

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

Lviv Polytechnic National University

ARCHITECTURAL STUDIES

International Journal about Architecture

Founded in 2014
Frequency of issue: 4 times a year

Volume 11, No. 4

Lviv – 2025

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

Національний університет «Львівська політехніка»

АРХІТЕКТУРНІ ДОСЛІДЖЕННЯ

Міжнародний науковий журнал про архітектуру

Заснований у 2014 році
Випускається 4 рази на рік

Том 11, № 4

Львів – 2025

Year of foundation: 2014

*Recommended for printing and distribution
via the Internet by the Academic Council
of Lviv Polytechnic National University
(Minutes No. 20 of February 25, 2025)*

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”. Specialties: 0731 – Architecture and town planning, 0732 – Building and civil engineering
(order of the Ministry of Education and Science of Ukraine No. 1693, dated December 23, 2025).

**Journal is presented in international scientometric databases,
repositories and scientific systems:**

Professional Publications of Ukraine, Crossref, Bielefeld Academic Search Engine (BASE), J-Gate,
Vernadsky National Library of Ukraine (VNLU), 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), Litmaps

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>

Рік заснування: 2014

*Рекомендовано до друку та поширення
через мережу Інтернет Вченою радою
Національного університету «Львівська політехніка»
(протокол № 20 від 25 лютого 2025 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: G17 (191) – Архітектура та містобудування, G19 (192) – Будівництво та цивільна інженерія (наказ МОН України № 1693 від 23.12.2025).

**Журнал представлено у міжнародних наукометричних базах даних,
репозитаріях та пошукових системах:**
Фахові видання України, Crossref, Bielefeld Academic Search Engine (BASE), J-Gate, Національна бібліотека України імені В. І. Вернадського (НБУВ), 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), Litmaps

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

Editor-in-Chief

Bohdan Cherkes

Doctor of Architecture, Professor, Director of the Institute of Architecture and Design, Lviv Polytechnic National University, Lviv, Ukraine

National Members of the Editorial Board

Mykola Habrel

Doctor of Technical Sciences, Professor, Head of the Department of Architectural Design, Lviv Polytechnic National University, Lviv, Ukraine

Yuliia Ivashko

Doctor of Architecture, Professor, Department of Fundamentals of Architecture and Architectural Design, Kyiv National University of Construction and Architecture, Kyiv, Ukraine

Olena Remizova

Doctor of Architecture, Professor, Department of Fundamentals of Architecture, Kharkiv National University of Construction and Architecture, Kharkiv, Ukraine

Nadiya Antonenko

PhD in Architecture, Senior Lecturer, Kyiv National University of Construction and Architecture, Kyiv, Ukraine

Maksym Yasynskyi

PhD in Architecture, Associate Professor, Department of Architecture and Conservation, Lviv Polytechnic National University, Lviv, Ukraine

Yaroslav Blikharsky

Doctor of Technical Sciences, Professor, Department of Highways and Bridges, Lviv Polytechnic National University, Lviv, Ukraine

Pavlo Vegera

PhD in Technical Sciences, Associate Professor, Department of Building Constructions and Bridges, Lviv Polytechnic National University, Lviv, Ukraine

Svitlana Linda

Doctor of Architecture, Professor, Lviv Polytechnic National University, Lviv, Ukraine

Iryna Pohranychna

PhD in Architecture, Associate Professor, Lviv Polytechnic National University, Lviv, Ukraine

International Members of the Editorial Board

Werner Durth

Doctor of Architecture, Professor, Darmstadt University of Technology, Darmstadt, Germany

Andreas Hofer

Doctor of Architecture, Professor, Institute of Urban Planning, Vienna University of Technology, Vienna, Austria

Caroline Jaeger-Klein

Doctor of Architecture, Professor, President of the Austrian National Committee ICOMOS, Vienna University of Technology, Vienna, Austria

Sebastian Macmillan

Doctor of Architecture, Professor, University of Cambridge, Cambridge, the United Kingdom

Boguslaw Podhalanski

Doctor of Architecture, Professor, Krakow Technical University, Krakow, Poland

Cor Wagenaar

Doctor of Architecture, Professor, Head of the Department of History and Theory of Architecture and Urbanism, University of Groningen, Groningen, the Netherlands

Dominika Kuśnierz-Krupa

Professor, Krakow University of Technology, Krakow, Poland

Tiago Miguel Ferreira

Doctor of Civil Engineering, University of the West of England (UWE Bristol), Bristol, the United Kingdom

Kęstutis Zaleckis

PhD in History and Theory of Architecture, Professor, Kaunas University of Technology, Kaunas, Lithuania

Miles Glendinning

PhD in Architectural History, Professor, University of Edinburgh, Edinburgh, Scotland

Mariaenrica Frigione

PhD in Polymer Science and Technology, Professor, University of Salento, Lecce, Italy

Mohammad Arif Kamal

Doctor of Architecture, Associate Professor, Aligarh Muslim University, Aligarh, India

Józef Hernik

Doctor Habilitatus, Doctor of Technical Sciences, Professor, University of Agriculture in Krakow, Krakow, Poland

Justyna Kobylarczyk

Doctor Habilitatus, Doctor of Architecture, Professor, Krakow University of Technology, Krakow, Poland

Редакційна колегія

Головний редактор

Богдан Черкес

доктор архітектури, професор, директор Інституту архітектури та дизайну, Національний університет «Львівська політехніка», м. Львів, Україна

Національні члени редколегії

Микола Габрель

доктор технічних наук, професор, завідувач кафедри архітектурного проектування, Національний університет «Львівська політехніка», м. Львів, Україна

Юлія Івашко

доктор архітектури, професор, професор кафедри основ архітектури та архітектурного проектування, Київський національний університет будівництва та архітектури, м. Київ, Україна

Олена Ремізова

доктор архітектури, професор, професор кафедри основ архітектури, Харківський національний університет будівництва та архітектури, м. Харків, Україна

Надія Антоненко

кандидат архітектури, старший викладач, Київський національний університет будівництва та архітектури, м. Київ, Україна

Максим Ясінський

кандидат архітектури, доцент, доцент кафедри архітектури та реставрації, Національний університет «Львівська політехніка», м. Львів, Україна

Ярослав Бліхарський

доктор технічних наук, професор, професор кафедри автомобільних доріг та мостів, Національний університет «Львівська політехніка», м. Львів, Україна

Павло Вегера

кандидат технічних наук, доцент, доцент кафедри будівельних конструкцій та мостів, Національний університет «Львівська політехніка», м. Львів, Україна

Світлана Лінда

доктор архітектури, професор, Національний університет «Львівська політехніка», м. Львів, Україна

Ірина Погранична

кандидат архітектури, доцент, Національний університет «Львівська політехніка», м. Львів, Україна

Міжнародні члени редколегії

Вернер Дурт

доктор архітектури, професор, Дармштадтський технологічний університет, м. Дармштадт, Німеччина

Андреас Гофер

доктор архітектури, професор, директор Інституту містобудування Віденського технічного університету, м. Відень, Австрія

Кароліне Єгер-Кляйн

доктор архітектури, професор, президент Австрійського національного комітету ICOMOS, Віденський технологічний університет, м. Відень, Австрія

Себастьян Макміллан

доктор архітектури, професор, Кембриджський університет, м. Кембрідж, Великобританія

Богуслав Подгалянський

доктор архітектури, професор, Краківський технічний університет, м. Краків, Польща

Кор Вагенаар

доктор архітектури, професор, директор Інституту історії і теорії архітектури і урбанізму, Гронінгенський університет, м. Гронінген, Нідерланди

Домініка Куснерж-Крупа

професор, Краківська політехніка ім. Тадеуша Костюшко, м. Краків, Польща

Тьяго Мігель Феррейра

доктор цивільної інженерії, Університет Західної Англії (UWE Bristol), м. Бристоль, Великобританія

Кястутіс Залецкіс

кандидат наук з історії та теорії архітектури, професор, Каунаський технологічний університет, м. Каунас, Литва

Майлз Глендіннінг

кандидат з історії архітектури, професор, Единбурзький університету, м. Единбург, Шотландія

Маріанріка Фрігіоне

кандидат з полімерної науки та технології, професор, Університет Саленто, м. Лечче, Італія

Мохаммад Аріф Камал

доктор архітектури, доцент, Алігарський мусульманський університет, м. Алігарх, Індія

Юзеф Гернік

доктор габілітований, доктор технічних наук, професор, Аграрний університет в Кракові, м. Краків, Польща

Юстина Кобилярчик

доктор габілітований, доктор архітектури, професор, Краківський політехнічний університет, м. Краків, Польща

CONTENTS

T. Dovhaliuk

The place and role of memorial murals in urban environments9

Kh. Sobol, A. Melnyk, O. Khita

Dry building mixes with secondary raw materials for building renovation:

Comparative analysis of properties and efficiency21

O. Iurchyshyn

Children's participation as an architectural component

of post-war reconstruction in Ukraine33

M.S. Farahza

A strategic urban framework for the reconstruction of war-damaged cities:

A case study of Kabul City43

A. Mudra

Traditional and innovative approaches to landscaping and principles

of their implementation in the context of urban space harmonisation53

K. Didenko, O. Vigdorovich

Typical projects for atypical urban formations: The science city Piatykhatty64

M. Bevz, M. Bordun, S. Shekhorkina, I. Merylova

A sustainable, energy-efficient and eco-friendly wall system

for building applications in Ukraine76

I. Gnes, L. Soloviy, V. Matsola

The impact of epidemics and pandemics on architectural

and urban transformations of cities91

ЗМІСТ

Т. Довгалюк Місце та роль меморіальних муралів в урбаністичному середовищі	9
Х. Соболев, А. Мельник, О. Хіта Сухі будівельні суміші з вторинною сировиною для реновації будівель: порівняльний аналіз властивостей і ефективності.....	21
О. Юрчишин Участь дітей як архітектурна складова післявоєнної відбудови України.....	33
М.С. Фарахза Стратегічна урбаністична концепція відновлення міст пошкоджених війною: дослідження міста Кабул.....	43
А. Мудра Традиційні та інноваційні підходи до озеленення та принципи їх впровадження в контексті гармонізації міського простору	53
К. Діденко, О. Вигдорович Типові проекти для нетипових містобудівних утворень: наукоград П'ятихатки.....	64
М. Бевз, М. Бордун, С. Шехоркіна, І. Мерилова Стійка, енергоефективна та екологічно чиста стінова система для будівельного застосування в Україні.....	76
І. Гнесь, Л. Соловій, В. Мацола Вплив епідемій та пандемій на архітектурно-містобудівні трансформації міст	91

UDC 7.038.53:316.722:72.025.3(477)

DOI: 10.56318/as/4.2025.09

ISSN: 2411-801X

e-ISSN: 2786-7374

Taras Dovhaliuk*

Specialist in Urban Planning, Architect
Lviv Polytechnic National University
79013, 12 Stepan Bandera Str., Lviv, Ukraine
<https://orcid.org/0009-0003-0858-5891>

The place and role of memorial murals in urban environments

Abstract. The relevance of this research was driven by the increasing demand for new commemorative practices amid the ongoing war caused by the armed aggression of the Russian Federation against Ukraine. The aim of this study was to analyse contemporary methods for creating memorial murals, to determine their role in shaping public memory, and to explore their integration into urban spaces. The research employed methods of visual analysis, field study, interviews, and discourse analysis. In research was examined the phenomenon of memorial murals as a distinctive form of public art operating within urban environments. It was defined that murals had emerged as an effective tool for documenting collective memory, constructing identity, and shaping the symbolic spatial landscape of cities. The focus was placed on mural practices in Ukrainian cities, with particular attention to the author's experience in implementing memorial mural projects. The findings identified key transformations in the design of such works across five dimensions: sociocultural, spatial, communicative, technological, and political. It was established that in wartime conditions (2022–2025), memorial murals transcended their artistic form and became carriers of meaning – acting as social markers, emotional responses, and critical interpretations. The study revealed that the effectiveness of such projects depended on the quality of engagement with local communities, professional dialogue with the urban context, and the presence of a solid methodological foundation. Risks associated with unprofessional approaches – such as retraumatisation, environmental distortion, and the loss of symbolic value – were also highlighted. The practical value of this research lies in the development of approaches for the meaningful creation of memorial murals, which can be scaled nationally and integrated into international cultural discourse.

Keywords: visual memory; public space; urban identity; collective memory; spatial commemoration

INTRODUCTION

A mural was a form of monumental painting executed directly on architectural surfaces and functioning within public space. The concept of the “mural” had been actively used in Ukrainian scholarly and artistic discourse since the late 20th century. Since the early 2000s, the term had acquired new meaning in the context of the growing popularity of street art, particularly murals, which had gradually evolved into one of the leading tools of visual communication in urban environments. Murals had become not only a means of façade decoration but also a significant

mechanism for encoding and transmitting identity, memory, and social messages. As S. Marusek & A. Wagner (2024) observed, “through the visible accessibility of public memory painted in dynamic spaces of public infrastructure, the mural enlivens the relationship between culture and cultural heritage, making visible the painted narrative and spatially significant public forum to which the public audience is invited”. A particularly relevant context for studying memorial murals was Russia's full-scale war against Ukraine. In these times, murals became carriers of memory

Suggested Citation:

Dovhaliuk, T. (2025). The place and role of memorial murals in urban environments. *Architectural Studies*, 11(4), 9-20. doi: 10.56318/as/4.2025.09.

Journal homepage: <https://arch-studies.com.ua/en>

Architectural Studies, 11(4), 9-20

Received: 15.08.2025 Revised: 18.11.2025 Accepted: 19.12.2025 Published: 29.12.2025

*Corresponding author



Copyright © The Author(s). This is an open access article distributed under the terms of the Creative Commons Attribution License 4.0 (<https://creativecommons.org/licenses/by/4.0/>)



that not only honoured the fallen but also form a symbolic map of the urban space. It became a form of visual resistance, a mode of social response, and a catalyst for collective reflection on events. At the same time, the rapid proliferation of commemorative murals brought with it a number of challenges – from the danger of superficial interpretation to the risk of losing deep historical meaning. B. Gavryliuk (2018) emphasised the growing role of murals in postcolonial societies. In post-Soviet countries, murals served as a means of distancing from the imperial past and forming new identities. T. Meikle (2020) noted that in Jamaica, memorial murals depicted not only criminal “dons” but also ordinary people, highlighting the multiple meanings and multifunctional nature of these commemorative works.

In Europe, the emphasis was on patriotic motifs: Polish patriotic murals served as “examples of forms of collective memory”, materialising a specific vision of the past (Hołda, 2020). A global trend was that memorial murals were increasingly designed as interactive “walls of memory” that included digital and social components. A similar effect had been described in the Portuguese context. A.V. Simões (2023) noted that in Aveiro, street art had become a “wall of memory” conveying the cultural narratives of the community, transforming residents’ relationships with their environment. In a study of rural historic settlements in China, the authors P. Wu *et al.* (2025) showed that artistic interventions significantly enhanced the environmental attractiveness, socio-cultural values, and economic development of such areas. A. Krzywik (2021) noted that memorial murals in Polish cities were increasingly perceived not only as decorative embellishments but as carriers of socially agreed memory, initiated by state or municipal structures. S. Juzeleniene & S. Petroniene (2025) indicated that multilingual urban murals function as a form of cultural activism – it promoted pride in the city and a deeper immersion in local history. Contemporary approaches to designing commemorative objects increasingly took into account not only formal symbolism but also the spatial integration of these objects into the urban fabric. G. Chen & V. Suneta (2024) noted that in the context of place-making, memorial objects were regarded as catalysts for social interaction, critical reflection, and cultural identity. Instead of a straightforward depiction, contemporary murals aim for emotional engagement and critical reflection on historical experience. The aim of this study was to examine contemporary trends, challenges, and prospects of memorial murals in Ukraine and to develop a methodology for devising approaches to and implementing memorial murals that correspond to the historical context, contemporary aesthetic criteria, and community needs.

MATERIALS AND METHODS

This study adopted an interdisciplinary approach that integrated both analytical and practical components, combining methods of visual analysis, field observation, interviews, discourse analysis, and self-reflection. Such a framework enabled an exploration of memorial murals not only as

artistic objects but also as complex sociocultural practices intimately linked to urbanism, historical memory, emotional response, and place-making. Visual content analysis – a systematisation and classification of memorial murals was conducted based on themes, stylistic features, locations, authorship, and degree of integration into the urban environment. Special attention was given to compositional strategies, symbolism, colour schemes, and common visual narratives. Field research – observations were carried out to document public and passerby reactions to existing memorial murals, as well as to record specific interactions between murals and the surrounding architectural context. Interviews and surveys – semi-structured interviews were conducted with artists, urban planners, project commissioners, local government representatives, and residents during the realisation of previous projects. The focus was placed on the experience of mural creation, attitudes toward such works, the perception of memory through visual means, and the perceived role of murals in public space. Communication took place in the format of working meetings, on-site studies, and informal discussions (no fewer than 2-3 meetings for each project). The main topics of discussion included project concepts, project development, the integration of murals into the environment, audience reactions, and the technical maintenance of the murals (The Declaration of Helsinki, 2013). Discourse analysis – media publications, social networks, cultural platforms, and specialised journals addressing memorial art and public space were examined to identify prevailing discursive frameworks and representations.

Also, attention was paid to documenting the stages of the process – from conceptualisation to realisation – including technological, communicative, social, and ethical dimensions. The application of these methods allowed for the reconstruction of the modern landscape of memorial murals as a coherent, multi-layered system operating at the intersection of visual art, collective memory, and urban development. The material for analytical interpretation was partially grounded in the author’s experience as curator and executor of memorial mural projects in Lviv, Stryi, Kamianets-Podilskyi, and other cities across Ukraine.

RESULTS

The process of creating murals is often a dilemma of balancing between an appropriate act of commemoration and public reception. In many cases, mural projects are initiated by private individuals who assume the role of institutions, managing projects based on ad hoc procedures. Due to a lack of experience in such matters, officials and institutions often hesitate to take responsibility for decisions related to memorialisation, visual representation, or anticipated public reactions. However, successful initial projects tend to become models for replication and improvement, providing a foundation for deeper analysis of memorialisation through murals within urban environments. Conversely, when projects are initiated by public institutions or communities, there is often a reluctance to embrace bold or unconventional decisions. Organisers may prioritise anticipated public reception



over artistic or conceptual integrity, placing creators within restrictive frameworks that limit freedom of expression. In many cases, the idea of memorialisation becomes a form of visual populism, reducing the artist to a hostage of broad audience expectations and aesthetic compromises. Combined with the frequent time constraints imposed on organisers, the mural creation process risks becoming a conveyor-belt product devoid of thematic depth, architectural coherence, or contemporary relevance. Such conditions may paradoxically generate negative impressions from well-intentioned efforts. Fostering public dialogue, involving qualified professionals, and ensuring personal responsibility from all stakeholders positively influences commemorative practices and their integration into the architectural and design fabric of the city. Memorial murals are becoming a vital component of the visual culture of Ukrainian cities and serve as a means of preserving and transmitting collective memory amid contemporary social transformations. Based on visual analysis, artistic practice, and shared experiences with colleagues, five key dimensions of transformation in the design of memorial murals in urban environments have been identified.

The sociocultural dimension concerns memorial murals that increasingly address themes of trauma, loss, solidarity, and empathy. They reshape societal expectations – shifting from conventional heroic imagery toward personal stories and visual narratives that represent local values, experiences, and emotions. The spatial dimension reflects the transition of murals from a marginal phenomenon to elements occupying central urban spaces and integrating into the symbolic landscape. They transform the environments in which they appear, alter the status of public places, and generate new points of attraction and routes of remembrance. The communicative dimension marks a shift from an authorial monologue to a dialogue with the community. The involvement of local residents in mural creation, open workshops, crowdfunding initiatives, and multimedia components (such as QR codes linking to personal stories) enhance interactivity and public engagement. The technological dimension is manifested in the growing application of emerging technologies, including augmented reality, digital design, 3D modelling, specialised effect paints, and programmable surfaces (Horichko, 2025). These innovations enable murals to offer new modes of perception that reinforce their commemorative function. The political dimension reveals that memorial murals function not only as civic initiatives but also as forms of political expression. Their creation becomes a site of symbolic contestation where official and unofficial memory narratives coexist and compete. At the same time, the lack of clear criteria or competitive selection mechanisms introduces risks of unprofessionalism and manipulation. An example of a mural in the sociocultural dimension is the mural dedicated to the serviceman Mykola Ozerov (Fig. 1). The mural was created by artists Taras Dovhaliuk and Andriy Savchyshyn in 2024. The mural was dedicated to the fallen Lieutenant Colonel Mykola Ozerov (“Krym”). The surface for the artwork was the end wall of a five-storey residential

building in one of the city’s residential districts, previously insulated, area – 230 m², materials – facade and artistic acrylic paint, aerosol paint, gold potal, protective varnish. The mural portrays the figure of the hero Mykola Ozerov, depicted as a guardian of the highest values. Grandeur is conveyed through a monumental full-length silhouette, with a determined gaze and confident posture, standing as a symbol to greet and accompany those who pass by in their “daily struggles”. The words of Lina Kostenko testified to his dedication and service. A restrained colour palette and the interplay of vertical and horizontal elements created a close dialogue with the surrounding architectural ensemble. The attributes, details, symbolic elements, and the type of military uniform underscored his image, character, and individuality. In the background of the composition was a battlefield landscape with silhouettes of soldiers, symbolically representing the wounded, the fallen, and those missing in action. Above the peaceful skies of Donetsk rose the “Ukrainian Sun” – a symbol of hope and a source of strength for everyone (made of gold potal). The next example was a mural in honour of Yuri Dadak (Fig. 2).



