.R., & Rahman, M.K. (2023). Fresh, mechanical, and durability properties of basalt fiber-reinforced concrete (BFRC): A review. *Developments in the Built Environment*, 14, article number 100155. doi: 10.1016/j.dibe.2023.100155.

[3] Anas, M., Khan, M., Bilal, H., Jadoon, Sh., & Khan, M.N. (2022). Fiber reinforced concrete: A review. *Engineering Proceedings*, 22(1), article number 3. doi: 10.3390/engproc2022022003.

[4] Biradar, S.V., Dileep, M.S., & Gowri, T.V. (2020). Studies of concrete mechanical properties with basalt fibers. *IOP Conference Series: Materials Science and Engineering*, 1006, article number 012031. doi: 10.1088/1757-899X/1006/1/012031.

[5] Dilbas, H., & Çakır, Ö. (2020). Influence of basalt fiber on physical and mechanical properties of treated recycled aggregate concrete. *Construction and Building Materials*, 254, article number 119216. doi: 10.1016/j.conbuildmat.2020.119216.

[6] Dvorkin, L., Bordiuzhenko, O., Tekle, B.H., & Ribakov, Yu. (2021). A method for the design of concrete with combined steel and basalt fiber. *Applied Sciences*, 11(19), article number 8850. doi: 10.3390/app11198850.

[7] Elshazli, M.T., Ramirez, K., Ibrahim, A., & Badran, M. (2022). Mechanical, durability and corrosion properties of basalt fiber concrete. *Fibers*, 10(2), article number 10. doi: 10.3390/fib10020010.

[8] John, V.J., & Dharmar, B. (2021). Influence of basalt fibers on the mechanical behavior of concrete – a review. *Structural Concrete*, 22(1), 491-502. doi: 10.1002/suco.201900086.

[9] Khan, M., Cao, M., Xie, Ch., & Ali, M. (2022). Hybrid fiber concrete with different basalt fiber length and content. *Structural Concrete*, 23(1), 346-364. doi: 10.1002/suco.202000472.

[10] Li, H., Lin, J., Lei, X., & Wei, T. (2022a). Compressive strength prediction of basalt fiber reinforced concrete via random forest algorithm. *Materials Today Communications*, 30, article number 103117. doi: 10.1016/j.mtcomm.2021.103117.

[11] Li, Y., Zhang, J., He, Yi., Huang, G., Li, J., Niu, Zh., & Gao, B. (2022). A review on durability of basalt fiber reinforced concrete. *Composites Science and Technology*, 225, article number 109519. doi: 10.1016/j.compscitech.2022.109519.

[12] Li, Zh., Shen, A., Zeng, G., Chen, Zh., & Guo, Yi. (2022). Research progress on properties of basalt fiber-reinforced cement concrete. *Materials Today Communications*, 33, article number 104824. doi: 10.1016/j.mtcomm.2022.104824.

[13] Liu, F., Xu, K., Ding, W., Qiao, Ya., & Wang, L. (2021). Microstructural characteristics and their impact on mechanical properties of steel-PVA fiber reinforced concrete. *Cement and Concrete Composites*, 123, article number 104196. doi: 10.1016/j.cemconcomp.2021.104196.

[14] Liu, Q., Song, P., Li, L., Wang, Yu., Wang, X., & Fang, J. (2022). The effect of basalt fiber addition on cement concrete: A review focused on basalt fiber shotcrete. *Frontiers in Materials*, 9, article number 1048228. doi: 10.3389/fmats.2022.1048228.

[15] Liu, R., Li, H., Jiang, Q., & Meng, X. (2020). Experimental investigation on flexural properties of directional steel fiber reinforced rubberized concrete. *Structures*, 27, 1660-1669. doi: 10.1016/j.istruc.2020.08.007.

[16] Mohamed, O.A., Al Hawat, W., & Keshawarz, M. (2021). Durability and mechanical properties of concrete reinforced with basalt fiber-reinforced polymer (BFRP) bars: Towards sustainable infrastructure. *Polymers*, 13(9), article number 1402. doi: 10.3390/polym13091402.

[17] Pastsuk, V., Kiisk, M., Lõhmus, R., Merisalu, M., Kovaljov, S., Biland, A., & Gulik, V. (2020). Selection of basalt fiber with resistance to concrete alkaline environment. *SN Applied Sciences*, 2, article number 1842. doi: 10.1007/s42452-020-03677-z.