Figure 1. Mural dedicated to Mykola Ozerov

Note: address – 15 Halytska Str., Stryi, Lviv region

Source: K. Tuziak (2024)



Figure 2. Mural dedicated to Yurii Dadak “Ruf”

Note: address – 12 Kolomyyska Str., Lviv

Source: V. Onisimova (2024)



The mural was created by artist Taras Dovhaliuk in 2024, project was created by artist Andrii Vlasniuk. The mural was dedicated to the fallen Ukrainian poet, publisher, screenwriter, founder of the conceptual literary project “Dukh Natsii” (The Spirit of the Nation), and soldier Yurii Dadak “Ruf”. The wall was the end façade of a nine-storey residential building in a suburban district, previously insulated, area – 330 m², materials – facade acrylic paint, aerosol paint. The mural symbolically integrated the fundamental principles of Ukrainian nationalist philosophy. The number 10 represented the “Decalogue” – the ten commandments

of the Ukrainian Nationalist; 12 stood for the twelve traits of a Ukrainian Nationalist; and 44 referred to the forty-four rules of life of a Ukrainian Nationalist. At the center of the composition was the “Dontsov Beast” – a symbol designed by D. Dontsov (2024) for the first edition of his book “Nationalism”, embodying the nobility of a lion, the strength of a wolf, and the impregnable nature of a hedgehog. The mural also featured the phrase “I am the spirit of the eternal element”, a line taken from the preamble to the points of the “Decalogue”. Interesting examples included the murals created by the artistic group Kailas-V and Andriy Palval (Fig. 3).



a)



b)

Figure 3. Murals dedicated to Kuzma Skryabin and Taras Shevchenko

Note: a – mural in honor of Kuzma Skryabin (address – 23A Rymarska Str., Kharkiv); b – mural in honor of Taras Shevchenko (address – 30 Sadovyi Ln., Kharkiv)

Source: MuKha (n.d.a; n.d.b)

The mural dedicated to Kuzma Skryabin was created by the artist group Kailas-V and Andrii Palval in 2020, area – 90 m², materials – acrylic paint, aerosol paint. The mural was dedicated to the Ukrainian singer, writer, TV host, producer, and actor Kuzma Skryabin and was created within the framework of the “Mural-Fest 2018” festival. The photograph used as the reference for the mural was taken during a photoshoot Skryabin did in Kharkiv. The people, who provided the photo knew the musician personally. Kuzma was a person, who walked a thorny path toward volunteering and self-sacrifice, embodying sincerity, courage, and dedication. The mural

dedicated to Taras Shevchenko also was created by this art group in 2014, area – 570 m², material – aerosol paint. The sketch for the mural was based on a portrait painted by Ivan Kramskoi. The mural featuring the portrait of the great Ukrainian poet Taras Shevchenko adorns the façade of a sixteen-storey residential building. It was created to commemorate the 200th anniversary of the poet’s birth. The artwork had been included in the National Register of Records of Ukraine as the largest portrait on the wall of a residential building (Official website of..., n.d.). The main works presented by Oles Baziuk were murals on honor of Oleh Kliufas and Avhustyn Voloshyn (Fig. 4).



a)



b)

Figure 4. Murals dedicated to Oleh Kliufas and Avhustyn Voloshyn

Note: a – mural in honor of Oleh Kliufas (address – Rynok Square, Mostyska, Lviv region); b – mural in honour of Avhustyn Voloshyn (address – Kapushanska Str., Uzhgorod)

Source: N. Studnya (2024), M. Pylypko (2024)



The mural dedicated to Oleh Kliufas was created in 2024, area – 60 m², material – facade and artistic acrylic paint. The mural depicted Oleh Kliufas in a symbolic image that unites his poetic talent, philosophical wisdom, and military bravery. Oleh Kliufas was killed on 13 June 2023 near the village of Rozdolivka in the Bakhmut district of Donetsk region. Oleh served as a senior mortar operator, performed his duties diligently and with high professionalism, distinguished by a strong sense of personal responsibility for every task entrusted to him. The mural on honour of Avhustyn Voloshyn was created in 2024, area – 64 m², material – facade and artistic acrylic paint, wall – facade of a residential building. Avhustyn Voloshyn – the first president in the history of Carpathian Ukraine – was not only a politician but also an outstanding public figure, priest, and writer. Voloshyn was an active participant in the national liberation movement and a significant figure in the history of Zakarpattia. The mural became a symbolic gift to Uzhhorod on the occasion of the 150th anniversary of Avhustyn Voloshyn's birth, and it served as the final element completing the commissioning of the residential complex. Figure 5 depicted a mural of Symon Petliura, created by Taras Dovhaliuk.



Figure 5. Mural of Symon Petliura

Note: address – 5b Zarvanska Str., Kamianets-Podilskyi, Khmelnytskyi region

Source: I. Oliynyk (2019)

The mural was created in 2019, area – 200 m², materials – facade acrylic paint, aerosol paint, wall – facade of a residential building. The mural depicted Symon Petliura, Head of the Directorate of the Ukrainian People's Republic. According to the project's organiser and patron Oleksandr Beilyk, this was not the first but the largest mural dedicated to honouring the memory of this prominent fighter for Ukraine's independence. The image of Symon Petliura, the Chief Otaman of the Armed Forces of the Ukrainian People's Republic, was based on a photograph taken during his stay in Kamianets-Podilskyi. Also, Taras Dovhaliuk and Andriy Savchyshyn were the authors of the murals depicted in Figure 6.



Figure 6. Murals dedicated to Nazar Pidkovych and Crimean Tatars

Note: a – mural in honour of Nazar Pidkovych (address – 127 Shevchenko Str., Stryi, Lviv region); b – mural in honour of Crimean Tatars (address – Zakhysnykiv Ukrainy Str., Lviv)

Source: O. Yarlykova (2018), The interactive platform “Memorial Heritage “Glory and Honour” (2024)

The mural was “Nazar Pidkovych” created by artists Taras Dovhaliuk and Andriy Savchyshyn in 2019. The wall was the end façade of a residential building, area – 126 m², materials – facade and artistic acrylic paint, aerosol paint. The mural was dedicated to Nazar Pidkovych, the fallen deputy commander of the 2nd Assault Company of the “Karpatska Sich named after Oleh Kutsyn” battalion. Also, this artists created the mural in commemoration of the 72nd anniversary of the deportation of the Crimean Tatars, in 2016. The artwork was located on a retaining wall, materials – acrylic paint, aerosol paint, area – 30 m². The artwork was complemented by a thematic poem by Lilia Budzhurova. Examples of murals that were no longer marginal phenomena, but had occupied central urban spaces and integrated into the symbolic landscape, included murals dedicated to Serhii Nigoyan and Naftali Herz Imber (Fig. 7). The Portuguese street artist Alexandre Farto (VHILS) created on the building overlooking Heavenly Hundred Heroes Square an image of Serhii Nihoyan in 2015. The wall was the end façade of a residential building. Area: 70 m², material – perforated plaster. The artist used a unique technique of carving and working through multiple layers of materials. In Kyiv, Alexandre Farto first applied layers of concrete and plaster onto the wall and, once dried, began chipping away fragments to reveal the portrait of the Hero of the Heavenly Hundred. The central element of the

composition was Nihoyan's eyes. According to Farto, it was the "eyes of the entire Heavenly Hundred" watching over the square that emerged on the site, where illegal construction had once been planned. The mural dedicated to Naftali Herz Imber was a part of the large-scale art project Art Meets History, initiated by the Embassy of the State of Israel in Ukraine, and created in 2023. The wall was the end façade of a residential building, previously insulated, area – 135 m²,

materials – facade and artistic acrylic paint, aerosol paint, gold potal, protective varnish. The project aimed to engage Ukrainian artists in creating murals portraying prominent Israeli figures – writers, poets, and public intellectuals – who were born in Ukraine, specifically in the cities, where they spent their childhood and youth. Another example of the work of the art group Kailas-V and Andriy Palval were murals in Chernivtsi and Kyiv in 2019 (Fig. 8).



Figure 7. Murals dedicated to Serhii Nigoyan and Naftali Herz Imber

Note: a – mural in honour of Serhii Nigoyan (address – Heavenly Hundred Heroes Square (Skver Nebesnoi Sotni), Kyiv); b – mural in honour of Naftali Herz Imber (address – Mykhailo Udatnyy Str., Lviv)

Source: T. Kaidan (2015), Ukrinform (2023)



Figure 8. Murals dedicated to Ivan Mykolaichuk and heroes of Kruty

Note: a – mural in honour of Ivan Mykolaichuk (address – 42 Holovna Str., Chernivtsi); b – mural in honour of heroes of Kruty (address – 111/113 Velyka Vasylkivska Str., Kyiv)

Source: Ukrinform (2019), O. Viruk (2019)

The mural "Ivan Mykolaichuk" was created in Chernivtsi, area – 120 m², material – aerosol paint. "Great personalities are with us" was the name of the project initiated by the Chernivtsi City Council. On the building, a large monumental portrait of Ivan Mykolaichuk has been painted, depicting him in the role of the village philosopher Fabian from the film "Babylon XX". The mural "Kruty" was created in Kyiv, area – 220 m², materials – acrylic paint, aerosol paint. The mural "Kruty" was a joint project of the creators of the film "Kruty 1918", the Department of Public Communications of the Kyiv City State Administration, the Pechersk District State Administration in Kyiv, the NGO "I love Ukraine", and the initiative "Kyiv

murals". In addition to works by Ukrainian artists, the works of foreign masters were also presented (Fig. 9). The mural "Maryna Marchenko" was created by the Australian artist Guido van Helten in 2017, material – aerosol paint. The mural was painted on a nine-storey residential building located near the contact line – one of the buildings shelled by tanks and artillery of the militants, the height of the artwork spans four floors. The woman depicted was Maryna Marchenko, a Ukrainian literature teacher from the city of Avdiivka in the Donetsk region. Its 15-meter-tall portrait appeared on one of the buildings damaged by shelling. Memorial murals have become a medium of not only civic initiative but also political expression (Fig. 10).

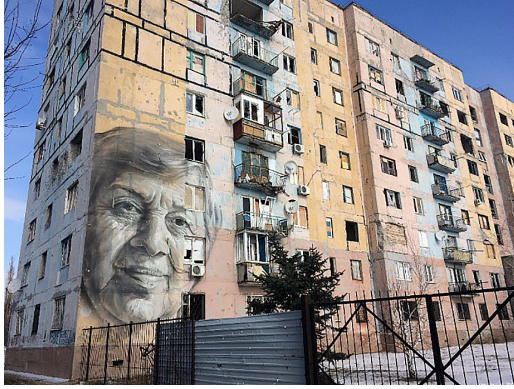


Figure 9. Mural dedicated to Maryna Marchenko

Note: address – Avdiivka, Donetsk region

Source: N. Dym (2016)



Figure 11. The artwork of Banksy

Note: address – Borodianka, Kyiv region

Source: A. Durbin (2022)



a)



b)

Figure 10. Examples of murals with a political dimension

Note: a – mural in honour of Petro Sahaidachnyi, Valerii Zaluzhnyi, Dmytro Dontsov, Sviatoslav Khorobryi (address – Dnipro River embankment, Kyiv); b – mural in honour of Volodymyr Zelenskyi (location – Warsaw, Poland)

Source: Mukachevo.net (2022), I. Miller (2025)

The mural in Figure 10 (a) was created by an unknown artist in 2025. The central figure on the wall was General Valerii Zaluzhnyi. Beside him were depictions of Sviatoslav the Brave, Petro Sahaidachnyi, and Dmytro Dontsov. The mural in Figure 10 (b) was created by the artist Yaroslava Holysh in 2022, area – 90 m², material – acrylic paint. The mural depicted Volodymyr Zelenskyy along with the inscription “Slava Ukraini!” (“Glory to Ukraine!”).

The artwork was likely created by the British artist Banksy in 2022, material – stencil, aerosol paint (Fig. 11). The image depicted a boy throwing Putin over his shoulder, with both figures wearing judo uniforms. So, the results of practical experience had demonstrated that: 1) in many cases, memorial murals were implemented without sufficient dialogue with the architectural context, resulting in visual dissonance; 2) the lack of professional competition or selection procedures endangered the representativeness and aesthetic quality of memory images; 3) without proper ethical guidance, memorial murals can provoke controversial reactions, from retraumatisation to trivialisation. The study found that, when guided by an interdisciplinary approach, meaningful community engagement, and careful site selection, murals can become not only acts of remembrance but also catalysts for deeper reflection on complex historical events. It may significantly influence the urban landscape – both visually and contextually. Within commemorative practices, both aesthetic and moral factors emerged, requiring a responsible approach to every stage of the process – from concept to realisation. An additional analytical vector involved comparing the architectural and urban contexts, in which memorial murals were created, particularly in democratic societies versus totalitarian regimes. This comparison proved essential for understanding the relationship between public space and the potential for collective memory.

In democratic urban environments, architecture and public space were structured around human needs: pedestrian-friendly scales, accessibility, inclusivity, and navigability prevail. In such settings, memorial murals became an organic part of the city’s daily rhythm, integrated rather than imposed. Commemorative projects often emerged from civic initiatives, public discourse, and community collaboration. In contrast, totalitarian urban structures used architecture as a tool of control and submission (Fig. 12). These spaces were shaped by centralisation, monumentalism, and rigid geometry. Rather than inviting interaction, it imposed authority. Monuments and large-scale imagery in these environments functioned rhetorically, reinforcing power and ideology. Citizens in such contexts were subjects rather than participants; the space became a stage

for power, not a site of memory. Quantity overrode quality, superficiality replaced depth, and form dominated substance. This was evident in the commemorative practices of the aggressor state – practices, whose replication under Ukrainian conditions presented real danger.



Figure 12. Propaganda

Note: Pyongyang, North Korea

Source: Unian (2017)

This mural located on one of the major central squares, where ideological monuments and propagandistic murals were typically concentrated. Theme of the mural: mass support for and glorification of the state leader. The comparison of these environments underscored the role of memorial murals as a living form of public art. In open societies, it served as interlocutors – provoking reflection and participation. In closed regimes, its risk becoming façades of control, where memory was not activated but preserved in state-sanctioned forms. Thus, a city's capacity to serve as a space of memory was directly shaped by the political nature of its urban environment.

Compared to European practices, creators of memorial murals in Ukraine were compelled to assume not only artistic but also ideological responsibility for the content of their works. Unlike most European countries, where clear competitive procedures, thematic frameworks, and selection mechanisms existed, in the Ukrainian context decisions regarding the appearance, content, and style of a mural were most often made by the artist or the commissioner without the involvement of a professional expert community. Such autonomy offered certain advantages (a high degree of creative freedom), but it also entailed significant risks – namely, the absence of a critical filter or methodological guidelines. The problem of non-professional approaches lay in the spontaneous creation of murals without consideration of architectural context or ethical dimensions. This results in several issues, such as: retraumatisation of audiences through aesthetically or conceptually inappropriate depictions of events; distortion of the environment due to unqualified intervention in façades or public space; and the speculative use of memory – such as the commercialisation of tragedy in visual form. Consequently, cases of social resistance or even prohibition of such initiatives (moratoria) arise, hindering the development of high-quality commemorative art.

The uniqueness of the Ukrainian context, in contrast to global traditions of commemoration, stemmed from its functioning within the conditions of ongoing war. This produced a dual task: to document events, heroes, and communities for future generations; to deconstruct the Soviet monumental legacy that still persisted in urban space as a form of visual noise. This necessitated new methodologies: artists must not merely depict, but create an ethical, emotional, and cultural alternative to the models of the past. In this sense, Ukrainian murals constituted not only artistic works but also political actions that asserted new values through imagery of memory. Such practices may form a foundation for future projects, provided it was critically examined and accompanied by effective implementation strategies; even negative examples can serve as points of reference and carry practical value. It was also important to note the shift from direct illustrativeness to interpretive openness. A significant number of murals do not convey events literally but instead create space for personal reflection. The artwork became a mediator between the environment and the viewer, who projected their memories, emotions, and interpretations onto the image. This mode of perception allowed for a deeper internalisation of experience – not merely as historical information, but as lived, participatory memory.

DISCUSSION

The findings of this study confirmed that memorial murals fulfilled a complex commemorative function within the urban environment. These works done more than convey memory of events or individuals – it was integrated into the social fabric of the city, influencing spatial perception, forming symbolic axes, and reshaping the routes of everyday attention. Murals became not simply paintings on façades, but interventions in public space, carrying distinct emotional, political, and identity-related meanings. Urban memorial murals functioned not only as artistic expressions, but also as complex communicative structures capable of embedding themselves into collective memory and contributing to the formation of national identity. Y. Zhou *et al.* (2024) emphasised that public art projects in urban contexts contributed to strengthening cultural values and social cohesion, while simultaneously supporting the economic growth of cities. S. Juzeleniene & S. Petroniene (2025) demonstrated that murals “are woven into collective memory”, transforming residents’ relationships with their surroundings. E. Doss (2010) emphasised that visual forms of public memory – including murals – were increasingly replacing traditional monuments by focusing not only on heroism, but also on emotional, traumatic, and controversial aspects of the past. Similarly, Ukrainian memorial murals often focused not on glorification, but on personalisation of loss, empathy, and collective solidarity. In A. Rigney’s (2018) terms, it became expressions of “memory of hope”, which not only recalled the past but also offered visions for the future.

An important outcome of the study was not only the identification of practical transformations in mural



production, but also the recognition of a new role of the city – as an active environment of mnemonic interaction that shaped not only the urban landscape but also the very mode of remembrance. In this context, the artist, architecture, and community became co-creators of a complex, multilayered narrative that not only represented but also interpreted historical trauma. The global context demonstrated that murals often functioned as forms of alternative historical narration. In the work of D. Drozdowski *et al.* (2016), a similar tendency was observed in Berlin and Warsaw, where street art reinterpreted traumatic pasts and contributed to the formation of local cultures of memory. Ukrainian memorial murals fitted within this logic but also encountered their unique challenges – particularly those related to the Soviet legacy of monumental art and the urgent need to de-aestheticise propagandistic narratives. I. Upalevski (2017) argued that, despite murals' potential to democratise memory, most Warsaw murals reproduced official, state-supported, nation-centered and male-dominated historical narratives – effectively acting as “secondary memory makers” under institutional influence rather than as independent, subversive voices. R. Schacter (2013) profiled over 100 of the most influential urban artists worldwide – from New York to São Paulo to Melbourne – and situated their work in both geographic and historical context, tracing the evolution of street art from its early mural roots in Latin America to the spray-can graffiti and mural culture of the 20th and 21st centuries.

Murals can contribute to social cohesion, give visual form to collective memory, and serve as instruments of cultural activism (Simões, 2023; Juzeleniene & Petroniene, 2025). The author R. Cappeller (2024) noted that the effective creation of a memorial mural was possible only through meaningful dialogue with the community and a contextually informed approach. B. Blankley (2021) emphasised the role of the artist not only as a documentarian but as a “memory-maker”, who introduced new meanings in relation to events and protagonists. Z. Ge & M.F. Sedon (2025) and H. Bitaieva (2025) noted that the sustainable development of a culture of remembrance in Ukraine required the establishment of ethical and methodological criteria that drawn upon global experience and promoted the responsible creation of murals as intentional artefacts of collective memory. The experience of Ukrainian memorial murals can be understood as a form of hybrid commemoration that combined elements of traditional monumental art, street-level activism, local self-organisation, and global visual trends. This highlighted the need to formalise methodological foundations for the creation of such works, as well as the necessity of involving a broad range of specialists – artists, urbanists, historians, and psychologists – in their development. Unlike many Western practices, the Ukrainian context was characterised by a lack of institutional support, the absence of standardised procedures, competitions, or criteria for producing commemorative murals. Successful projects – such as the memorial mural dedicated to Mykola Ozerov in Stryi, the work

commemorating Naftali Herz Imber in Lviv, and pieces by Vhils in Kyiv – demonstrated that, when artistic, ethical, and urbanistic principles were respected, memorial murals can acquire profound symbolic power. These works had the potential to transform the urban environment not only physically but mentally – creating places of memory, emotional resonance, and social discourse.

CONCLUSIONS

So, throughout the research, five key dimensions of transformation in mural design were identified: sociocultural, spatial, communicative, technological, and political, which helped to better understand how memorial murals were shifting the function of public art – from the aesthetic enhancement of urban space to a tool for remembrance, critical reflection, and communal identification. The mural dedicated to Mykola Ozerov in Stryi illustrated the socio-cultural relevance. It transformed a residential facade into a site of collective memory and hope through a heroic narrative. In Kyiv, the mural depicting Serhiy Nigoyan demonstrated spatial transformation. Its carved portrait overlooks the Heroes of the Heavenly Hundred Square, symbolically recreating a contested urban space as a sacred landscape of memory. The mural on the Dnipro Embankment in Kyiv features Petro Sahaidachny, Valerii Zaluzhnyi, Dmytro Dontsov and Prince Sviatoslav the Brave demonstrated the political dimension of the confrontation between official and unofficial narratives of memory. Experience in mural implementation confirmed that effective creation of a memorial mural required a holistic and considered approach. Key factors included the architectural and social context, the community's emotional state, the nature of the commemorated event, and visual representation that avoided superficiality or trauma. Dialogue between the artist, community, experts, and space was essential. Misguided decisions may provoke reactions, from indifference to rejection. Excessive literalism can devalue memory, while artistic metaphor or open interpretation encouraged deeper engagement and lasting emotional impact. In the context of Russian full-scale invasion, the role of murals had grown significantly. It allowed for the visual expression of loss, solidarity, resistance, and dignity in everyday urban spaces. Its scale, placement, and emotional power helped overcome indifference and evoke resonance. Memorial murals brought the past into the present, integrating symbolic and emotional experiences into the city landscape. It also served as focal points for community identification, embedding collective memory into the city's architecture and daily life. Creating memorial murals required not only artistic skill but also conscious responsibility to society and future generations. The process must be intentional, as any lack of awareness could lead to devaluation. Prospect of the research is to develop ethical, methodological, and artistic criteria as a framework of responsibility that will provide a foundation for the sustainable development of visual culture of memory in Ukraine – one that remains meaningful and comprehensible for generations to come.





ACKNOWLEDGEMENTS

I extend my sincere gratitude to the colleagues who shared their experiences in the implementation of memorial murals, as well as to experts in urban studies, cultural theory, and monumental art for their public comments and ideas. I am grateful to the participants of civic initiatives, private sponsors, and institutions who engaged in discussions on the role of memory in public space and contributed to the realisation of bold and meaningful projects. Special thanks

are also due to my colleague Andriy Savchyshyn for his professional support in the development, implementation, and analysis of monumental projects.

FUNDING

None.

CONFLICT OF INTEREST

None.

REFERENCES

- [1] Bitaieva, H. (2025). Murals as an indicator of socio-cultural transformations in urban space: Global experience and the Ukrainian context. *Ukrainian Culture: The Past, Modern Ways of Development*, 50, 242-251. [doi: 10.35619/ucpmk.50.967](https://doi.org/10.35619/ucpmk.50.967).
- [2] Blankley, B. (2021). Murals as memorials: The artist's responsibility. *UXUC – User Experience and Urban Creativity*, 3(1), 144-147. [doi: 10.48619/uxuc.v3i1.486](https://doi.org/10.48619/uxuc.v3i1.486).
- [3] Cappeller, R. (2024). Artistic interventions for urban innovation: Comparing new forms of engagement in public space by two local initiatives. *Cities*, 147, article number 104792. [doi: 10.1016/j.cities.2024.104792](https://doi.org/10.1016/j.cities.2024.104792).
- [4] Chen, G., & Suneta, V. (2024). Design transformations in monuments and memorials as monumental buildings: New perspectives on the place-making model. *Heritage Science*, 12, article number 325. [doi: 10.1186/s40494-024-01446-4](https://doi.org/10.1186/s40494-024-01446-4).
- [5] Dontsov, D. (2024). *Nationalism*. Ternopil: Kryla.
- [6] Doss, E. (2010). *Memorial mania: Public feeling in America*. Chicago: The University of Chicago Press.
- [7] Drozdowski, D., De Nardi, S., & Waterton, E. (2016). Geographies of memory, place and identity: Intersections in remembering war and conflict. *Geography Compass*, 10(11), 447-456. [doi: 10.1111/gec3.12296](https://doi.org/10.1111/gec3.12296).
- [8] Durbin, A. (2022). Banksy revealed a graffiti in Borodyanka, Kyiv region. *BBC News. Ukraine*. Retrieved from <https://www.bbc.com/ukrainian/news-63607895>.
- [9] Dym, N. (2016). The name of the honored teacher, who became the heroine of a 4-story mural in Avdiivka has been revealed. Photo. *Novynarnia*. Retrieved from <https://surl.li/ybtzmc>.
- [10] Gavryliuk, B. (2018). *Ukrainian mural art in terms of global art*. *Bulletin of Lviv National Academy of Arts*, 37, 241-254.
- [11] Ge, Z., & Sedon, M.F. (2025). Constructing a place of urban memory: Exploring the post-industrial landscape of Ma'anshan through painting. *International Journal of Academic Research in Business and Social Sciences*, 15(6), 1194-1211. [doi: 10.6007/IJARBS/v15-i6/25611](https://doi.org/10.6007/IJARBS/v15-i6/25611).
- [12] Hołda, R. (2020). "You are in our memory": Polish murals as memory medium and a popular form of patriotism. *Intercultural Relations*, 4(1), 47-64. [doi: 10.12797/RM.01.2020.07.03](https://doi.org/10.12797/RM.01.2020.07.03).
- [13] Horichko, Ya. (2025). Sacralisation of the female image during wartime in Ukraine and its reflection in graphic artworks. *Art and Design*, 8(1), 23-44. [doi: 10.30857/2617-0272.2025.1.2](https://doi.org/10.30857/2617-0272.2025.1.2).
- [14] Juzeleniene, S., & Petroniene, S. (2025). Painting the linguistic landscape of Kaunas: A study of multilingual murals in public spaces. *Journal of Multilingual and Multicultural Development*, 1-17. [doi: 10.1080/01434632.2025.2539916](https://doi.org/10.1080/01434632.2025.2539916).
- [15] Kaidan, T. (2015). The face of Serhiy Nigoyan has appeared in the Heavenly Hundred Square. *Khmarochos*. Retrieved from <https://hmarochos.kiev.ua/2015/07/09/u-skveri-nebesnoyi-sotni-z-yavilos-oblichchya-sergiya-nigoyana/>.
- [16] Krzywik, A. (2021). Murals as memory carriers. Analysis of the meanings given to them and the attitudes of their creators. *On the W@terfront. Public Art. Urban Design. Civic Participation. Urban Regeneration*, 63(11), 49-72. [doi: 10.1344/waterfront2021.63.11.03](https://doi.org/10.1344/waterfront2021.63.11.03).
- [17] Marusek, S., & Wagner, A. (2024). Public art and the mural: Interpreting public memory through prominence, place, and color. *Law, Culture and the Humanities*. [doi: 10.1177/17438721241300651](https://doi.org/10.1177/17438721241300651).
- [18] Meikle, T. (2020). The multivalency of memorial murals in Kingston, Jamaica: A photo-essay. *Interventions*, 22(1), 106-115. [doi: 10.1080/1369801X.2019.1659163](https://doi.org/10.1080/1369801X.2019.1659163).
- [19] Miller, I. (2025). A mural featuring General Zaluzhnyi has appeared for the second time in Kyiv (photo). *Glavcom*. Retrieved from <https://glavcom.ua/kyiv/photo/u-kijevi-vdruhe-zjavivsja-mural-iz-heneralom-zaluzhnyim-1061756.html>.
- [20] Mukachevo.net. (2022). A woman from Mukachevo painted a mural of Zelensky on a wall in Warsaw (Photo). Retrieved from https://mukachevo.net/news/mukachivka-namaliuvala-mural-zelenskoho-na-stini-u-varshavi-foto_3472199.html.
- [21] MuKha. (n.d.a). *The mural is dedicated to Kuzma Skryabin*. Retrieved from <https://mural.kh.ua/skryabin/>.
- [22] MuKha. (n.d.b). *The mural of Taras Shevchenko*. Retrieved from <https://mural.kh.ua/shevchenko/>.
- [23] Official website of the National Register of Records of Ukraine. (n.d.). Retrieved from <https://nationalrecords.world/>.
- [24] Oliynyk, I. (2019). A mural in honor of Symon Petliura has appeared in Kamianets-Podilskyi. *Ye.ua*. Retrieved from https://ye.ua/syspilstvo/43982_U_Kam_yanci_Podilskomu_z_yavivsy_mural_na_chest_Simona_Petlyiri.html.



- [25] Onisimova, V. (2024). "I am the spirit of the eternal element": A mural in honor of the fallen poet and soldier Yuriy Ruf has been unveiled in Lviv. *Novynarnia*. Retrieved from <https://novynarnia.com/2024/06/09/ya-duh-odvichnoyi-styhiyi-u-lvovi-vidkryly-mural-na-chest-zagyblogo-poeta-i-vijskovogo-yuriya-rufa/>.
- [26] Pylypko, M. (2024). A mural dedicated to Augustyn Voloshyn has appeared in Uzhhorod. *Mukachevo.net*. Retrieved from https://mukachevo.net/news/v-uzhorodi-ziavyvsia-mural-prysviachenyy-avhustynu-voloshynu_6266127.html.
- [27] Rigney, A. (2018). Remembering hope: Transnational activism beyond the traumatic. *Memory Studies*, 11(3), 368-380. doi: 10.1177/1750698018771869.
- [28] Schacter, R. (2013). *The world atlas of street art and graffiti*. New Haven: Yale University Press.
- [29] Simões, A.V. (2023). Street art in Aveiro: City walls as dialogic spaces of collective memories and identity. *Societies*, 13(3), article number 54. doi: 10.3390/soc13030054.
- [30] Studnya, N. (2024). A mural in honor of Oleh Klyufas has been unveiled in Mostyska. *Fotografii Staroho Lvova*. Retrieved from <https://photo-lviv.in.ua/v-mostyskakh-vidkryly-mural-na-chest-oleha-kliufasa/>.
- [31] The Declaration of Helsinki. (2013). Retrieved from <https://www.wma.net/what-we-do/medical-ethics/declaration-of-helsinki/>.
- [32] The interactive platform "Memorial Heritage "Glory and Honor". (2024). *Mural in honor of Pidkovych Nazar*. Stryi, Vyhovskogo Str. Retrieved from <https://memorial.stryi.org/?p=8295>.
- [33] Tuziak, K. (2024). A mural dedicated to a defender of Donetsk airport has been unveiled in the Lviv region. *Lviv Post*. Retrieved from <https://www.lvivpost.net/war/na-lvivshhyini-vidkryly-mural-zahysnyku-donetskogo-aeroportu/>.
- [34] Ukrinform. (2019). *A mural featuring a portrait of Mykolaichuk has been unveiled in Chernivtsi*. Retrieved from <https://www.ukrinform.ua/rubric-regions/2774398-u-chernivcah-vidkrili-mural-z-portretom-mikolajcuka.html>.
- [35] Ukrinform. (2023). *A mural dedicated to the author of the national anthem of Israel has been unveiled in Lviv*. Retrieved from <https://surl.li/chdxva>.
- [36] Unian. (2017). *North Korea raises the "iron curtain": Journalists reveal how tourism is developing in the most closed country in the world*. Retrieved from <https://www.unian.ua/world/2013624-pivnichna-koreya-pidnimae-zaliznu-zavisu-jurnalisti-rozpovili-yak-rozvivaetsya-turizm-v-naybilsh-zakritiy-krajini-svitu.html>.
- [37] Upalevski, I. (2017). Murals make (our) history: Paintings on the wall as media of cultural memory. Interpreting the current state of Warsaw's commemorative murals. *Qualitative Sociology Review*, 13(4), 114-135. doi: 10.18778/1733-8069.13.4.07.
- [38] Viruk, O. (2019). What does the "Kruty" mural near the "Ukraine" Palace look like. *Village*. Retrieved from <https://www.village.com.ua/village/city/city-news/281031-yakiy-viglyad-mae-mural-kruti-bilya-palatsu-ukrayina>.
- [39] Wu, P., Li, X., Feng, Y., & Liu, Y. (2025). The impact and transformation evaluation of art intervention in public space on ancient villages: A case study of Tengchong, Yunnan Province. *Scientific Reports*, 15, article number 2354. doi: 10.1038/s41598-025-87008-5.
- [40] Yarlykova, O. (2018). Mural navigator: Lviv. *Rubryka*. Retrieved from <https://rubryka.com/photo/navigator-po-muralam-lviv/>.
- [41] Zhou, Y., Sanz-Hernández, A., & Hernández-Muñoz, S.M. (2024). Artistic interventions in urban renewal: Exploring the social impact and contribution of public art to sustainable urban development goals. *Societies*, 14(10), article number 204. doi: 10.3390/soc14100204.



Тарас Довгалюк

Спеціаліст з містобудування, архітектор
Національний університет «Львівська політехніка»
79013, вул. Степана Бандери, 12, м. Львів, Україна
<https://orcid.org/0009-0003-0858-5891>

Місце та роль меморіальних муралів в урбаністичному середовищі

Анотація. Актуальність цього дослідження зумовлена зростаючою потребою у нових комеморативних практиках в умовах триваючої війни, спричиненої збройною агресією російської федерації проти України. Метою дослідження став аналіз сучасних методів створення меморіальних муралів, визначення їхньої ролі у формуванні публічної пам'яті та дослідження особливостей їх інтеграції в міський простір. У роботі застосовано методи візуального аналізу, польового дослідження, інтерв'ю та дискурсивного аналізу. У межах дослідження розглянуто феномен меморіальних муралів як специфічну форму публічного мистецтва, що функціонує в урбаністичному середовищі. Визначено, що мурали постали ефективним інструментом фіксації колективної пам'яті, конструювання ідентичності та формування символічного просторового ландшафту міста. Основну увагу зосереджено на муральних практиках в українських містах, із особливим акцентом на авторському досвіді реалізації проєктів меморіальних муралів. У результаті дослідження виявлено ключові трансформації дизайну таких творів за п'ятьма вимірами: соціокультурним, просторовим, комунікативним, технологічним і політичним. Встановлено, що в умовах воєнного часу (2022-2025) меморіальні мурали виходять за межі суто художньої форми та набувають значення носіїв смислів – виконуючи функції соціальних маркерів, емоційних реакцій і засобів критичної інтерпретації дійсності. Дослідження засвідчило, що ефективність реалізації таких проєктів залежить від якості взаємодії з локальними спільнотами, професійного діалогу з міським контекстом та наявності ґрунтовної методологічної основи. Також окреслено ризики, пов'язані з непрофесійним підходом, зокрема ретравматизацію, спотворення середовища та втрату символічної цінності. Практична значущість дослідження полягає у формуванні підходів до змістовного створення меморіальних муралів, які можуть бути масштабовані на національному рівні та інтегровані в міжнародний культурний дискурс.

Ключові слова: візуальна пам'ять; публічний простір; урбаністична ідентичність; колективна пам'ять; просторове вшанування

UDC 691.5:666.972.16
DOI: 10.56318/as/4.2025.21

ISSN: 2411-801X
e-ISSN: 2786-7374

Khrystyna Sobol

Professor
Lviv Polytechnic National University
79013, 12 Stepan Bandera Str., Lviv, Ukraine
<https://orcid.org/0000-0003-0798-413X>

Andriy Melnyk

Assistant
Lviv Polytechnic National University
79013, 12 Stepan Bandera Str., Lviv, Ukraine
<https://orcid.org/0000-0001-7246-5227>

Oleksandr Khita*

Postgraduate Student
Lviv Polytechnic National University
79013, 12 Stepan Bandera Str., Lviv, Ukraine
<https://orcid.org/0009-0003-1221-0603>

Dry building mixes with secondary raw materials for building renovation: Comparative analysis of properties and efficiency

Abstract. The aim of the study was to provide a theoretical assessment of the use of recycled construction and industrial waste in dry renovation mixes. The methodology covered a comprehensive approach to waste utilisation in the context of sustainable development and identifying prospects for Ukraine. It was found that partial replacement of cement with granulated blast-furnace slag (25-50%) reduces the carbon footprint by 30-40% without loss of strength and durability, while the addition of recycled aggregates (20-30% of natural sand) ensures a strength ≥ 10 MPa, provided that grading and cleanliness were properly controlled. The combination of glass and slag increases matrix density and reduces water absorption, but requires monitoring of alkali reactivity. Life-cycle analysis has shown a 20-40% reduction in CO₂ emissions, when recycled raw materials are used, while substantial savings of primary resources decreases environmental pressure and waste volumes. The use of methods of mathematical experimental design made it possible to select optimum formulations more rapidly, reducing the number of experiments by a factor of 8-10. Field tests in Portugal, India and the Republic of South Africa confirmed the feasibility of using mixes with secondary materials in plastering and masonry works. In Ukraine, the potential for applying such technologies was considerable in view of post-war reconstruction needs and the availability of large volumes of construction and demolition waste. The most promising solutions for renovation mixes were granulated blast-furnace slag; classified fine fractions (which, after cleaning, can replace 20-30% of sand without loss of properties); combinations of granulated blast-furnace slag and glass powder; and formulations optimised using machine learning. In Ukraine, the main barriers were the insufficient level of quality control and a weak laboratory base; however, regional mix-manufacturing plants were able to ensure effective use of construction waste in reconstruction. The practical significance lies in the possibility of using the results by construction companies and material producers for environmentally friendly mixes and for restoration standards

Keywords: waste utilisation; alternative binders; mortar durability; laboratory tests; field tests; resistance to aggressive environments; resource efficiency

Suggested Citation:

Sobol, Kh., Melnyk, A., & Khita, O. (2025). Dry building mixes with secondary raw materials for building renovation: Comparative analysis of properties and efficiency. *Architectural Studies*, 11(4), 21-32. doi: 10.56318/as/4.2025.21.

Journal homepage: <https://arch-studies.com.ua/en>

Architectural Studies, 11(4), 21-32

Received: 09.07.2025 Revised: 31.10.2025 Accepted: 19.12.2025 Published: 29.12.2025

*Corresponding author



Copyright © The Author(s). This is an open access article distributed under the terms of the Creative Commons Attribution License 4.0 (<https://creativecommons.org/licenses/by/4.0/>)



INTRODUCTION

In the context of growing scarcity of natural resources and the need to reduce the carbon footprint, the construction industry was increasingly oriented towards the principles of sustainable development. One of the key directions was the use of secondary raw materials in the production of dry building mixes, widely applied in plastering, masonry and repair-renovation works, which was particularly relevant for countries with large volumes of construction waste and a need for large-scale infrastructure restoration. In Ukraine this problem became even more critical due to war-related destruction, which had generated significant flows of construction debris potentially suitable for reuse in production processes.

In the international discourse there have been a number of attempts to systematically assess the potential of such materials. D. Duan *et al.* (2022) showed that the use of fly ash, carbide slag and gypsum from flue-gas desulphurisation units made it possible to produce dry mixes with acceptable mechanical characteristics, while simultaneously reducing cement consumption. This indicated the considerable potential of industrial waste as active mineral additives. A. Pietrzak & M. Ulewicz (2025) demonstrated that using ash from municipal solid-waste incineration together with cement-kiln dust produced environmentally friendly mortars that retained strength at the level of traditional ones, but required careful control of harmful impurities. This approach confirmed the feasibility of re-using industrial waste streams, while at the same time outlining barriers associated with the quality and standardisation of secondary raw materials.

A significant line of technological development remained the activation of slags as alternative binders. In a pilot study, J. Sengupta *et al.* (2024) proved that the use of granulated blast-furnace slag in combination with soda and hydrated lime provided strengths of around 40 MPa, while reducing the cost of the mixes. This meant that even relatively simple and accessible activators can ensure efficiency comparable with that of expensive alkali-activation systems, which opened up prospects for practical implementation in resource-constrained countries. Equally promising was the use of recycled aggregates and powders. Z. Ma *et al.* (2023) analysed the possibility of using waste from high-quality mortars in new cement systems and showed that this approach significantly affected the material's microstructure and chloride-transport processes, which determined the durability of structures. The repeated use of finely dispersed demolition products can not only reduce the demand for natural resources, but also increase resistance to reinforcement corrosion. This broadened understanding of the role of microstructural changes in shaping performance characteristics and outlined prospects for further work in the field of renovation materials.

The greening of plaster mortars through the use of alternative raw materials has been the subject of research by N.A. Valoni *et al.* (2025). The authors found that microstructural parameters directly influenced the mechanical

properties and durability of the material, and that appropriate selection of components makes it possible to combine high strength with environmental benefits. This formed the concept of balancing microstructural and performance characteristics as a key guideline for creating eco-friendly mixes for renovation. V. Grigorjev *et al.* (2025) focused on the use of recycled fine fractions as a replacement for natural aggregates in cement-lime mortars. Researchers found that the resulting compositions maintain an adequate level of strength and adhesion, sufficient for use in masonry and repair works. This confirmed the possibility of integrating secondary materials into traditional binder systems, which was a step towards implementing circular-economy principles in construction practice.

In Ukrainian academic discourse there was also a growing interest in the use of secondary resources in construction materials. A. Melnyk *et al.* (2024) presented dry mixes for flooring elements, which partly incorporate secondary components, confirming the possibility of their practical use in innovative structural solutions. In the study by M. Oleksyn & Z. Obynochna (2023), practices of using secondary raw materials in architecture and construction were summarised, with an emphasis on the combination of environmental and economic advantages of this approach. Ukrainian publications highlighted the lack of a sufficient body of field tests and standardised quality-control procedures, which complicated the scaling up of such solutions. Despite the existence of research results, the practical integration of secondary materials into dry building mixes for renovation tasks remains limited. Existing studies showed progress in creating mixes with waste, but at the same time outline several unresolved issues: durability under real service conditions, variability of raw-material properties and the risk of undesirable chemical reactions (in particular, alkali-aggregate reaction). In Ukraine these challenges were exacerbated by the scale of destruction and the absence of an effective waste-sorting system. Therefore, the aim of this study was to theoretically determine the possibilities and limitations of using secondary raw materials in dry mortars for restoration works.