[18] Sagyndykov, A., Nurlybayev, B., Meirmanov, A., & Jappar, E. (2023). Foam fiber made of basalt fiber. *Mechanics and Technologies*, 3, 136-142. doi: 10.55956/GOKU4360.

[19] Tahwia, A.M., Helal, K.A., & Youssf, O. (2023). Chopped basalt fiber-reinforced high-performance concrete: An experimental and analytical study. *Journal of Composites Science*, 7(6), article number 250. doi: 10.3390/jcs7060250.
[20] Tamayo, P., Aghajanian, A., Rico, J., Setién, J., Polanco, J.A., & Thomas, C. (2022). Characterization of the adherence strength and the aggregate-paste bond of prestressed concrete with siderurgical aggregates. *Journal of Building Engineering*, 54, article number 104595. doi: 10.1016/j.jobe.2022.104595.
[21] Tashpolotov, Y., & Mamatov, E. (2022). Chemical composition of basalt rocks of the Kyzyl-Kiy deposit of the Kyrgyz Republic. *Bulletin of Osh State University. Mathematics. Physics. Technical Sciences*, 1, 81-91. doi: 10.52754/16948645_2022_1_8.
[22] Yang, L., Xie, H., Fang, S., Huang, C., Yang, A., & Chao, Y.J. (2021). Experimental study on mechanical properties and damage mechanism of basalt fiber reinforced concrete under uniaxial compression. *Structures*, 31, 330-340. doi: 10.1016/j.istruc.2021.01.071.
[23] Yu, H., Meng, T., Zhao, Yu., Liao, J., & Ying, K. (2022). Effects of basalt fiber powder on mechanical properties and microstructure of concrete. *Case Studies in Construction Materials*, 17, article number e01286. doi: 10.1016/j.cscm.2022.e01286.
[24] Zajac, M., Skocek, J., Durdzinski, P., Bullerjahn, F., Skibsted, J., & Haha, M.B. (2020). Effect of carbonated cement paste on composite cement hydration and performance. *Cement and Concrete Research*, 134, article number 106090. doi: 10.1016/j.cemconres.2020.106090.
[25] Zhang, Ch., Wang, Ya., Zhang, X., Ding, Ya., & Xu, P. (2021). Mechanical properties and microstructure of basalt fiber-reinforced recycled concrete. *Journal of Cleaner Production*, 278, article number 123252. doi: 10.1016/j.jclepro.2020.123252.
[26] Zhang, P., Wang, C., Gao, Zh., & Wang, F. (2023). A review on fracture properties of steel fiber reinforced concrete. *Journal of Building Engineering*, 67, article number 105975. doi: 10.1016/j.jobe.2023.105975.
[27] Zhao, Yu., Taheri, A., Karakus, M., Chen, Zh., & Deng, A. (2020). Effects of water content, water type and temperature on the rheological behaviour of slag-cement and fly ash-cement paste backfill. *International Journal of Mining Science and Technology*, 30(3), 271-278. doi: 10.1016/j.ijmst.2020.03.003.
[28] Zheng, Yu., Zhang, Y., Zhuo, J., Zhang, Ya., & Wan, C. (2022). A review of the mechanical properties and durability of basalt fiber-reinforced concrete. *Construction and Building Materials*, 359, article number 129360. doi: 10.1016/j.conbuildmat.2022.129360.
[29] Zhou, H., Jia, B., Huang, H., & Mou, Ya. (2020). Experimental study on basic mechanical properties of basalt fiber reinforced concrete. *Materials*, 13(6), article number 1362. doi: 10.3390/ma13061362.

Туратбек Касимов

Кандидат технічних наук, професор
Міжнародний університет інноваційних технологій
720048, вул. Анкара, 1/17, м. Бішкек, Киргизька Республіка
https://orcid.org/0000-0003-3039-2001

Бакитбек Барпієв

Кандидат фізико-математичних наук, професор
Інститут фізики ім. акад. Ж. Жеєнбаєва Національної академії наук Киргизької Республіки
720071, просп. Чуй, 265А, м. Бішкек, Киргизька Республіка
https://orcid.org/0009-0006-0369-2964

Жанболот Айдаралієв

Доктор технічних наук, професор
Інститут фізики ім. акад. Ж. Жеєнбаєва Національної академії наук Киргизької Республіки
720071, просп. Чуй, 265А, м. Бішкек, Киргизька Республіка
https://orcid.org/0000-0002-1100-3237