MATERIALS AND METHODS

The study employed a comprehensive approach, which involved using methods of analysis and synthesis to assess the possibilities of integrating secondary raw materials into dry building mixes, determined their properties and identify promising directions for implementation in the context of Ukraine's post-war reconstruction. To characterise regulatory requirements, a comparative-analysis method was used, enabling the systematisation of EU and European Economic Area standards – European Standard EN 197-1:2011 (2011), European Standard EN 998-1:2016 (2016), and Ukrainian national standards – DSTU B V.2.7-126:2011 (2011), DSTU EN 998-2:2023 (2024). These documents were selected because they regulate the key characteristics of cement and mortars for masonry and plastering



that were directly related to the use of secondary materials in dry mixes. Comparing the requirements made it possible to identify differences between European and Ukrainian standards and to outline directions for further adaptation of regulations to the conditions of post-war reconstruction.

To systematise international experience, the comparative-analysis method and the case-study method were applied to examine practical implementation models in various countries (India, Portugal, Saudi Arabia, Australia, Brazil, the Republic of South Africa, Pakistan, Switzerland, France, and Ukraine). Key aspects of the use of waste in renovation mixes were identified, gaps (technical, environmental or regulatory) were revealed and real examples of application were presented. The choice of countries was justified by the fact that it represented different types of approaches:

- 1) states with large volumes of waste and a need for its utilisation (India, Pakistan, Brazil, Republic of South Africa);
- 2) countries with developed EU-level standards (Portugal, France, Switzerland);
- 3) innovation-oriented countries with an emphasis on digitalisation (Saudi Arabia and Australia);
- 4) Ukraine as a practical centre for applying international experience in post-war reconstruction.

This was done in order to compare international experience in the use of secondary materials in renovation mixes, to identify effective technologies and solutions that can be scaled up in Ukraine, to identify weaknesses and to assess practicality of implementation (strength, durability, functional properties, limitations/risks, practical cases of use in the countries concerned that indicated potential scalability and compliance with regulatory requirements), taking local conditions (post-war rebuilding) into account. International experience and characteristics of secondary raw materials were analysed specifically from the standpoint of their suitability for use in dry building mixes. Methods of analysis and synthesis of academic sources were used to systematise approaches to the utilisation of construction and industrial waste in building mixes: the use of industrial by-products (slags, power-station fly ash, metallurgical waste) as supplementary cementitious materials; the integration of waste into the materials-science cycle within the concept of the circular economy; the combination of laboratory and field tests to verify the suitability of mixes; the combination of different waste fractions to achieve synergistic effects; and the application of digital technologies and machine learning to optimise formulations according to criteria of technical performance (strength, durability, water absorption), environmental impact (reduction of carbon footprint, reduction of waste), economic feasibility (replacement of expensive primary materials) and regulatory potential (compliance with standards and the possibility of further standardisation). This made it possible to identify key opportunities for reducing dependence on traditional non-renewable materials and to form guidelines for the development of innovative technologies in the context of post-war reconstruction.

To characterise the various types of secondary materials used in dry building mixes, a comparative-analysis and systematisation method was applied on the basis of data from scientific publications: reclaimed cement powder and reclaimed fine aggregate from construction waste; different fractions of recycled construction debris; recycled glass in combination with granulated blast-furnace slag; glass, granite and marble powders; supplementary cementitious materials (slags, ash) in dry mixes; blast-furnace slag and crushed concrete scrap; waste for lightweight and insulating mortars (expanded polystyrene, perlite); construction waste combined with digital optimisation of composition (machine learning); and waste powders (glass, ceramics, stone) as cement replacements. The criteria used were: ranges of cement and sand replacement; strength; conditions of testing (laboratory research, life-cycle assessment, modelling); limitations and risks; and the readiness level of each approach (assessed using the Technology Readiness Level scale, ISO 16290:2013 (2013); in most cases it corresponds to a “medium” level – confirmed by laboratory and modelling tests but without long-term standardisation). The materials and criteria were selected to ensure a balance between environmental effect (waste utilisation, reduction of carbon footprint) and technical feasibility (strength, durability, standardisation). The aim of this stage was to create a consolidated knowledge base allowing different types of secondary raw materials to be compared according to key indicators. This made it possible to identify the strengths and weaknesses of each material, assess their suitability for different types of building mixes and determine, where further standardisation or optimisation was required. To classify promising directions (slags, glass powders, fine classified fractions) and identify key challenges (variability of raw materials, increased water demand, risks of chemical instability, sorting costs), an analytical-synthetic method was used. In addition, a forecasting approach was applied to determine optimal material platforms (granulated blast-furnace slag as a supplementary cementitious material; classified and washed fine fractions of construction and demolition waste as sand replacements; limited addition of glass powder as a reactive component) for renovation mixes and to outline guidelines for further research. The task of this stage was to delineate the boundaries of existing studies and to identify promising directions for the use of secondary raw materials in dry building mixes, as well as to identify key challenges and gaps. This made it possible to formulate benchmarks for subsequent work.

RESULTS AND DISCUSSION

Circular economy, waste utilisation and standardisation of renovation mixes

The utilisation of construction and industrial waste was not only a technological, but also a conceptual task in the field of sustainable development. Turning waste into resources was seen as a key direction for reducing the carbon footprint of the construction sector. Secondary raw materials can perform a dual function: on the one hand, reducing





dependence on traditional non-renewable materials (cement, natural sand, aggregates), and on the other, minimising the negative environmental impacts of landfilling or incineration (Fernando *et al.*, 2025). A more detailed examination of approaches to the use of industrial by-products (slag, power-station fly ash, metallurgical waste) in the production of building mixes shows that these materials can not only replace part of the cement or aggregates, but also act as functional additives, improving specific properties of materials such as water resistance and durability in aggressive environments. Conceptually, waste utilisation was viewed as integrating waste into the materials-science cycle rather than simply “disposing” of it (Yeo *et al.*, 2023).

Applying waste through the prism of the circular economy implied a shift from a linear model (“production – use – disposal”) to an approach, in which materials were repeatedly reintroduced into the production cycle. In the case of building mixes, this meant the possibility of repeatedly converting structural waste into secondary aggregates and binders. The circular economy in construction had not only an environmental dimension, but also a socio-economic one. It contributed to reducing the need for extraction of primary resources, creating new value-added chains and lowering the burden on waste-management infrastructure. In addition, such an approach stimulated the development of new regulations and standards capable of integrating waste into formalised requirements for the quality of dry building mixes (Bansal *et al.*, 2024). At the theoretical level, the use of secondary raw materials in dry building mixes was considered part of a broader strategy for transforming the construction industry towards a circular-economy model, in which waste ceased to be an end product and became a resource for new production.

The use of secondary aggregates obtained from construction debris under real site conditions brought the focus onto the transition from laboratory experiments to practical field trials. This made it possible to assess not only the physical and mechanical properties of the resulting mortars, but also the effectiveness of technological processes on site. One specific feature of this approach was taking into account the heterogeneity of secondary raw materials and adapting technological parameters to real conditions. This demonstrated the scalability of solutions and underlined the need for flexible technological approaches (Chen *et al.*, 2024). Combining technical and environmental assessment of mortars made from recycled construction debris made it possible to achieve acceptable mechanical characteristics, while simultaneously reducing the carbon footprint. Such an approach emphasised the importance of an integrated perspective, in which technical feasibility was assessed alongside environmental performance, reflecting the growing trend to evaluate materials in the context of sustainable development (Ohemeng *et al.*, 2024).

The impact of using blast-furnace slag and crushed concrete rubble in mortars showed that partial cement replacement with slag can significantly reduce primary-resource consumption, while ensuring an acceptable level

of strength. The use of concrete rubble as a fine aggregate improved waste utilisation without a significant reduction in performance characteristics (Farooq *et al.*, 2023). The combined use of waste glass and blast-furnace slag in dry building mixes had shown that such a combination can be effectively employed in the production of environmentally friendly building materials. This made it possible to reduce the environmental impact of these materials and to use large volumes of secondary raw materials without critical deterioration in properties, and demonstrated the potential of combined use of different waste streams to create multifunctional solutions (Baah *et al.*, 2025).

The standardisation of dry mixes containing supplementary cementitious materials obtained from industrial waste was a crucial aspect for the development of this technology. This raised questions not only of technical efficiency, but also of the need to regulate the use of such materials. The establishment of standards may become a key factor for large-scale implementation, since without harmonised regulations their practical use will remain limited (Antunes *et al.*, 2024). Analysis of the properties of blended mortars made from waste from different streams showed that a multicomponent approach made it possible to achieve synergistic effects, where the drawbacks of one type of waste were offset by the advantages of another. This approach was an example of seeking an optimal balance between technical and environmental indicators and can serve as a basis for creating new mix designs that reflected the complex structure of waste under real-world conditions, as noted by K. Zhang *et al.* (2023).

An innovative direction associated with the use of machine learning for optimising mortar compositions showed that adaptive algorithms can significantly accelerate the selection of effective formulations, reducing the need for large numbers of experimental tests. This opened up a new perspective for the integration of digital technologies into materials science and paved the way for the “personalised” selection of formulations, depending on the available raw materials (Abbas, 2025). Predictive modelling of the mechanical properties of cement replacements derived from waste showed that mathematical models were able to forecast material behaviour with a high degree of accuracy, making them a valuable tool for pre-selecting technological solutions. This approach was a logical extension of the concept of the digitalisation of the construction sector, where empirical data were combined with intelligent algorithms (Ranasinghe *et al.*, 2024). Multidimensional analysis of the properties of mortars containing recycled waste covered not only mechanical, but also thermal and chemical characteristics, allowing a comprehensive assessment of materials. The integration of waste was not limited to strength indicators; rather, it shaped a broader range of performance parameters that determined the suitability of mixes for renovation works (Wu *et al.*, 2025). To summarise approaches to the utilisation of construction and industrial waste, Table 1 presented types of raw materials, replacement ranges, properties, limitations and readiness level for use in renovation mixes.

**Table 1.** Characteristics of secondary materials for dry building mixes

Type of waste	Replacement range	Strength	Conditions	Limitations/risks	Readiness level
Reclaimed cement powder and reclaimed fine aggregate from construction waste	20% of cement, 100% of sand	With 20% replacement of cement by reclaimed powder, strength increased by 8%. With 100% sand replacement, water absorption and density decreased	Laboratory tests	Strict quality control of secondary fractions is required	Medium
Various fractions of recycled construction debris	Replacement of sand with recycled aggregate at 25%, 50%, 75% and 100%	As the proportion of recycled aggregate increased, there was a gradual decrease in strength and an increase in water absorption	Laboratory studies + life-cycle assessment	Additional cleaning and sorting of secondary materials are required	Medium
Recycled glass in combination with granulated blast-furnace slag	Approx. 91% glass and 26% slag (optimum conditions)	Achieved strength of about 36.5 MPa, reduced water absorption, denser structure	Laboratory tests	Risk of alkali-aggregate reaction of glass	Medium
Glass, granite and marble powders	5-15% of cement, 10-30% of sand	At 5-10% glass, strength increased (by 11% at 28 days); granite above 10% reduced strength, marble above 10% increased water absorption	Laboratory tests	Critical importance of fineness of grinding	Medium
Supplementary cementitious materials (slag, ash) in dry mixes	15-50% of cement replaced by waste	Slight reduction in early strength; in the long term, increased density and reduced permeability	Laboratory studies + analysis of regulatory requirements	Need for standardisation and regulation	Medium
Blast-furnace slag and crushed concrete rubble	Several levels of cement and sand replacement	Reduced consumption of primary resources, acceptable strength	Laboratory tests with environmental assessment	Limited data on durability	Medium
Waste for lightweight and insulating mortars (expanded polystyrene, perlite)	Depending on waste type	Mechanical, thermal and chemical properties analysed comprehensively; risks of reduced strength at high contents of lightweight fractions identified	Laboratory tests	Possible issues with durability and compatibility	Medium
Construction waste combined with digital optimisation of composition (machine learning)	Adaptive replacement ranges	Normative strength achieved; the speed of formulation selection increased by about a factor of 10 compared with traditional experimental methods (series of mixes and trial-and-error testing)	Laboratory tests + modelling	Effectiveness depends on the quality of input data	Medium
Waste powders (glass, ceramics, stone) as cement replacements, application of machine learning	5-50% of cement	An optimum of 10-15% gives the best results; models accurately predict properties	Laboratory tests + modelling	Stable data sets required	Medium

Note: “normative strength achieved” means that in tests with digital optimisation of compositions (machine learning), the values obtained fell within the range defined by European Standard EN 197-1:2011 (2011) for the specific type of mortar, typically 7-10 MPa and above for masonry and repair mortars

Source: based on O. Farooq *et al.* (2023), J.S. Yeo *et al.* (2023), S. Bansal *et al.* (2024), A. Antunes *et al.* (2024), E.A. Ohemeng *et al.* (2024), R.C. Malladi *et al.* (2025), P.M. Borges *et al.* (2025), T.T. Baah *et al.* (2025), M.M. Abbas (2025)

Most secondary materials provided acceptable technical characteristics and a medium level of technological readiness; however, their effectiveness depended on quality control, cleaning and standardisation. The most promising systems were those with blast-furnace slag, glass and digitally optimised compositions, while the main constraints remained raw-material variability and long-term durability. At the same time, the key challenges continued to be the variability of waste properties, limited durability data and the lack of standardised procedures for large-scale implementation. Assessing the feasibility of using secondary materials in dry building mixes required consideration of current standards that defined requirements for composition, properties and quality control. At

international level, the basic documents were European Standard EN 197-1:2011 (2011), which defined the composition and conformity criteria for common cements, including requirements for clinker and mineral additions, and European Standard EN 998-1:2016 (2016), which regulated the properties of plastering and renovation mortars, including requirements for strength, adhesion, water absorption and durability. The Ukrainian regulatory framework was harmonised with the European one, but also had its own standards: DSTU B V.2.7-126:2011 (2011) regulated the properties of mortars used in construction, including strength, workability and durability; DSTU EN 998-2:2023 (2024) provided the basis for regulating the quality of masonry mixes in Ukraine in line with European requirements.





European standards provided the methodological foundation, while Ukrainian documents required further adaptation and harmonisation to take into account the specifics of local waste streams and post-war reconstruction tasks.

The results of the study showed that waste utilisation was understood not as disposal but as integration into the materials-science cycle. This approach goes beyond the traditional concept of “getting rid of rubbish” and forms a new logic of the circular economy. This correlated with the work of N. Ranasinghe *et al.* (2024), who emphasised the critical importance of data traceability and transparent control mechanisms, without which genuine circularity cannot be achieved. The authors demonstrated that simply incorporating secondary raw materials does not guarantee sustainable development if compliance with standards and quality control at all stages of the life cycle is not ensured. The concept of “waste as a resource” can become the methodological basis for transforming the construction sector. The combination of materials-science integration, traceability and digital control tools forms the key to an effective transition of construction to a circular-economy model.

In the study by J. Wu *et al.* (2025) it was underlined that existing approaches to the use of secondary materials in construction cannot be limited exclusively to mechanical parameters, since sustainable development requires simultaneous consideration of environmental, energy and durability criteria. The authors found that integrating multidimensional indicators – from strength and adhesion to carbon footprint and resource efficiency – was becoming a global standard in scientific research and practical development. This corresponded to the results of the present study, according to which field tests on construction sites demonstrated the feasibility of an integrated approach combining technical and environmental assessment of mortars. This made it possible not only to establish compliance of materials with regulatory requirements for strength or water absorption, but also to evaluate their actual behaviour in field conditions, taking long-term environmental impacts into account, and indicated the need for a multidimensional assessment of material performance, in which environmental sustainability and resource efficiency were as important as technical characteristics.

The results of the study established that the use of waste through the prism of the circular economy implies a shift from the linear model “production – use – disposal” to repeated reintroduction of materials into the production cycle, which significantly reduced the burden on natural resources and waste-management infrastructure. This aligned with H. Shajidha & M. Mortula (2025), who stressed that the effectiveness of circular solutions is determined not only by the level of innovative technologies, but also by the quality of systemic management. The authors emphasised that public policy, regulatory mechanisms and economic incentives were critical factors in scaling up such practices in different countries. This meant that technological solutions in the field of waste reuse must be accompanied by institutional support that ensured the integration of

circular models into construction standards and infrastructure programmes. Accordingly, the circular economy in construction was emerging as a multilevel system that combined materials-science innovation, management strategies and political instruments of sustainable development.

R.M. Cigala *et al.* (2025) showed that geopolymers produced from industrial waste, particularly from secondary sources of silicates and aluminates, can provide increased resistance to aggressive environments, while forming a dense matrix with improved performance properties. Such materials do not merely act as replacements; it serve as active modifiers of the structure of building mortars, creating a new functional level of application. This resonated with the present study, in which it was found that the use of blast-furnace slag and crushed concrete allowed a significant reduction in primary-resource consumption, while maintaining acceptable physical and mechanical properties. Both studies confirmed that industrial waste can play a role not only in reducing environmental impact, but also in creating materials with additional functional characteristics.

The results of the study showed that key barriers to the widespread introduction of secondary materials into dry building mixes remain the absence of specialised standards and regulations capable of formalising requirements for the quality and durability of such solutions. Even, where experimental formulations were technically successful, their scaling was blocked by legal and regulatory uncertainty, which created risks for both manufacturers and consumers. This was consistent with G.C.R. Hasibuan *et al.* (2025), who emphasised that the lack of regulatory infrastructure was one of the main obstacles to the practical integration of circular-economy principles into the construction sector. Scientists noted that the absence of unified protocols and harmonised requirements led to fragmented solutions and limits the possibility of their international recognition. This meant that even the most convincing technological advances will not have the potential for wide application without systematic adaptation of standards, which must encompass both local conditions and global regulatory approaches. Thus, the recycling of construction and industrial waste emerged as a key mechanism for developing the circular economy, simultaneously reducing environmental risks and opening the way to creating materials with enhanced functional properties. However, the absence of harmonised standards and adequate control mechanisms significantly limited the prospects for large-scale application, even of technologically effective solutions.

Assessment of suitability and global experience of using secondary raw materials, with adaptation to the conditions of Ukraine

The key criterion for the suitability of secondary raw materials in dry renovation mixes was durability. The use of recycled fillers and supplementary cementitious materials (slag, fly ash, microsilica) can alter the degradation mechanisms of the matrix, accelerate carbonation and cause sulphate attack in the presence of gypsum-bearing impurities;



in systems with crushed glass, the risk of alkali-aggregate reaction remains. For this reason, tests were required for resistance to carbonation, sulphates and frost, as well as checks of adhesion and shrinkage with the use of inhibitors and modifiers. Field data have confirmed that replacing 20-30% of natural sand with recycled aggregates ensured a strength of 7-10 MPa, while laboratory tests have demonstrated higher values for systems with granulated blast-furnace slag and glass (Chen *et al.*, 2024; Abbas, 2025).

Replacing 25-50% of clinker with slag reduced the carbon footprint by 30-40% without loss of durability, and the thermal conductivity of materials can fall to 0.35-0.4 W/m-K, while maintaining strength above 15 MPa. To reduce variability, standardised procedures were needed for sorting, cleaning and classification of fractions, control of sulphate, organic and salt content, as well as incoming inspection protocols with “batch passports”. The use

of machine learning speeded up formulation selection several-fold and increases reproducibility, but required high-quality stable data and integration with field monitoring. Overall, the use of 20-30% recycled aggregates and 25-50% granulated blast-furnace slag was recognised as appropriate, providing strengths of 10-20 MPa and a 20-40% reduction in carbon dioxide emissions (Ohemeng *et al.*, 2024). Global experience showed significant differences in the use of construction and industrial waste for producing dry mixes. Different countries have developed their own approaches to replacing cement and natural aggregates, depending on the local raw-materials base, climatic conditions and regulatory infrastructure. The synthesis in Table 2 made it possible to trace strengths, existing gaps and practical examples of technological applications, forming a basis for adapting effective practices to the conditions of Ukraine.

Table 2. Characteristics of international studies on the use of waste in renovation mixes

Country	Key aspects	Gap	Real-world examples
India	Recycling of construction waste: 20% replacement of cement by reclaimed powder (+8.07% compressive strength), 100% sand replacement (-11.48% water absorption, -5.21% porosity); acid separation method for a closed-loop economy	Resistance to freeze-thaw cycles in a continental climate; combination with supplementary binders for hybrid repair mortars	Laboratory tests; recycled construction waste in mortars for façade repair (global life-cycle assessment models)
Portugal	Recycled aggregates (concrete, brick, ceramics): replacement of natural sand up to 100% with adjustment of water-cement ratio (0.15% per % of recycled aggregate), laboratory and field adhesion/capillarity tests	Long-term adhesion in historic masonry (over 5 years); impact on vapour permeability in energy-efficient renovation	Field trials: mortar with recycled aggregates for plastering/masonry in Portugal; use of recycled aggregates in masonry mortars for renovation in Europe
Saudi Arabia	Waste (ceramics, glass, granite, marble, brick) as cement replacements: 5-50% replacement (optimum 10-15%), strength prediction using machine learning (neural networks)	Stability of machine-learning models for local wastes; combination with additives against alkali-aggregate reaction for renovation adhesives	Laboratory modelling; prediction of properties of mortars with waste in construction projects (pilot tests in Saudi Arabia)
Brazil	Fine recycled aggregates from construction waste: 25-100% sand replacement, life-cycle assessment (84-337 kg CO ₂ /m ³), carbonation tests (3% CO ₂)	Water demand under high humidity; additives against sulphate attack to ensure durability in renovation	Laboratory tests with life-cycle assessment; mortars with recycled aggregates for building repair
South Africa	Blast-furnace slag + concrete rubble: 60% rubble + 10% slag, -12.8-32.5% strength, -4.5% water absorption, life-cycle assessment	Durability of concrete rubble under freeze-thaw cycles	Laboratory environmental tests; mortars with concrete rubble for robust renovation
Pakistan	Blended mortars with waste (glass, granite, marble): 5-15% of cement, 10-30% of sand; strength increase, structural analysis	Rheology under high humidity; multicomponent mixes for levelling layers in renovation	Laboratory structural tests; blended mortars for renovation layers
Australia	Recycled glass + fly ash as a suppressant of alkali-aggregate reaction: durability, improved strength	Behaviour in combinations with aggregates; field tests for plasters in renovation	Laboratory durability tests; glass-containing mortars for durable renovation
Ukraine/ Switzerland/ France	Recycled concrete for post-war reconstruction: -10% strength, risks of sulphates/chlorides, 20-30 million m ³ of concrete debris	Standards for fine aggregates; carbonation/heat treatment for stability in the Ukrainian climate	Processing of 50 thousand tonnes of rubble for residential projects; recycling brick/concrete for restoration of “war waste”
Ukraine	Recycling of construction waste: 6% utilisation, crushing/briquetting technologies, secondary materials (rubber, paper, wood, 15,500 J/kg for briquettes). Secondary wastes in dry mixes: diatomite, limestone, quartz sand; + density, -shrinkage, strength class M100+ without additional binders	Recycling centres; integration of secondary materials into dry renovation mixes by 2030, economic model. Resistance to freeze-thaw cycles; optimisation for repair mixes of class M100+ without binders	Rubber crumbs for asphalt; eco-wool from paper for low-rise housing; wood briquettes; concrete rubble. Quarry waste in dry mixes for low-cost renovation

Note: M100 is a concrete grade that defines compressive strength. This means that the mix can reach a strength of 100 kg/cm² (or 10 MPa) after 28 days of curing. In the case of M100+, this refers to a mix that may have a strength higher than 100 (e.g., 120, 150 kg/cm² or more), but without the use of binders

Source: based on V. Troian *et al.* (2022), O. Farooq *et al.* (2023), K. Zhang *et al.* (2023), S. Bansal *et al.* (2024), A. Antunes *et al.* (2024), L. Chen *et al.* (2024), A. Bondar *et al.* (2024), W.C.V. Fernando *et al.* (2025), P.M. Borges *et al.* (2025)





The scale and outcomes of using construction waste in dry mixes depended on local conditions and the regulatory framework. The most successful examples were associated with combining laboratory research and field trials, while the key gaps remained long-term durability and the absence of unified standards. For Ukraine, it was appropriate to adapt global experience to post-war reconstruction and to develop regional recycling centres. Despite substantial progress in studying the use of waste in dry building mixes, a number of areas remained under-researched. Although there were individual examples of creating dry-mix systems with secondary raw materials (Yeo *et al.*, 2023; Bansal *et al.*, 2024), there were no comprehensive comparative studies specifically on renovation plastering, masonry and self-levelling mixes. Most works were limited to mechanical properties and water absorption (Antunes *et al.*, 2024; Cigala *et al.*, 2025). There was a lack of comprehensive tests on vapour permeability, salt migration and efflorescence formation on real cultural-heritage objects.

Studies on upcycling binders and modelling compositions using machine learning provided predictive assessments, but there were no field investigations longer than 5-10 years, particularly with regard to freeze-thaw and wetting-drying cycles (Abbas, 2025; Fernando *et al.*, 2025). Despite individual proposals for standardising dry-mix compositions (Bansal *et al.*, 2024) and Ukrainian reviews (Hudym *et al.*, 2022; Bondar *et al.*, 2024), there were no clear methods for controlling contamination of waste and no specialised regulations specifically for renovation mixes. Some studies covered life-cycle assessment and eco-technical aspects, but there were no regionally specific life-cycle assessments for Ukraine that would take into account logistics and the stability of secondary raw-material quality (Ohemeng *et al.*, 2024; Borges *et al.*, 2025). Fire-performance characteristics and scenarios for repeated recycling were also insufficiently studied, although some publications analyse thermal and chemical properties of mixes; systematic research in this area was lacking (Ranasinghe *et al.*, 2024). For instance, N. Kostyra & O. Bashynskyi (2025) investigated the fire resistance of steel floor beams during a building's renovation, underlining the need to address fire performance in reconstruction projects.

Nevertheless, even in the absence of standardisation and long-term trials, secondary materials showed substantial potential. Slags and other supplementary cementitious materials reduced heat release and formed a denser matrix; fine waste fractions effectively replaced natural sand; and combinations of glass and slag reduced water absorption and improved structure. At the same time, challenges remained – variability of raw materials, increased water demand and risks of chemical instability, all of which required control and formulation adaptation. The use of secondary resources helped to reduce the carbon footprint and extraction of primary materials, but high costs of sorting and cleaning slow large-scale implementation, underlining the importance of developing local recycling chains. Among different types of waste, granulated blast-furnace

slag was the most promising for renovation dry mixes. Its effectiveness had been confirmed by field studies and multidimensional assessments: it reduced the carbon footprint by 30-40%, forms a denser matrix and increases durability. Another robust solution was classified and washed fine fractions (0-2/4 mm) of construction and demolition waste, which can replace up to 20-30% of natural sand in plastering and masonry mixes, especially in levelling layers.

Systems based on combinations of granulated blast-furnace slag and glass powder had medium-term prospects: laboratory data showed synergy in reactivity and particle packing, significant strength and low water absorption (Botirov & Botirova, 2024). However, control of the alkali reactivity of glass and the development of unified methods for dry mixes were required. A similar situation existed for multi-stream composites (concrete + ash): it ensured formulation flexibility and the possibility of machine-learning optimisation for local raw materials, but required a well-developed system of incoming quality control. Prospective, subject to risk management, were mixed construction and demolition wastes containing gypsum, wood or organic impurities. It can be used only after aggressive sorting and washing, otherwise there was a high risk of shrinkage, salt-related and sulphate-induced defects. Practical guidelines for designing renovation mixes involved identifying an optimal material platform based on the use of granulated blast-furnace slag in the range of 15-50% of binder mass in combination with classified sand from construction and demolition waste (20-30% of aggregate), with the possible introduction of up to 10% glass powder as a reactive component. Control of rheological properties was achieved through the use of superplasticisers, adjustment of fineness modulus and pre-saturation of recycled sand fractions. Ensuring durability require tests for sulphate and carbonation resistance, adhesion, shrinkage and frost resistance. Quality control presupposes checking impurity content (sulphates, organics, salts), incoming batch-control protocols and the introduction of a “batch passport” system with fixed characteristics. Digitalisation of the process included the creation of databases of local wastes and the use of machine-learning cycles (from design to retraining based on feedback from construction sites). The most convincing and practically substantiated option for renovation mixes was the combination of granulated blast-furnace slag as a supplementary cementitious material with classified fine fractions of construction and demolition waste, whereas systems based on combinations of slag and glass or multi-stream composites required further standardisation and field verification.

In Ukraine, the raw-material base was favourable, but the wastes were characterised by variability of composition (concrete, brick, mixed impurities), which required efficient systems for sorting and cleaning. The regulatory framework does not reflect the specifics of dry mixes with secondary components, creating barriers to certification and wide implementation of the technologies; therefore, adaptation of international standards and the development



of Ukrainian documents that take local waste streams into account are necessary. In logistical and economic terms, a problem was the concentration of large volumes of construction debris in regions of active hostilities, which complicated transport and increased processing costs; at the same time, using such waste as a replacement for natural sand or as partial cement substitution can significantly reduce reconstruction costs. Promising directions included the use of classified and washed sand from construction and demolition waste in plastering and masonry mixes; the use of granulated blast-furnace slag and power-station ash as supplementary cementitious materials to reduce carbon dioxide emissions and lower costs; and the creation of regional centres for sorting and producing dry mixes, integrated into large-scale reconstruction projects. The main risks remained the absence of systematic quality control of secondary raw materials, the lack of laboratory infrastructure for testing and limited possibilities for long-term monitoring of service durability.

The results of the study showed that the effect of blast-furnace slag in combination with recycled aggregates manifested itself in maintaining normative strength even, when 20-30% of natural sand and 25-50% of clinker was replaced. Such a formulation also reduced the carbon footprint by 20-40%, increasing the environmental efficiency of the materials. This correlated with I. Beigh & M.Z. ul Haq (2024), who concluded that partial cement replacement with slag and the use of recycled aggregate stabilise composite structure and made it possible to achieve acceptable strength characteristics in geopolymer systems. Similar conclusions were reported by P. Zhang *et al.* (2023), who emphasised that using recycled aggregate together with slag-based binders reduced permeability, densified the microstructure and enhanced durability, which was consistent with this study. Industrial waste can act not only as a substitute for traditional materials, but also as an active modifier of microstructure. Integrating recycled aggregate and blast-furnace slag was an optimal strategy for creating renovation mixes that combined technical reliability with a low environmental burden.

A.T. Balasbaneh *et al.* (2025) stressed that construction-waste management required a systemic approach based on life-cycle analysis. The authors showed that applying the Life Cycle Sustainability Assessment framework allowed solutions to be evaluated not only in terms of mechanical or economic indicators, but in a broader dimension, taking into account carbon footprint, energy consumption and resource efficiency. The absence of policy incentives and adequate regulatory support hampers scaling up even the most technically sound practices. This corresponded to the results of this study, which showed that combining technical and environmental assessment of materials was necessary, but insufficient without institutional backing. In practical terms, this meant that circular solutions in the field of dry renovation mixes must be implemented in tandem with state programmes and supportive policies. Only the integration of Life Cycle Sustainability Assessment methodology with

management and policy mechanisms can ensure large-scale dissemination and real environmental effectiveness.

The results of the study showed that enhancing durability in dry renovation mixes was directly linked to modifying the composition and introducing functional additives that changed matrix degradation mechanisms. Systems based on granulated blast-furnace slag and crushed glass exhibit higher density, reduced water absorption and improved resistance to sulphate attack, but their effectiveness depended on curing regimes. This was in line with the experimental work of S. Irum *et al.* (2025), which demonstrated that introducing graphite nanoplatelets in combination with optimised heat-curing or ambient-curing regimes significantly increases strength and durability of geopolymer composites made from recycled materials. The authors showed that nanomodifiers not only improve mechanical characteristics, but also form a more stable microstructure with enhanced resistance to long-term freeze-thaw cycles. This meant that combining secondary resources with nano-additives produced a new generation of materials, whose durability was determined not only by composition, but also by controlled structuring mechanisms. Such an approach may become fundamental for renovation mixes adapted to aggressive service conditions.

G. Bonifazi *et al.* (2025) found that key trends in recycling construction and demolition waste include the introduction of high-precision sorting (sensor- and spectroscopy-based technologies), contamination control (gypsum, organics, salts), the formation of “end-of-waste” criteria and harmonised standards, as well as digital traceability of batches. Researchers stressed that variability of secondary raw-material properties and the absence of unified technical specifications remained the main barriers limiting the scaling of even technically mature solutions. This was consistent with the results of this study, which indicated that the durability of dry-mix systems depended on strict control of impurities, standardised sorting procedures and the introduction of “batch passports”. Without harmonised regulations and digital traceability mechanisms, even material platforms, whose effectiveness had been proven in laboratory and field conditions cannot be scaled up at industry level. Thus, integrating recycled construction and industrial waste into dry renovation mixes was a technically and environmentally justified strategy that can simultaneously reduce the carbon footprint and dependence on non-renewable resources. The key conditions for scaling up were standardised sorting and impurity control, incoming inspection protocols and the use of machine learning, and for Ukraine – adaptation of standards and the creation of regional recycling centres.

CONCLUSIONS

The results of the study have shown that the utilisation of construction and industrial waste in dry mixes made it possible to significantly reduce dependence on primary non-renewable resources and cut the carbon footprint. The transition to a circular economy in construction ensured the reintroduction of waste into the production





cycle. Technical results indicated high effectiveness of secondary materials: 20% replacement of cement with reclaimed powder increases strength by $\approx 8\%$, whereas 100% replacement of sand with recycled aggregate reduced water absorption and density, although it required careful control. The use of 15-50% slag or fly ash provided a denser matrix and lower permeability in the long term, even if strength decreased at early ages. Combining glass and slag (an optimum proportion of 91% glass and 26% granulated slag yields a strength of ≈ 36.5 MPa) significantly reduced water absorption and formed a denser structure. In addition, the addition of 5-10% glass powder to cement provided $\approx 11\%$ strength growth at 28 days. International experience confirmed the effectiveness of such solutions: in India, 20% replacement of cement by reclaimed powder delivered a strength increase of 8.07%, while 100% replacement of sand led to an 11.48% reduction in water absorption and a 5.21% decrease in porosity. In South Africa, a combination of 60% concrete rubble and 10% slag showed a 12.8-32.5% decrease in strength, but a 4.5% reduction in water absorption.

However, challenges remained: variability in raw-material composition, a lack of long-term durability data (frost resistance, sulphate attack, carbonation), high costs

of sorting and cleaning, and the absence of unified standards. It was necessary to introduce “batch passports”, to control the presence of sulphates, organics and salts, and to regulate the risks of alkali-aggregate reaction of glass. For Ukraine, the most practical and justified approach was to use 15-50% granulated blast-furnace slag in the binder together with 20-30% classified washed sands from construction waste. This approach, combined with the development of regional recycling centres and digital quality control, will make it possible to achieve a balance between strength, durability and environmental efficiency. Further studies should focus on field durability research, the development of standardised quality-control methods, regional life-cycle assessments for Ukraine and the integration of digital technologies with practical data.

None.

None.

None.

ACKNOWLEDGEMENTS

FUNDING

CONFLICT OF INTEREST

REFERENCES

- [1] Abbas, M.M. (2025). Recycling waste materials in construction: Mechanical properties and predictive modeling of Waste-Derived cement substitutes. *Waste Management Bulletin*, 3(1), 168-192. doi: 10.1016/j.wmb.2025.01.004.
- [2] Antunes, A., Costa, H., do Carmo, R., & Júlio, E. (2024). Mortars produced with recycled aggregates from construction and demolition waste – analysis and construction site application. *Construction and Building Materials*, 457, article number 139395. doi: 10.1016/j.conbuildmat.2024.139395.
- [3] Baah, T.T., Zeng, H., Latypov, M.I., & Kim, H.J. (2025). Design of sustainable mortar incorporating construction and demolition waste through adaptive experiments accelerated by machine learning. *Results in Engineering*, 25, article number 104264. doi: 10.1016/j.rineng.2025.104264.
- [4] Balasbaneh, A.T., Sher, W., Li, J., & Ashour, A. (2025). Systematic review of construction waste management scenarios: Informing life cycle sustainability analysis. *Circular Economy and Sustainability*, 5, 529-553. doi: 10.1007/s43615-024-00424-z.
- [5] Bansal, S., Bansal, P., Gautam, L., & Sharma, K.V. (2024). Development and standardization of sustainable dry mix mortars with supplementary cementitious materials. *Journal of Building Pathology and Rehabilitation*, 9, article number 49. doi: 10.1007/s41024-024-00400-y.
- [6] Beigh, I., & ul Haq, M.Z. (2024). A review of geopolymer concrete incorporating recycled aggregates. *AIP Conference Proceedings*, 3050(1), article number 030004. doi: 10.1063/5.0196292.
- [7] Bondar, A., Hristych, O., Bondar, O., & Safronenko, I. (2024). Prospects of use of secondary waste of the construction industry in the production of dry building mixtures. *Modern Technology, Materials and Design in Construction*, 36(1), 64-70. doi: 10.31649/2311-1429-2024-1-64-70.
- [8] Bonifazi, G., Grosso, C., Palmieri, R., & Serranti, S. (2025). Current trends and challenges in construction and demolition waste recycling. *Current Opinion in Green and Sustainable Chemistry*, 53, article number 101032. doi: 10.1016/j.cogsc.2025.101032.
- [9] Borges, P.M., Rother, L.A., da Silva, S.R., Possan, E., & de Oliveira Andrade, J.J. (2025). Environmental and technical assessment of mortars produced with recycled aggregate from construction and demolition waste. *Construction and Building Materials*, 467, article number 140407. doi: 10.1016/j.conbuildmat.2025.140407.
- [10] Botirov, B., & Botirova, N. (2024). Identification of physical and mechanical characteristics of high strength heavy concrete. *Architecture. Construction*, 1(1), 134-140.
- [11] Chen, L., et al. (2024). Conversion of waste into sustainable construction materials: A review of recent developments and prospects. *Materials Today Sustainability*, 27, article number 100930. doi: 10.1016/j.mtsust.2024.100930.
- [12] Cigala, R.M., Papanikolaou, G., Lanzafame, P., Sabatino, G., Tripodo, A., La Ganga, G., Crea, F., Ielo, I., & De Luca, G. (2025). Transforming waste into sustainable construction materials: Resistant geopolymers from recycled sources. *Recycling*, 10(3), article number 118. doi: 10.3390/recycling10030118.



- [13] DSTU B V.2.7-126:2011. (2011). *Building mortars: General technical specifications*. Retrieved from <https://surl.li/prjrxg>.
- [14] DSTU EN 998-2:2023. (2024). *Technical conditions for masonry mortar. Part 2. Masonry mortars*. Retrieved from https://online.budstandart.com/ua/catalog/doc-page.html?id_doc=104882.
- [15] Duan, D., Liao, H., Wei, F., Wang, J., Wu, J., & Cheng, F. (2022). Solid waste-based dry-mix mortar using fly ash, carbide slag, and flue gas desulfurization gypsum. *Journal of Materials Research and Technology*, 21, 3636-3649. doi: 10.1016/j.jmrt.2022.10.157.
- [16] European Standard EN 197-1:2011. (2011). *Cement – part 1: Composition, specifications and conformity criteria for common cements*. Retrieved from <https://standards.iteh.ai/catalog/standards/cen/64d327b1-d5ac-45e3-8b04-fafec9e0698e/en-197-1-2011>.
- [17] European Standard EN 998-1:2016. (2016). *Specification for mortar for masonry – part 1: Rendering and plastering mortar*. Retrieved from <https://standards.iteh.ai/catalog/standards/cen/a04c7a2d-0378-4f9d-a044-d0b53ac93d61/en-998-1-2016>.
- [18] Farooq, O., Bilal, H., Cavaleri, L., & Khan, A. (2023). Properties of blended mortars produced with recycled by-products from different waste streams. *Developments in the Built Environment*, 14, article number 100156. doi: 10.1016/j.dibe.2023.100156.
- [19] Fernando, W.C.V., Lokuge, W., Wang, H., Gunasekara, C., & Dhasindrakrishna, K. (2025). Sustainable mortar with waste glass fine aggregates and pond ash as an alkali-silica reaction suppressor. *Case Studies in Construction Materials*, 22, article number e04269. doi: 10.1016/j.cscm.2025.e04269.
- [20] Grigorjev, V., Azenha, M., & De Belie, N. (2025). Towards sustainable masonry construction through natural aggregate replacement by fine recycled aggregates in cement-lime mortars. *Sustainability*, 17(3), article number 1269. doi: 10.3390/su17031269.
- [21] Hasibuan, G.C.R., Al Fath, M.T., Yusof, N., Dewi, R.A., Syafridon, G.G.A., Jaya, I., Anas, M.R., & Syahrizal. (2025). Integrating circular economy into construction and demolition waste management: A bibliometric review of sustainable engineering practices in the built environment. *Case Studies in Chemical and Environmental Engineering*, 11, article number 101159. doi: 10.1016/j.cscee.2025.101159.
- [22] Hudym, M., Kononenko, H., & Izbash, Yu. (2022). Current state, issues and perspectives of construction waste recycling in Ukraine. *International Science Journal of Engineering & Agriculture*, 1(5), 65-69. doi: 10.46299/j.isjea.20220105.08.
- [23] Irum, S., Shabbir, F., Salahuddin, H., & Waqas, R.M. (2025). Performance evaluation of sustainable recycled aggregates geopolymer concrete using cement and graphite nano/micro platelets under heat and ambient curing. *Emergent Materials*, 8, 4963-4987. doi: 10.1007/s42247-025-01057-0.
- [24] ISO 16290:2013. (2013). *Space systems – definition of the technology readiness levels (TRLs) and their criteria of assessment*. Retrieved from <https://www.iso.org/standard/56064.html>.
- [25] Kostyra, N., & Bashynskyi, O. (2025). Research on fire resistance of steel floor beams during reconstruction of the UN office building in Ukraine. *IOP Conference Series: Earth and Environmental Science*, 1499, article number 012026. doi: 10.1088/1755-1315/1499/1/012026.
- [26] Ma, Z., Liu, X., Hu, R., Ba, G., & Wang, C. (2023). Using recycled aggregate and powder from high-strength mortar waste for durable cement-based materials: Microstructure and chloride transport. *Journal of Cleaner Production*, 417, article number 137998. doi: 10.1016/j.jclepro.2023.137998.
- [27] Malladi, R.C., Ajayan, S.A., Chandran, G., & Selvaraj, T. (2025). Upcycling of construction and demolition waste: Recovery and reuse of binder and fine aggregate in cement applications to achieve circular economy. *Cleaner Engineering and Technology*, 24, article number 100864. doi: 10.1016/j.clet.2024.100864.
- [28] Melnyk, A., Pozniak, O., & Marushchak, U. (2024). Development of dry mix mortars for floor elements. *Theory and Building Practice*, 6(1), 25-31. doi: 10.23939/jtbp2024.01.025.
- [29] Ohemeng, E.A., Ramabodu, M.S., Nena, T.D., & Kancheva, Ya. (2024). Performance of sustainable mortars containing blast furnace slag and fine concrete waste: An environmental perspective. *Cogent Engineering*, 11(1), article number 2313053. doi: 10.1080/23311916.2024.2313053.
- [30] Oleksyn, M., & Obynochna, Z. (2023). Use of secondary materials in architecture and construction. *Theory and Practice of Design*, 29-30, 105-111. doi: 10.32782/2415-8151.2023.29-30.12.
- [31] Pietrzak, A., & Ulewicz, M. (2025). The mechanical strength of ecological cement mortars based on fly ash from the combustion of municipal waste and cement kiln dust. *Applied Sciences*, 15(6), article number 3215. doi: 10.3390/app15063215.
- [32] Ranasinghe, N., Domingo, N., & Kahandawa, R. (2024). Enhancing building material circularity: A systematic review on prerequisites, obstacles, and the critical role of data traceability. *Journal of Building Engineering*, 98, article number 111136. doi: 10.1016/j.jobbe.2024.111136.
- [33] Sengupta, J., Dhang, N., & Deb, A. (2024). A cost-effective slag-based mix activated with soda ash and hydrated lime: A pilot study. *Practice Periodical on Structural Design and Construction*, 29(2). doi: 10.1061/PPSCFX.SCENG-1426.
- [34] Shajidha, H., & Mortula, M. (2025). Sustainable waste management in the construction industry. *Frontiers in Sustainable Cities*, 7, article number 1582239. doi: 10.3389/frsc.2025.1582239.