Улугбек Бегалієв

Доктор технічних наук, професор
Міжнародний університет інноваційних технологій
720048, вул. Анкара, 1/17, м. Бішкек, Киргизька Республіка
https://orcid.org/0000-0002-5596-5737

Ислан Омурбеков

Кандидат технічних наук, доцент
Киргизький інженерно-будівельний інститут ім. Н. Ісанова Киргизького державного технічному університеті ім. І. Раззакова
720000, вул. А. Малдибаєва, 34Б, м. Бішкек, Киргизька Республіка
https://orcid.org/0009-0006-0841-6205

Фізико-механічні властивості легких і важких бетонів, армованих базальтовою фіброю

Анотація. Це дослідження було спрямоване на вивчення впливу базальтових фібр у бетонних сумішах для поліпшення їхніх фізико-механічних властивостей. Під час роботи використовували портландцемент марки ПЦ400 Д0, гранітний щебінь, перлітове гравійне наповнення і піщану крупку для створення бетонних сумішей різної щільності. Результати проведеної роботи підтвердили, що оптимальне дозування базальтових волокон відіграє ключову роль у досягненні найкращих механічних властивостей бетону. При правильному дозуванні до 3 %, волокна покращують структуру бетону, підвищуючи його міцність і тріщиностійкість. Однак при перевищенні цього рівня до 5 %, агломерація волокон і нестача цементної пасти для зв'язування заповнювачів призводять до зниження міцності бетону на вигин. Дослідження також виявило, що міцність на розрив і міцність на стиск бетону змінюються залежно від вмісту базальтових фібр. Міцність на розрив (вигин) показала тенденцію до збільшення при додаванні до 3 % волокон, з максимальним збільшенням на 11,3 % порівняно з вихідним зразком. Однак при подальшому збільшенні вмісту базальтових фібр, міцність почала знижуватися, підкреслюючи важливість дотримання оптимального дозування. Усадка бетону також змінювалася залежно від вмісту волокон: при збільшенні вмісту базальтових фібр усадка зменшувалася, що пов'язано з формуванням внутрішньої армувальної структури, яка перешкоджає переміщенню частинок бетону. У разі легких бетонів було виявлено аналогічні тенденції: міцність на стиск і міцність на вигин збільшувалися до певного рівня вмісту базальтових фібр, але потім знижувалися в разі перевищення оптимального дозування. Отримані результати підкреслюють важливість ретельного контролю дозування базальтових фібр під час проєктування бетонних конструкцій, оскільки недостатній або надлишковий вміст базальтових фібр може негативно вплинути на механічні властивості бетону. Оптимальне використання базальтових фібр може значно поліпшити міцність, тріщиностійкість та інші характеристики бетону, роблячи його більш стійким і довговічним у різних умовах експлуатації

Ключові слова: структура будівельних матеріалів; фібробетон; міцність на вигин; стиск; розривний розтяг; міцність на розрив; розривне розтягнення

ARCHITECTURAL STUDIES
International Journal about Architecture

Volume 10, No. 1
2024

Literary editor:
D. Chokhlenko

Editing bibliographic lists:
D. Chokhlenko

Desktop publishing:
O. Glinchenko

Signed to the print 27/02/2024
Format 60×84/8
Conventional Printed Sheet 19.1
Circulation 100 copies

Publisher: Lviv Polytechnic National University
79013, 12 Stepan Bandera Str., Lviv, Ukraine
Tel.: +380322584100
E-mail: info@arch-studies.com.ua
https://arch-studies.com.ua/en

АРХІТЕКТУРНІ ДОСЛІДЖЕННЯ
Міжнародний науковий журнал про архітектуру

Том 10, № 1
2024

Літературний редактор:
Д. Чохленко

Редагування бібліографічних списків:
Д. Чохленко

Комп'ютерна верстка:
О. Глінченко

Підписано до друку 27.02.2024 р.
Формат 60×84/8
Ум. друк. арк. 19,1
Наклад 100 прим.

Видавництво: Національний університет «Львівська політехніка»
79013, вул. Степана Бандери, 12, м. Львів, Україна
Тел.: +380322584100
E-mail: info@arch-studies.com.ua
https://arch-studies.com.ua/uk