- [35] Troian, V., Gots, V., Keita, E., Roussel, N., Angst, U., & Flatt, R.J. (2022). Challenges in material recycling for postwar reconstruction. *RILEM Technical Letters*, 7, 139-149. doi: [10.21809/rilemtechlett.2022.171](https://doi.org/10.21809/rilemtechlett.2022.171).
- [36] Valoni, N.A., Sáez del Bosque, I.F., Medina, G., & Medina, C. (2025). Formulation of eco-friendly rendering mortars based on new alternative raw materials: Performance and microstructure. *Journal of Building Engineering*, 109, article number 113008. doi: [10.1016/j.jobbe.2025.113008](https://doi.org/10.1016/j.jobbe.2025.113008).
- [37] Wu, J., Ye, X., & Cui, H. (2025). Recycled materials in construction: Trends, status, and future of research. *Sustainability*, 17(6), article number 2636. doi: [10.3390/su17062636](https://doi.org/10.3390/su17062636).
- [38] Yeo, J.S., Koting, S., Onn, C.C., Radwan, M.K.H., Cheah, C.B., & Mo, K.H. (2023). Optimisation and environmental impact analysis of green dry mix mortar paving block incorporating high volume recycled waste glass and ground granulated blast furnace slag. *Environmental Science and Pollution Research*, 30, 58493-58515. doi: [10.1007/s11356-023-26496-2](https://doi.org/10.1007/s11356-023-26496-2).
- [39] Zhang, K., Qing, Y., Umer, Q., & Asmi, F. (2023). How construction and demolition waste management has addressed sustainable development goals: Exploring academic and industrial trends. *Journal of Environmental Management*, 345, article number 118823. doi: [10.1016/j.jenvman.2023.118823](https://doi.org/10.1016/j.jenvman.2023.118823).
- [40] Zhang, P., Sun, X., Wang, F., & Wang, J. (2023). Mechanical properties and durability of geopolymers recycled aggregate concrete: A review. *Polymers*, 15(3), article number 615. doi: [10.3390/polym15030615](https://doi.org/10.3390/polym15030615).

Христина Собољ

Професор

Національний університет «Львівська політехніка»

79013, вул. Степана Бандери, 12, м. Львів, Україна

<https://orcid.org/0000-0003-0798-413X>

Андрій Мельник

Асистент

Національний університет «Львівська політехніка»

79013, вул. Степана Бандери, 12, м. Львів, Україна

<https://orcid.org/0000-0001-7246-5227>

Олександр Хіта

Аспірант

Національний університет «Львівська політехніка»

79013, вул. Степана Бандери, 12, м. Львів, Україна

<https://orcid.org/0009-0003-1221-0603>

Сухі будівельні суміші з вторинною сировиною для реновації будівель: порівняльний аналіз властивостей і ефективності

Анотація. Метою дослідження була теоретична оцінка використання перероблених будівельних і промислових відходів у сухих реноваційних сумішах. Методологія охоплювала комплексний підхід до утилізації відходів у контексті сталого розвитку та визначенні перспектив для України. Встановлено, що часткова заміна цементу гранульованим доменним шлаком (25-50 %) знижує вуглецевий слід на 30-40 % без втрати міцності та довговічності, додавання перероблених заповнювачів (20-30 % від природного піску) забезпечує міцність ≥ 10 МПа при належному контролі гранулометрії та чистоти. Поєднання скла та шлаку підвищує щільність матриці й зменшує водопоглинання, але потребує контролю лужної реактивності. Виявлено, що аналіз життєвого циклу підтверджує зниження CO_2 -викидів на 20-40 % при використанні переробленої сировини, водночас значна економія первинних ресурсів зменшує тиск на довкілля та обсяги відходів. Використання методів математичного планування експерименту дозволяє швидше підбирати оптимальні рецептури, зменшуючи кількість експериментів у 8-10 разів. Натурні випробування у Португалії, Індії та Південно-Африканській Республіці підтвердили можливість практичного використання сумішей із вторинними матеріалами у штукатурних і мурувальних роботах. В Україні потенціал застосування таких технологій став значним з огляду на потреби післявоєнної відбудови та наявність великих обсягів будівельних і демонтажних відходів. Найперспективнішими рішеннями для реноваційних сумішей стали гранульований доменний шлак, класифіковані дрібні фракції (після очищення можуть заміщати 20-30 % піску без втрати властивостей), комбінації гранульованого доменного шлаку та скляного порошку, склади, оптимізовані за допомогою машинного навчання. В Україні головними бар'єрами стали недостатній рівень контролю якості та слабка лабораторна база, однак регіональні виробництва сумішей здатні забезпечити ефективне використання відходів будівництва у відбудові. Практична значимість полягає у використанні результатів будівельними компаніями, виробниками матеріалів для екологічних сумішей і стандартів відновлення.

Ключові слова: утилізація відходів; альтернативні в'язучі матеріали; довговічність розчинів; лабораторні випробування; польові випробування; стійкість до агресивного середовища; ресурсоефективність

Oksana Iurchyshyn*

PhD, Associate Professor
Lviv Polytechnic National University
79013, 12 Stepan Bandera Str., Lviv, Ukraine
<https://orcid.org/0000-0002-3250-636X>

Children's participation as an architectural component of post-war reconstruction in Ukraine

Abstract. In the context of full-scale war and post-war transformation, Ukrainian architecture faced the challenge of transitioning from the technocratic reconstruction of physical objects to the restoration of the social fabric of cities. The aim of the study was to determine the role of children's participation in the humanisation of the architectural environment and to justify new approaches to the formation of educational and public spaces in the post-war period. The methodological basis of the work was the concepts of dialogical space, co-design and spatial agency, integrated into the architectural analysis of reconstruction processes. The article considered children's participation as a potentially strategic architectural component capable of influencing the rethinking of established approaches to spatial planning. Based on the systematisation of theoretical models and the analysis of international and Ukrainian practical cases, it was shown that the integration of children's experience influenced the morphology and functional organisation of architectural objects. In the spatial plane, the results of the study indicated an increase in attention to alternative design approaches, within which, along with rigid functional zoning, the principles of polyvalence were considered, and the monumental scale in certain contexts was complemented by solutions focused on the commensurability, tactility, and accessibility of the environment. It has been established that taking into account the children's perspective changes the approach to the safety of architectural space – from the logic of isolation to the concept of “active safety” based on transparency, visual connections and social presence. An analysis of priority reconstruction environments – educational, public and transitional – showed that participatory practices help to identify hidden spatial conflicts and design “blind spots” that remain unnoticed in technocratic models. In educational spaces, this has contributed to the formation of environments oriented towards research behaviour; in public spaces, to increased inclusiveness for different age groups; and in temporary and transitional spaces, to rapid adaptation and mastery of space by users in the context of post-traumatic experiences of home loss. The results obtained form the methodological basis for institutionalising child participation in architectural and planning processes, outlining the role of interdisciplinary interaction as a key condition for the humanisation of space and the sustainability of initiatives in the post-war period

Keywords: reconstruction architecture; space and place; participatory design; humanisation of architecture; public spaces

INTRODUCTION

The full-scale war in Ukraine since 2022 has radically changed the spatial and social structure of cities, revealing the limitations of the centralised planning system. J. Gil-Mastalerczyk *et al.* (2025) showed that reconstruction

processes often reproduce established technocratic approaches. The authors highlighted the complex humanitarian, demographic and socio-economic consequences of the war, as well as the importance of international cooperation

Suggested Citation:

Iurchyshyn, O. (2025). Children's participation as an architectural component of post-war reconstruction in Ukraine. *Architectural Studies*, 11(4), 33-42. doi: 10.56318/as/4.2025.33.

Journal homepage: <https://arch-studies.com.ua/en>

Architectural Studies, 11(4), 33-42

Received: 01.08.2025 Revised: 14.11.2025 Accepted: 19.12.2025 Published: 29.12.2025

*Corresponding author



Copyright © The Author(s). This is an open access article distributed under the terms of the Creative Commons Attribution License 4.0 (<https://creativecommons.org/licenses/by/4.0/>)



and strategies for the sustainable recovery of affected areas. A. Anisimov *et al.* (2024) emphasised the prevalence of normative decisions and the weak integration of the social dimension in contemporary development practices. This orientation often left connections and practices of coexistence out of focus. The destruction of residential areas, educational institutions and public spaces demonstrated not only the scale of material damage, but also the depth of social vulnerability – breaks in the networks of trust, communication and coexistence practices that shaped the resilience of urban communities.

In the context of post-war transformation, there was a need to rethink architecture – not as a technical process, but as a socio-humanistic one aimed at restoring not so much the physical structure as the meaningful unity of urban life. In this context, scientific discourse has focused more attention on approaches to the formation of architecture that centre on the interaction between people and space. It was in this interaction that space acquired meaning and was transformed into a place filled with significance. V.A. Cordero-Vinueza *et al.* (2023) emphasised in their socio-spatial review that a focus on the everyday experience of users was a prerequisite for the formation of sensitive urban environments. The researchers identified a significant gap in knowledge about the governance mechanisms that transform rights into concrete spatial practices and proposed directions for further research to address these gaps. S.A. Ensarioğlu & F.A. Özsoy (2021) considered co-design as an approach, where space was shaped through shared experience. The researchers emphasised the importance of integrating children into decision-making about the built environment as a way to increase urban awareness and develop cooperation skills between the younger generation and architecture and design professionals. H. Badland *et al.* (2023) linked this focus to principles of social justice. In theoretical interpretations, S. Molloy (2025) noted that children's participation was seen as one of the processes of forming spatial agency, which transformed the interaction between users, the professional community and institutions. This transition “from space to place” shifted the focus of design from physical parameters to the experience, perception, and identity of users. The implementation of this approach created new challenges, blurring the boundaries between expert and user positions, which raised the issue of balancing professional responsibility and the distribution of initiative. This was clearly evident in the practices of child participation, where interaction went beyond the professional field and took on pedagogical and ethical content.

Children's participation in architectural and planning processes has actively developed in a global context, demonstrating the potential for shaping a culture of spatial responsibility. G. Katsavounidou & S. Sousa (2024) emphasised that the lack of a stable institutional model limited children's influence on decisions and reduced their involvement to a symbolic level. A similar problem of formalisation was noted by T. Strachan (2024), who

emphasised the risk of declarativeness in the absence of clear procedures. E.A. Haklıdır *et al.* (2023) showed that participation in planning does not have a single meaning and was interpreted differently depending on the implementation framework. This indicated the need for a theoretical understanding of child participation as a component of a humanistic approach and an indicator of sensitivity to the experiences of different user groups. In Ukraine, these practices have largely remained experimental and have not been integrated into official mechanisms. B. McAteer *et al.* (2023) noted that even, when children were recognised as capable of participating in decision-making, the political landscape remained “adult-centric”. The problem of child participation in the context of reconstruction was the fragmentation of existing practices and the lack of a clear concept that would define their place in architectural thinking. Post-war reality has turned this participation into a test for the humanistic paradigm: whether architectural practice was capable of expanding its boundaries to recognise the child as an active subject in shaping the environment and a bearer of unique experience, opening new perspectives in understanding space, trust and community. The aim of the article was to provide a theoretical justification of children's participation as a component of post-war reconstruction and to define its role in the humanistic transformation of the architectural process.

LITERATURE REVIEW

Research into child participation in architecture and urban planning emerged in an interdisciplinary field combining theories of democratic planning, humanistic architecture, children's rights and social geography (Convention..., 1989). Scientific works focused on justifying children's participation as a component of the democratisation of urban development and the expansion of the circle of decision-makers. S. Bartlett (2002) interpreted children's participation as a tool for identifying social inequalities that were invisible in adult-centred models. The author emphasised that children's experiences allowed for a different interpretation of the accessibility, safety and quality of public spaces. The authors M. Francis & R. Lorenzo (2006) developed this thesis, pointing out that the involvement of children transforms the understanding of design – from functional organisation to a focus on everyday experience.

The philosophical dimension was revealed through a rethinking of space. A. Rigolon (2011) introduced the idea of a transition “from space to place”, emphasising that the social value of the environment was formed through bodily experience and the practice of interaction. This approach made it possible to analyse space not as a neutral shell, but as an environment of meanings. J. Birch *et al.* (2016) described design as a dialogical process, where the meaning of a place arose through communication and co-creation between different groups of users. The psychological aspects of this process were analysed by M. Anbari & H. Soltanzadeh (2015), who identified the involvement of children



in design as a factor in the formation of spatial identity. The researchers showed that children's perceptions capture alternative ways of understanding the environment, different from the rationalised approaches of adults, which complemented the understanding of function, safety and comfort. The practical dimension was represented by interaction studies. K. Bishop & L. Corkery (2017) considered designing with children as a process that goes beyond the creation of specialised areas and requires a rethinking of the role of the architect. Here, the specialist became a facilitator of cooperation rather than the sole author of the decision. V. Derr *et al.* (2013), researching the participation of marginalised groups, proved that participation only made sense if it has a real impact on the outcome. V. Derr & E. Tarantini (2016) added that involvement in the planning of public spaces promotes a sense of belonging and responsibility. The methodology of participation was developed at the intersection of architecture, pedagogy, and sociology. A. Clark (2007) emphasised early involvement as a way of capturing unique experiences. The author emphasised that the active participation of children in the design process not only improved the quality of the environment but also opened up important opportunities for understanding their experiences and developing skills that were often ignored by traditional approaches to design. P. Christensen *et al.* (2017) linked this to the principles of sustainable development: children's perspectives revealed the long-term social and environmental consequences of decisions. The researchers also examined how children's needs and voices remained marginalised in the planning and design of sustainable urban spaces and emphasised the need to integrate children's perspectives into sustainable urban development policies and practices.

The political and ethical dimension was explored by C. Feinstein *et al.* (2010), who interpreted participation as a right and an ethical challenge. The authors pointed to the asymmetry of power and emphasised that genuine participation implied influence, not symbolic presence. A critical perspective was offered by B. Cooke & U. Kothari (2001), who warned against turning participatory approaches into a tool for legitimising ready-made decisions. The authors emphasised that without an analysis of power and context, the idea of participation in social development projects risks becoming a form of opaque control rather than genuine democratic inclusion. B. Flyvbjerg (2003) elaborated on the idea that rationality in design was often subordinate to power, creating risks of formalisation. Thus, scientific discourse outlined a broad theoretical and methodological field, where children's participation was seen as a complex phenomenon. In the works of researchers, it emerged as an instrument of democratisation, a source of alternative knowledge, a method of co-creation, and an object of critical analysis through the prism of power and ethics.

MATERIALS AND METHODS

The research was qualitative and theoretical-analytical in nature, which was due to the need for a comprehensive

study of the phenomenon of child participation, which was at the intersection of architecture, social sciences and pedagogy. The methodological structure of the work was based on the principles of the humanistic paradigm, within which architectural space was interpreted not as a static physical form or neutral object, but as a dynamic field of social interaction, co-creation and restoration of meaning. This approach became relevant to the context of post-war reconstruction, where physical reconstruction processes were linked to the tasks of social rehabilitation and restoring trust. The material basis of the study was formed by selecting strategic and regulatory documents according to criteria of relevance to the challenges of democratic transformation and the availability of engagement mechanisms. The analysis included recommendations from the public sector and EU regulations, in particular the report "Build Forward: NGO recommendations on Ukraine recovery and reconstruction" (Save the Children, 2023), which was included in the sample as a document reflecting civil society's demand to overcome formalism in the management of reconstruction. The Build Ukraine Back Better (2025) strategy was analysed as a basic state scenario that defined decentralisation and inclusiveness as the main principles of recovery. In contrast, the European Commission (n.d.) regulations were considered a normative imperative that required the adaptation of Ukrainian procedures to European standards of democratic participation. The empirical component of the work consisted of case studies of international programmes (Growing Up Boulder, Junges Wien, Kinderfreundliche Kommune) and Ukrainian pilot initiatives (The City Has Me, School of Young Ambassadors of Participation), which served as the basis for comparing theoretical models with real practice.

The logic of the research was implemented through four interrelated stages. In the first, analytical and research stage, methods of systematisation and critical analysis of literature were used to identify key categories of architectural discourse, such as agency, institutional-ity and the right to the city. The second stage involved interpretative analysis aimed at revealing the deep semantic connections between spatial solutions, user experience and the transformation of the professional role of the architect from that of "author" to that of facilitator of interaction. The third, methodological stage defined organisational models of children's participation and communication tools in the interdisciplinary triangle of "architect-educator-community". The final stage was based on comparative analysis and typology methods, which made it possible to compare large-scale international and Ukrainian practices in terms of duration, level of integration, and impact on decision-making. This became the basis for constructing an empirical-evaluative typology of architectural environments. The analytical conclusions were based on a qualitative comparison of approaches and do not claim to be statistically representative, but they do offer a comprehensive model for the humanisation of reconstruction processes.



RESULTS AND DISCUSSION

Systematisation of approaches and determination of the humanistic potential of children's participation in architecture

The generalisation of philosophical, social and pedagogical approaches made it possible to identify common vectors of humanisation of the architectural process. Based on this analysis, a classification of basic terms and concepts was carried out. This systematisation made it possible to organise the field of contemporary participation theories and present a comprehensive conceptual framework. Child agency became a key concept that determined the balance between protection and participation. The traditional approach, where priority was given to protection, paradoxically limited children's ability to influence the processes, in which they were involved. At the same time, in the context of co-design, agency was seen as recognition of the value and expert knowledge of all participants, including children, which formed the basis for equal participation (Stavholm *et al.*, 2024). Experience as a source of meaning consisted in recognising the

uniqueness of children's knowledge. It manifested itself through creative forms (drawings, games) that reflected the symbolic and mental perception of space (Anbari & Soltanzadeh, 2015). Children were able to transform this experience into concrete spatial images, for example by creating "risk maps", which demonstrated their active participation in learning about the environment. Dialogue as the basis for co-creation was interpreted not as a one-sided expression, but as a process of mutual exchange. This created an open social space with transformative potential, in which meaning was born through the interaction of different perspectives (Birch *et al.*, 2016). The game served as a methodological tool for learning about and mastering space, combining experimentation, imagination, and learning. Children's participation was realised through constructive play and drawing (Ensari-oğlu & Özsoy, 2021), as well as through the integration of digital technologies. An example of such a tool was the #stadtsache mobile app, designed to collect photos, videos and route recordings, turning children and young people into "urban experts" (Fig. 1).



Figure 1. Map of urban routes created by children during the study of public spaces

Note: an example of visualising the results of children's spatial research using the mobile application #stadtsache. Caption on the map: "This is not only a bus stop, but also a meeting place for teenagers"

Source: Stadtsache (n.d.)

Trust served as an ethical condition for interaction, based on empathy and a shared search for meaning, in which architects, "losing control", gained a "sense of community" that formed the ethical basis for cooperation. Institutionality became a fundamental condition for the transition from episodic to systematic participation of children in the design processes. An analysis of strategic documents revealed a significant gap between the current state of affairs and international requirements. While the Build Ukraine Back Better (2025) strategy diagnosed low citizen engagement as a general challenge, in the context of urban planning, this meant a lack of mechanisms for children to influence the formation of their environment. Without separate procedural approaches (Pasyuta *et al.*, 2023), the

"inclusiveness" embedded in the strategy risked remaining a declaration, and the restored spaces risked remaining unfriendly to young people. At the same time, the recommendations of Save the Children (2023) and the requirements of the European Commission (n.d.) regarding the democratisation of processes should be interpreted as a requirement to change the role of the architect. In European practice, this meant a transition from designing "for children" (protection) to designing "with children" (participation). For Ukrainian reconstruction, this opened up the possibility of legitimising child participation not as volunteering, but as a mandatory pre-project stage. This meant the need to adapt the regulatory field, where children were recognised as full-fledged decision-makers at



the community level. An example of overcoming this gap was the School of Young Ambassadors of Participation project, which proved the effectiveness of local partnerships

in the absence of systemic state mechanisms. Table 1 summarised the dimensions of humanistic architecture and presented its main key ideas.

Table 1. Conceptual framework for understanding children's participation in architecture

Dimensions of humanistic architecture	Key ideas	Core concepts
Institutional	Participation as a right and an indicator of social maturity; participation as a component of reconstruction policies; build back better	Agency, institutionality, trust
Empirical-spatial	Philosophy of space: space as a place of interaction; the architect as a facilitator. Play as a way of cognition and co-creation; Spielraum as a space of freedom	Experience, play
Socio-communicative	Educational/social practice; co-design, digital platforms, cooperative modelling	Dialogue, interdisciplinarity

Source: based on C. Feinstein *et al.* (2010), M. Anbari & H. Soltanzadeh (2015), Save the Children (2023), N. Sevinçli & B.E. Şahin (2024), Build Ukraine Back Better (2025), S. Molloy (2025)

Thus, the institutional dimension (socio-political legitimacy) outlined the transition from symbolic participation to sustainable co-creation, in which children were recognised as full-fledged social and political subjects of understanding and interpreting space. Young people were often underrepresented in planning decisions and face a deficit of rights, so sustainability required the “legalisation” of participation as a democratic principle and routine procedure (Save the Children, 2023). A prime example of such integration was the Vienna initiative Junges Wien, which transformed the urban management process by drawing on the opinions of more than 22,000 children (City of Vienna, n.d.). Within the strategic direction “Platz und Raum” (Place and Space), children were given a direct influence on the architectural appearance of the city. This was achieved not only through consultations, but also through the participatory budgeting tool “Children and Youth Million” (Kinder- und Jugendmillion), which financed specific infrastructure projects. Among the cases implemented were the redesign of school grounds (Schulvorplätze) to improve pedestrian safety, the redesign of city parks with zoning for different age groups, and the creation of inclusive public spaces designed with the direct participation of young users. Overcoming adult-centred practices was made possible by ethical partnerships that eliminated marginalisation and made participation part of professional ethics (Cath, 2023).

In the empirical-spatial dimension (knowledge and meanings of the environment), participation was interpreted as a form of learning about architecture through the unique bodily and sensory experience of the child. This experience became an autonomous source of knowledge, distinct from the rational priorities of adults. T. Wilhelmsen *et al.* (2023) noted that children prefer physical challenges and fantasy, while adults prefer safety. In the context of child-oriented environments, architectural approaches that go beyond technocratic thinking allow for a balance of autonomy, mobility, and opportunities for creative play (Ezzatian, 2017). This was consistent with the “child-friendly city” approach, according to which taking into account the child's perspective made it possible to identify the needs of a wider range of vulnerable groups. In the space of play and experimentation, children transformed the environment into a space of presence, giving meaning to the concept of “humanity” in design. The social-communicative dimension viewed co-design as a transformative practice (Fig. 2) in which communication, learning, and social interaction became integral components of environment creation. The architectural process was transformed into a dialogue arena where knowledge was born in the interaction between specialists and the community. In this model, the architect acted not as a sole author, but as a facilitator of mutual learning (Birch *et al.*, 2016).



Figure 2. A socio-communicative practice of interaction between children and professionals in the process of shaping architectural space

Note: a – teenagers plan and design playgrounds, Regensburg. Author: Peter Ferstl; b – a “speed-date” session with the mayor, the commissioner for education and the head of the department, Regensburg. Author: Stefan Effenhauser

Source: Stadt Regensburg (n.d.)

In humanistic architecture and participatory pedagogy, facilitation was understood not as technical “process management” but as creating conditions for equal interaction, self-expression, and collaborative learning. It acted as a value-based approach that determined the quality of interaction: the facilitator (architect, educator, social moderator) does not impose decisions, but helps participants to reveal their own ideas, managing not the content, but the dynamics of the process – trust and creativity. This transformed the architect from the position of “author” to the position of coordinator of joint decision-making. The transition to a real partnership is only possible if clear principles are implemented, the effectiveness of which is proven by international initiatives such as UNICEF (n.d.) and Growing Up Boulder (ICMA, 2017).

Growing Up Boulder demonstrated a unique example of trilateral cooperation between the municipality, the university and children, where architects acted as a kind of “translato” of children’s visions into professional language. Using adapted methods – from digital mapping to physical modelling – the initiative integrated young people’s proposals into more than 50 real projects, including the reconstruction of the Civic Area central park, proving that children were capable of proposing competent spatial solutions. Such practices combined architectural, pedagogical, and social knowledge to create inclusive and humanistic reconstruction environments. The conceptual dimensions of humanistic participation were embodied in the principles of humanistic facilitation, which were summarised in Table 2.

Table 2. Systematisation of the principles of humanistic facilitation

Principle	Level of facilitation action	Facilitative function	Type of interaction
Co-design	Structural/process and structure of action	Structure organiser: creates the framework for a process in which participants jointly formulate tasks and seek solutions	Equality in joint action; partnership
Dialogical space	Communicative/communicative form and culture of interaction	Meaning moderator: practises active listening, empathy and non-dominance, and supports reflection	Practice of mutual understanding and exchange of experience
Play as a cognitive practice	Cognitive-emotional/methodological	Scenario designer: develops play-based methods (model-making, quests) that enable children to enter the process naturally	Experimentation, a safe and motivating environment
Interdisciplinary cooperation	Institutional-team-based/organisational	Expertise coordinator: brings together efforts with educators and social workers to support the process	A system of comprehensive support

Source: based on J. Birch *et al.* (2016), S.A. Ensarioğlu & F.A. Özsoy (2021), T. Wilhelmsen *et al.* (2023), E. Stavholm *et al.* (2024), N. Sevinçli & B.E. Şahin (2024)

Thus, co-design emerged as a form of collective design, in which the process took on the significance of social and educational practice. Participants jointly identify problems and overcome tensions between children’s and adults’ perspectives. Such facilitation was based on recognising children’s agency, transforming the space into a platform for social programming, where the environment was created through the transformation of social relations and practices. The dialogical space implements the principle of dialogue as a format for co-creation, where knowledge was born through interaction rather than through the hierarchical transfer of information. Facilitation here was based on empathy and a willingness to lose control for the sake of meaning. In such an environment, dialogue does not seek consensus but recognises differences in positions as a source of new meanings. Materiality, gestures and non-verbal communication became important tools, allowing individual ways of perceiving space to be recorded and translated into joint discussion. Play as a cognitive practice became a natural mechanism of engagement, where the concept of Spielraum (“play space”) defined the environment as a zone of experimentation. The participation of children became a source of creative solutions that went beyond the imagination of adults, whose focus is usually limited by safety standards. Thus, facilitation in this dimension had to be based not on formal procedures,

but on creating conditions for direct experience and free self-expression. Interdisciplinary cooperation involved the synthesis of the competencies of architects, educators, and social facilitators to take into account the emotional, educational, and communicative experiences of children. This approach was implemented on the basis of ecological psychology and considered social participation as a tool for urban planning.

Typology of environments and analysis of the effect of facilitated participation

The implementation of specific facilitative principles in different types of environments has a varying impact on social integrity. The experience of participatory design showed that the humanistic effect was characteristic of spaces associated with everyday life (learning, play, communication, leisure), which form a sense of security, comfort and belonging in children. In post-war reconstruction, such environments became priority objects of reconstruction. In educational environments, children’s participation implements the principle of a child-centred environment (Ensarioğlu & Özsoy, 2021). For younger participants, short participation cycles were effective – redesigning schoolyards, play areas or indoor installations that produced quick, visible results (Rigolon, 2011). Such interventions created an atmosphere of trust, where children feel like



co-authors of change. In urban and public spaces, child participation contributed to the restoration of the social fabric and intergenerational interaction. Examples of such approaches were demonstrated by international initiatives that made participation a systematic element of planning. In particular, the Growing Up Boulder initiative (USA) used mental mapping and photo documentation tools to integrate young people's decisions into the redevelopment of the Alpine-Balsam neighbourhood, prioritising pedestrian

connections and areas of contact with nature. In Germany, as part of the Kinderfreundliche Kommune programme (e.g. in Regensburg), there was a mechanism of "children's inspections" and direct consultations with the mayor, which allowed children to verify public space projects before construction begins. Another striking example of technological facilitation was the development of Mauerpark in Berlin, where children used the #stadtsache app to participate in the renovation of the historic part of the park (Fig. 3).



Figure 3. Children explore Mauerpark: urban space through the eyes of primary school pupils

Source: Stadtsache (n.d.)

In the Ukrainian context, similar participatory practices were being implemented by the educational and urban platforms The City Has Me (Urban Rukh, n.d.) and School of Young Ambassadors of Participation (Vinnytsia City Council, n.d.). The first initiative functioned as a comprehensive ecosystem that used illustrated guides and interactive programmes to help children understand how a city works, teaching them to identify barriers and propose inclusive solutions. The second, implemented by the Vinnytsia City Council, focused on a youth audience (high school and university students), creating institutional platforms for dialogue with the authorities and teaching young people tools for advocating change in local recovery strategies.

Even local urban interventions had a distinct therapeutic effect here, transforming reconstruction into a process of collective rethinking of the city as a space of trust. Flexible and transitional spaces (temporary hubs, children's centres, mobile educational spaces) embodied the principle of everyday placemaking. Here, architects, social workers, psychologists, volunteers and educators jointly shaped a space, in which children could regain a sense of stability, autonomy and control after traumatic events. The flexibility of the environment became a symbol of restored freedom and partnership. The identified types of architectural environments reflected different ways of children's participation and expected social effects, which were systematised in Table 3.

Table 3. Empirical-evaluative typology of children's participation

Type of environment	Examples of implementation	Dominant form of participation	Social effect
Educational	Schools, kindergartens, playground installations	Joint planning, children-initiated decisions	Development of competencies, restoration of trust, local identity
Urban/public	Parks, residential courtyards, mobility routes	Co-design, civic activism, mapping	Social cohesion, spatial safety, responsibility
Flexible/transitional	Hubs, laboratories, youth centres, mobile spaces	Everyday placemaking, tactical urbanism	Psychological stabilisation, sense of control, adaptability to change

Source: developed by the author

The presented typology was not rigid: the principles of co-design, dialogue, play and interdisciplinary cooperation were interrelated and implemented in each of the types listed, depending on the goal, age group and context. A comparative analysis of the types of environments showed that the most pronounced humanistic effect was observed, when children's participation was integrated into the actual design processes. In educational spaces, it was a factor in building trust; in public spaces, it was a factor in social

responsibility; and in flexible spaces, it was a factor in mutual support. The study proved the thesis that children's participation goes beyond specialised children's spaces, as children were full users of the entire urban landscape. In the practices analysed, the focus on children's experience was linked to the application of project logic, which made it possible to identify areas of excessive control, social isolation or alienation that often remained invisible to adults. Children's participation was identified as a factor



in the humanisation of architecture and the democratisation of reconstruction processes. Within the context of the problem of the dominance of power over rationality, examples of institutionalised child participation (Growing Up Boulder, Junges Wien, Kinderfreundliche Kommune) have become important architectural and political tools. It demonstrated that consistent and ethically oriented interaction can transform the “weak power of reason” (Flyvbjerg, 2003) into a sustainable mechanism capable of counteracting structural inequality of interests for the sake of balanced spatial development.

In post-war Ukraine, this potential will take on special significance. The participation of children in planning and reconstruction had a clear political dimension, as it reflected the degree of openness of the system to dialogue. In this context, the study by U. Banakh & R. Lozynskyy (2024) was indicative, demonstrating the possibilities of institutionally supported involvement of schoolchildren in spatial analysis of the city within the concept of Child-Friendly Cities. Although such participation was mainly implemented in the form of research activities, the very fact of including the children's perspective demonstrated a gradual expansion of the democratic framework in design. While strategic documents outlined the value framework, the methodological recommendations of D. Pasyuta *et al.* (2023) provided the necessary operational tools. The urban planning protocols proposed by the authors made it possible to avoid declarativeness and transform community involvement into a clear technological process. This approach minimised the threat of structural inequality, as pointed out by civil sector analysts (Datchenko, 2019). Thus, the integration of child participation in the reconstruction process became not only an indicator of democratic maturity, but also a professional prerequisite for the creation of sustainable and inclusive spaces. Ukrainian pilot projects demonstrated the formation of a new culture of interaction, in which architecture was understood as a social process and a space of trust. Institutional facilitation became important – the creation of interdisciplinary teams, where children were recognised as equal co-creators of the environment. It was this approach that improved the quality of architectural solutions, viewing reconstruction as a process of restoring social cohesion and post-war sustainability.

CONCLUSIONS

The article substantiated a comprehensive conceptual framework for humanistic facilitation of child participation, which was defined as a strategic tool for overcoming technocratic models in the architectural processes of post-war reconstruction in Ukraine. The study allowed

to interpret children's participation not as a local pedagogical practice, but as an indicator of the level of social sensitivity of architectural and planning processes. The systematisation of legal, empirical-spatial and methodological dimensions laid the theoretical foundation for the transition to a co-creation model, in which the child was recognised as an active social actor capable of influencing the formation of fair and safe environments, and the architect transforms their professional role from a sole author to a facilitator of dialogue. The key result of the work was the identification and justification of four principles of humanistic facilitation: co-design, dialogical space, play as a cognitive practice, and interdisciplinary cooperation. It has been established that their comprehensive implementation ensured a transition from formal participation to real interaction, which helped to overcome adult-centredness in urban planning. Particular attention was focused on the need to involve interdisciplinary teams, bringing together architects, educators and social workers, to provide emotional and communicative support to participants in the process. The developed assessment and methodological typology confirmed that priority reconstruction environments – educational institutions, urban public spaces and flexible transition zones that function as laboratories of humanistic architecture – have significant potential for restoring a culture of trust and social cohesion. The analysis showed that achieving a sustainable social effect was impossible without institutionalising participatory practices and replacing episodic initiatives with systematic municipal policy. The results confirmed that the integration of humanistic facilitation principles into national reconstruction strategies has become an important component for taking into account the experience of vulnerable population groups and democratising spatial decisions. Prospects for further scientific research should be directed towards developing criteria for assessing the socio-spatial effectiveness of child participation, adapting international institutional models to the Ukrainian legislative field, and researching digital facilitation tools that ensure the inclusiveness, scalability and transparency of decision-making processes at the community level.

ACKNOWLEDGEMENTS

None.

FUNDING

None.

CONFLICT OF INTEREST

None.

REFERENCES

- [1] Anbari, M., & Soltanzadeh, H. (2015). [Child-oriented architecture from the perspective of environmental psychology](#). *European Online Journal of Natural and Social Sciences*, 4(3), 137-144.
- [2] Anisimov, O., Smirnova, M., & Dulko, I. (2024). Establishment of a new planning system in Ukraine: Institutional change between Europeanization and post-socialist path dependence. *Planning Theory & Practice*, 25(4), 482-501. [doi: 10.1080/14649357.2024.2414973](#).



- [3] Badland, H., Villanueva, K., Alderton, A., Davern, M., & Goldfeld, S. (2023). An urban neighbourhood framework for realising progress towards the New Urban Agenda for equitable early childhood development. *Children's Geographies*, 21(6), 1087-1105. doi: 10.1080/14733285.2023.2192339.
- [4] Banakh, U., & Lozynskyy, R. (2024). Child-friendly cities: The essence of the concept and students' participation in their planning (based on the example of Lviv physics and mathematics lyceum). *Visnyk of the Lviv University. Series Geography*, 57, 204-214. doi: 10.30970/vgg.2024.57.10685.
- [5] Bartlett, S. (2002). Building better cities with children and youth. *Environment & Urbanization*, 14(2), 3-10. doi: 10.1177/095624780201400201.
- [6] Birch, J., Parnell, R., Patsarika, M., & Šorn, M. (2016). Participating together: Dialogic space for children and architects in the design process. *Children's Geographies*, 15(2), 224-236. doi: 10.1080/14733285.2016.1238039.
- [7] Bishop, K., & Corkery, L. (2017). *Designing cities with children and young people: Beyond playgrounds and skate parks*. London: Routledge.
- [8] Build Ukraine Back Better. (2025). *Roadmap for the sustainable recovery of Ukraine*. Kyiv: Build Ukraine Back Better Platform.
- [9] Cath, L. (2023). Deeping the roots of children's participation. *Sociedad e Infancias*, 7(1), 147-151. doi: 10.5209/soci.88645.
- [10] Christensen, P., Hadfield-Hill, S., Horton, J., & Kraftl, P. (2017). *Children living in sustainable built environments: New urbanisms, new citizens*. London: Routledge. doi: 10.4324/9781315750019.
- [11] City of Vienna. (n.d.). *Vienna Strategy for Children and Youth 2025 to 2030 is adopted*. Retrieved from <https://www.wien.gv.at/zusammenleben/kinder-und-jugendstrategie>.
- [12] Clark, A. (2007). Early childhood spaces: Involving young children and practitioners in the design process. *Working Papers in Early Childhood Development*, No. 45. Retrieved from <https://eric.ed.gov/?id=ED522693>.
- [13] Convention "On the Rights of the Child" Adopted by General Assembly Resolution No. 44/25. (1989, November). Retrieved from <https://www.ohchr.org/sites/default/files/crc.pdf>.
- [14] Cooke, B., & Kothari, U. (2001). *Participation: The new tyranny?* London: Zed Books.
- [15] Cordero-Vinueza, V.A., Niekerk, F., & van Dijk, T. (2023). Making child-friendly cities: A socio-spatial literature review. *Cities*, 137, article number 104248. doi: 10.1016/j.cities.2023.104248.
- [16] Datchenko, N. (2019). *Child and youth friendly cities: Global and Ukrainian perspective*. (Master's thesis, Ukrainian Catholic University, Lviv, Ukraine).
- [17] Derr, V., & Tarantini, E. (2016). "Because we are all people": Outcomes and reflections from young people's participation in the planning and design of child-friendly public spaces. *Local Environment*, 21(12), 1534-1556. doi: 10.1080/13549839.2016.1145643.
- [18] Derr, V., Chawla, L., Mintzer, M., Cushing, D.F., & Van Vliet, W. (2013). A city for all citizens: Integrating children and youth from marginalized populations into city planning. *Buildings*, 3(3), 482-505. doi: 10.3390/buildings3030482.
- [19] Ensarioğlu, S.A., & Özsoy, F.A. (2021). Children's participation in built environment design: The case of "Play Without Barriers" project. *ITU Journal of the Faculty of Architecture*, 18(2), 347-364. doi: 10.5505/ituifa.2021.52386.
- [20] European Commission. (n.d.). *Child participation in political and democratic life*. Retrieved from <https://surl.li/gwwqen>.
- [21] Ezzatian, S. (2017). *Barriers to child participation in the formation of urban space*. *MANZAR, the Scientific Journal of Landscape*, 9(39), 38-49.
- [22] Feinstein, C., Giertsen, A., & O'Kane, C. (2010). *Children's participation in armed conflict and post-conflict peace building*. In *Armed conflict and peace building* (pp. 53-62). London: Routledge.
- [23] Flyvbjerg, B. (2003). *Rationality and power*. In S. Campbell & S.S. Fainstein (Eds.), *Readings in planning theory* (pp. 318-329). Oxford: Blackwell.
- [24] Francis, M., & Lorenzo, R. (2006). Children and city design: Proactive process and the 'renewal' of childhood. In C. Spencer & M. Blades (Eds.), *Children and their environments: Learning, using and designing spaces* (pp. 217-237). Cambridge: Cambridge University Press. doi: 10.1017/CBO9780511521232.014.
- [25] Gil-Mastalerczyk, J., Proskuryakov, V., & Bosyy, P. (2025). Urbicide in Ukraine: Analysis of environmental destruction – challenges, strategies, and international cooperation (Part 1). *Housing Environment*, 51(2), 66-76. doi: 10.2478/he-2025-0013.
- [26] Haklıdır, E.A., Orbey, B., & Şahin, P. (2023). Multiple meanings of child participation in architecture and planning: Revisiting the participation ladder. *Tasarım+Kuram*, 19(39), 406-426. doi: 10.59215/tasarimkuram.401.
- [27] ICMA. (2017). *Boulder's plan to become a child- and youth-friendly city. A city that is friendly to children is a city that is friendly to all*. Retrieved from <https://icma.org/articles/article/boulders-plan-become-child-and-youth-friendly-city>.
- [28] Katsavounidou, G., & Sousa, S. (2024). Reimagining urban spaces for children: Insights and future directions. *Urban Planning*, 9, article number 9434. doi: 10.17645/up.9434.
- [29] McAteer, B., Loudon, E., & Higgins, K. (2023). 'We live here and play here, we should have a say': An exploration of children's perceptions of place-making in the market community, Belfast. *Children & Society*, 38(5), 1602-1621. doi: 10.1111/chso.12827.





- [30] Molloy, S. (2025). Living apart together: Child participation in the context of peace process theory and practice. *Peacebuilding*, 1-18. doi: [10.1080/21647259.2025.2505381](https://doi.org/10.1080/21647259.2025.2505381).
- [31] Pasyuta, D., Ludviková, D., Treffers, F., Korniyenko, G., Van Epp, T., & Zhang, J. (2023). *The public participation handbook of urban planning for Ukraine*. Kyiv: Rozkvit Urban Coalition for Ukraine & Ukraine Rebuilding Action Group. doi: [10.36196/0726.2023](https://doi.org/10.36196/0726.2023).
- [32] Rigolon, A. (2011). *A space with meaning: Children's involvement in participatory design processes*. *Design Principles and Practices: An International Journal – Annual Review*, 5(2), 1833-1874.
- [33] Save the Children. (2023). *Build Forward: NGO recommendations on Ukraine recovery and reconstruction*. Retrieved from <https://surl.li/cxtkix>.
- [34] Sevinçli, N., & Şahin, B.E. (2024). Rethinking the designs of private spaces in kindergartens through the views of children. *Childhood*, 31(2), 152-175. doi: [10.1177/09075682241246117](https://doi.org/10.1177/09075682241246117).
- [35] Stadt Regensburg. (n.d.). *Children and young people plan and design playgrounds*. Retrieved from <https://surl.li/vrloxm>.
- [36] Stadtsache. (n.d.). Retrieved from <https://stadtsache.de/quartiere.php>.
- [37] Stavholm, E., Mackley, H., Caughey, J., Heard, A., & Edwards, S. (2024). Co-design with children, families, and educators for understanding children's digital life-worlds for play and learning. *CoDesign*, 21(3), 382-397. doi: [10.1080/15710882.2024.2427011](https://doi.org/10.1080/15710882.2024.2427011).
- [38] Strachan, T. (2024). *Engaging children and young people in planning*. New York: Routledge. doi: [10.4324/9781003271383](https://doi.org/10.4324/9781003271383).
- [39] UNICEF. (n.d.). *Child-friendly cities*. Retrieved from <https://www.unicef.org/ukraine/en/topics/child-friendly-cities>.
- [40] Urban Rukh "The City Has Me". (n.d.). Retrieved from <https://www.urbanrukh.com/>.
- [41] Vinnytsia City Council. (2024). *Becoming leaders of change in the Vinnytsia community: The "School of Young Ambassadors of Participation" invites high school students and university students to join its sessions*. Retrieved from <https://surl.li/nkyins>.
- [42] Wilhelmsen, T., Øvreås, S., Roll-Hansen, H., Bjerknes, A.-L., & Thorrud, S. (2023). Developing child-friendly cities: Young children's participation in urban planning. *Journal of Childhood, Education & Society*, 4(3), 274-290. doi: [10.37291/2717638X.202343290](https://doi.org/10.37291/2717638X.202343290).

Оксана Юрчишин

Доктор філософії, доцент

Національний університет «Львівська політехніка»

79013, вул. Степана Бандери, 12, м. Львів, Україна

<https://orcid.org/0000-0002-3250-636X>

Участь дітей як архітектурна складова післявоєнної відбудови України

Анотація. В умовах повномасштабної війни та повоєнної трансформації архітектура України постала перед викликом переходу від технократичної відбудови фізичних об'єктів до відновлення соціальної тканини міст. Метою дослідження стало визначення ролі дитячої участі в гуманізації архітектурного середовища та обґрунтування нових підходів до формування освітніх і громадських просторів у післявоєнний період. Методологічну основу роботи становили концепції діалогічного простору, со-дизайну та просторової агентності, інтегровані в архітектурний аналіз процесів відбудови. У статті розглянуто дитячу партисипацію як потенційно стратегічну архітектурну компоненту, здатну впливати на переосмислення усталених підходів до просторового планування. На основі систематизації теоретичних моделей і аналізу міжнародних та українських практичних кейсів показано, що інтеграція дитячого досвіду впливає на морфологію та функціональну організацію архітектурних об'єктів. У просторовій площині результати дослідження вказали на зростання уваги до альтернативних проєктних підходів, у межах яких поряд із жорстким функціональним зонуванням було розглянуто принципи полівалентності, а монументальний масштаб у певних контекстах доповнився рішеннями, орієнтованими на співмірність, тактильність і доступність середовища. Встановлено, що врахування дитячої перспективи змінює підхід до безпеки архітектурного простору – від логіки ізоляції до концепції «активної безпеки», заснованої на прозорості, візуальних зв'язках і соціальній присутності. Аналіз пріоритетних середовищ відбудови – освітніх, громадських і перехідних – показав, що партисипативні практики сприяють виявленню прихованих просторових конфліктів та «сліпих зон» проєктування, які залишаються непоміченими в технократичних моделях. В освітніх просторах це сприяло формуванню середовищ, орієнтованих на дослідницьку поведінку; у громадських – підвищенню інклюзивності для різних вікових груп; у тимчасових і транзитних – швидкій адаптації та освоєнню простору користувачами в умовах посттравматичного досвіду втрати дому. Отримані результати формують методологічне підґрунтя для інституціоналізації дитячої партисипації в архітектурних і планувальних процесах, окреслюючи роль міждисциплінарної взаємодії як ключової умови гуманізації простору та стійкості ініціатив у післявоєнний період.

Ключові слова: архітектура відбудови; простір і місце; партисипативне проєктування; гуманізація архітектури; громадські простори

UDC 711.453
DOI: 10.56318/as/4.2025.43

ISSN: 2411-801X
e-ISSN: 2786-7374

Mohammad Sayed Farahza*

PhD Candidate
Vienna University of Technology
1040, 13 Karlsplatz Str., Vienna, Austria
<https://orcid.org/0009-0004-0878-4353>

A strategic urban framework for the reconstruction of war-damaged cities: A case study of Kabul City

Abstract. Urban reconstruction post-war was one of the most challenging problems of modern planning, in which physical loss, institutional collapse, and social exposures came together to thwart post-war recovery. Kabul, the capital of Afghanistan, presented the ideal study of the issues caused by war that had weakened its city infrastructure and institutions. The purpose of study was to construct a strategic urban plan for Kabul encompassing resilience, sustainability, and citizen participation in post-war reconstruction. The findings showed deep spatial inequities in urban exposure to damage throughout Kabul. An analysis of destruction data indicated Dasht-e-Barchi district suffered most damage with 60% of buildings destroyed, while the greatest damage to the transport network, which included 18 important roads, was borne along the Jalalabad Road corridor. Composite Vulnerability Index modeling emphasised that just 18% of the city's territory, defined as "Red zones", held 63% of Kabul's key infrastructure and 68% of overall building loss and required urgent consideration. Stakeholder interviews also reflected systematic institutional deficits: 92% of the stakeholders name data shortages and institutional duplication as the key obstacles, and 76% name corruption as a persistent inhibition. The adoption of geospatial technologies (68%), participatory planning models (81%), and enhanced inter-agency collaboration (68%) were the major opportunities. Thematic interview coding reiterated governance fragmentation, ethnic cleavages, and short-sighted planning horizons as common challenges. The proposed conceptual framework was based on three pillars that were interdependent: passive defense (spatial planning and resilient networks), sustainable development (green, critical, and equitable infrastructure-based reconstruction), and local participation (accountability mechanisms and community-led planning). These observations proved rehabilitation of Kabul was contingent on spatially focused resource allocation, reform of institutions, and representative government. In practice, the study provided an application model for post-conflict urban rehabilitation in conflict-affected cities to inform resilient and efficient post-conflict urban rehabilitation

Keywords: urban planning; post-war reconstruction; sustainable redevelopment; urban resilience; post-conflict urban recovery

INTRODUCTION

Post-conflict cities were confronted with multidimensional challenges marked by widespread physical destruction, social dislocation, institutional disintegration, and environmental degradation. In such complex contexts, standard forms of urban planning were unsuitable, and strategic

frameworks were needed to tackle simultaneously both post-war vulnerabilities and possibilities for long-term sustainable change. R.A. Mushkani & H. Ono (2022) noted that Kabul, the capital of Afghanistan, was a prime example of such challenges, as decades of conflict had opened

Suggested Citation:

Farahza, M.S. (2025). A strategic urban framework for the reconstruction of war-damaged cities: A case study of Kabul City. *Architectural Studies*, 11(4), 43-52. doi: 10.56318/as/4.2025.43.

Journal homepage: <https://arch-studies.com.ua/en>

Architectural Studies, 11(4), 43-52

Received: 05.08.2025 Revised: 17.11.2025 Accepted: 19.12.2025 Published: 29.12.2025

*Corresponding author



Copyright © The Author(s). This is an open access article distributed under the terms of the Creative Commons Attribution License 4.0 (<https://creativecommons.org/licenses/by/4.0/>)



systematically ever-wide voids in infrastructure, impaired governance structures, and dislocated coherent patterns of urban development. A.A.R.M. Al-Samurai & A.S.R. Al-Qaraghuli (2021) illustrated in their Mosul case study the essential value of integrating sustainable development values for designing conflict-affected towns resilient to prospective crises and showed how environmental considerations were an intrinsic companion to physical rebuilding. Researchers D. Dimelli & A. Kotsoni (2023) advocated integrated Aleppo conservation plans for its reconstruction and highlighted the subtle interplay between contemporary needs for modern infrastructure and the protection of cultural patrimony and provided instructive methodological insights for cities experiencing parallel challenges. The systematic Urban Recovery Framework outlined by UN-Habitat (2022) brought forward a holistic methodology combining area-based approaches, participatory planning instruments, and multi-level governance arrangements designed to ensure successful post-crisis rebuilding of cities. This framework was of particular application to cities such as Kabul, whose institutional disunity and slender means were compounded challenges. In complement to this viewpoint, M.H. Ebrahimi *et al.* (2022) discussed sustainable forms of Kabul's low-cost constructions, showing how locally modified types of building can improve both environmental sustainability and community acceptability. Kabul's pattern of urban planning demonstrated a concerning history of disjointed intervention and donor-driven approaches often lacking long-term perspective and local ownership.

Scientists F. Sarwari & H. Ono (2022) scrutinised ethnic inclusivity in Kabul's master plans and showed how planning documents tend to ignore the rich ethnic complexities of the city, thus compromising social cohesion. Diverging research proposed ever-more sophisticated methodological insights for the analysis of cities in conflict zones. A.S. Jahani (2023) investigated the use of zoning ordinances as development instruments for Kabul and presented useful regulation insights for controlling urban expansion in conflict zones. The author's M. Amini *et al.* (2024) showcase sophisticated geospatial analysis procedures for New Kabul City and showed how GIS modeling may provide evidence-based planning decisions. M.R. Amiryar *et al.* (2022) further validated such evidence, showing how the systematic marginalisation of community participation had continuously hampered Kabul's development of sustainable, inclusive cities. Recent world reconstruction experiences still reinforced the importance of adaptive, context-aware planning paradigms.

To supplement such technical procedures, A. Hanif *et al.* (2024) analysed physical attributes of Herat's unauthorised settlements, yielding comparative insights of informal urbanisation patterns also found in Kabul's expansion. Most methodological innovations continually supplemented reconstruction planning tools. V. Chaturvedi & W.T. de Vries (2025) employed agent-based modelling to analyse the preferences for residential site selection within Kabul New City, yielding novel means of forecasting

post-conflict modes of settlement. D. Vishnevsky (2024) discussed risk management measures for urban plan initiatives within post-war reconstruction contexts, focusing on prioritising the application of proactive risk analysis within risky environments. The study aimed to develop a strategic urban planning framework for Kabul that bridged the gap between theoretical insight and practical application by integrating resilience, sustainability, and community-focused, institutionally informed spatial approaches for post-war reconstruction.

MATERIALS AND METHODS

This study addressed the strategic framework for reconstruction of cities affected by war, focusing specifically on Kabul. It employed a descriptive-analytical approach placing emphasis on qualitative methodologies. In the first stage, it was selected relevant documents and data concerning urban planning for Kabul, which included master plans, reports from international bodies, like Japan International Cooperation Agency to assess the level of post-conflict reconstruction progress (Japan International Cooperation Agency..., 2009). QGIS and tools under the umbrella of Geographic Information Systems (GIS) were used for the spatial analysis. The geospatial data included urban base layers, for example, road networks and landuse, post conflict damage Shapefile from OSM, as well as demographic and infrastructure data from the World Bank (World Bank Group, 2021; OpenStreetMap Data Extracts, n.d.). These datasets underwent quality assessment and geometric corrections, in addition to coordinate system unification with WGS84/UTM Zone 42N before being used in QGIS.

To explore the institutional and social gaps in the reconstruction of Kabul, it was carried out semi-structured interviews with experts in urban planning, faculty members, and representatives of local organisations. To complement the spatial and documentary analysis, the study incorporated qualitative data from 25 semi-structured interviews with key stakeholders of Kabul's urban reconstruction process. The group of interviewees was purposefully selected and comprised eight urban and architectural experts, six municipality and governmental authorities, six national and international NGO (Non-Governmental Organisation) officials, and five local community leaders and civil activists. Interviews were conducted virtually on secure internet platforms from March to June 2023. An interview protocol was designed to elicit information on perceived strengths and weaknesses, opportunities and threats in the planning process; inter-institutional coordination and its efficacy; the extent and improvement of community participation and its role; and constraints to the application of modern tools such as GIS (The Declaration of Helsinki, 2013). The qualitative data from interviews were correctly transcribed and analysed stringently along a thematic framework. A SWOT analysis was conducted to systematically structure and condense qualitative results along four strategic axes: inner strengths and weaknesses of Kabul's urban planning machinery and external opportunities and threats conditioning

In the analysis stage, the topological error correction, duplicate geometry removal, and boundary refinement land use cuts were done as a preprocessing task. After this, overlay analysis followed by zonal statistics was performed to reveal the areas with severely high damage adjacent to the population zones with a high concentration of people.

ensuring the accurate integration and overlay of various datasets such as land use, infrastructure, and damage maps – within a unified and consistent geographical context (Fig. 1).

Source: LatLong.net (n.d.)

Description	Latitude (N)	Longitude (E)
City centre (Approximate)	34.5553°	69.2075°
Northern boundary	34.6500°	69.2000°
Southern boundary	34.4500°	69.2200°
Western boundary	34.5500°	69.1000°
Eastern boundary	34.5500°	69.3000°

Source: based on A.S. Jahani (2023)

RESULTS AND DISCUSSION

within the city. In the Dasht-e-Barchi area, which experienced the greatest extent of devastation, roughly 60% of the structures were destroyed. This level of destruction was due to period of intense military fighting coupled with the prevailing construction standards in this district. However, M.S. Barabash *et al.* (2024) demonstrated that explosive loads can precipitate building collapse when construction standards are insufficient, underscoring the need for more robust building design in conflict-prone

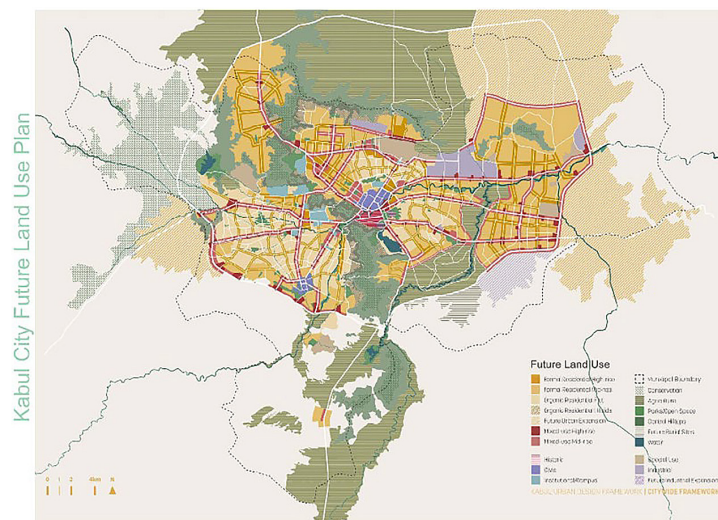


Figure 1. Land use plan in Kabul based on the detailed plan

areas. With 18 damaged roads, the Jalalabad Road corridor had sustained the most extensive damage to the transportation network in the city, which was detrimental to the economy and citizens' access to services. Even though the city centre showed a moderate destruction rate (45%), the

destruction of 8 critical facilities, like hospitals and government offices required urgent attention. The outlying areas, although having lower destruction rates at 22%, exhibit greater social vulnerability due to the lack of adequate primary infrastructure (Fig. 2).

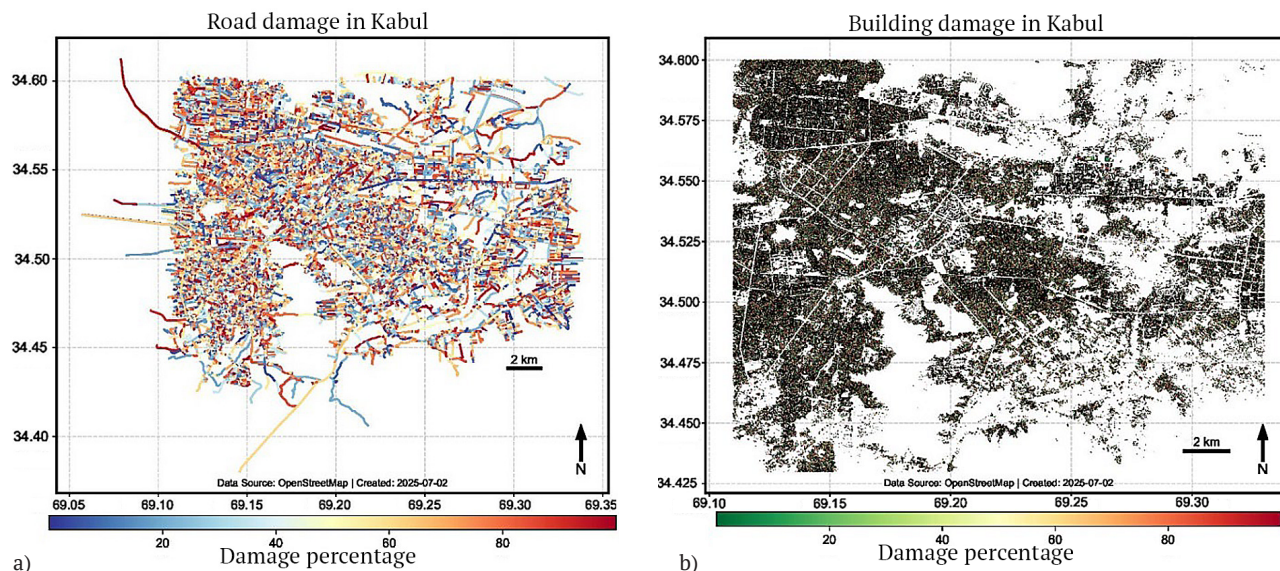


Figure 2. Spatial distribution of destruction in Kabul City

Note: a – road damage network map; b – building destruction density map

Source: OpenStreetMap Data Extracts (n.d.)

This spatial analysis presents Kabul's destruction patterns through two complementary maps. Figure 2, a showed building destruction density, with colour gradients indicating damage severity from low (green) to high (red). Figure 2, b displayed damaged road networks and critical

infrastructure points. Together, these maps provided essential spatial intelligence for prioritising reconstruction efforts in the most severely affected areas. Table 2 demonstrated quantitative assessment of urban destruction across various districts of Kabul.

Table 2. Quantitative measures of urban damage in different areas of Kabul

Area	Building destruction rate	Number of damaged roads	Number of destroyed critical facilities
City centre	45%	12	8 (hospitals, government offices)
Jalalabad Road	32%	18	3 (bridges, terminals)
Dasht-e-Barchi	60%	9	5 (schools, medical centres)
Peripheral areas	22%	5	1 (police stations)

Note: total buildings: 424,370; total roads: 19,300

Source: OpenStreetMap Data Extracts (n.d.)

Figure 3 presented a comprehensive typological analysis of Kabul's urban fabric, complementing the damage assessment reported in Table 2 by characterising the composition and prevalence of building and road types that constitute the city's physical assets. The figure comprised four complementary charts: Figure 3 (a) depicted the proportional distribution (%) of the top five building types, highlighting the dominance of residential structures; Figure 3 (b) showed the proportional distribution (%) of the top five road types, emphasising the high prevalence of residential roads; Figure 3 (c) presented the absolute count of the top ten building types, providing a quantitative assessment of different structural uses; and Figure 3

(d) illustrated the absolute count of the top ten road types, detailing the composition of the transportation network. The analysis of Kabul's CVI revealed an uneven distribution of multidimensional risks across the city (Table 3). According to this assessment, the Central and Northwestern districts of Kabul demonstrated the highest vulnerability levels due to a combination of factors including high population density, deteriorating infrastructure, and proximity to strategic centres. These areas were classified as "Red zones" requiring immediate interventions, such as rehabilitation of critical infrastructure, implementation of early warning systems, and execution of community training programmes.

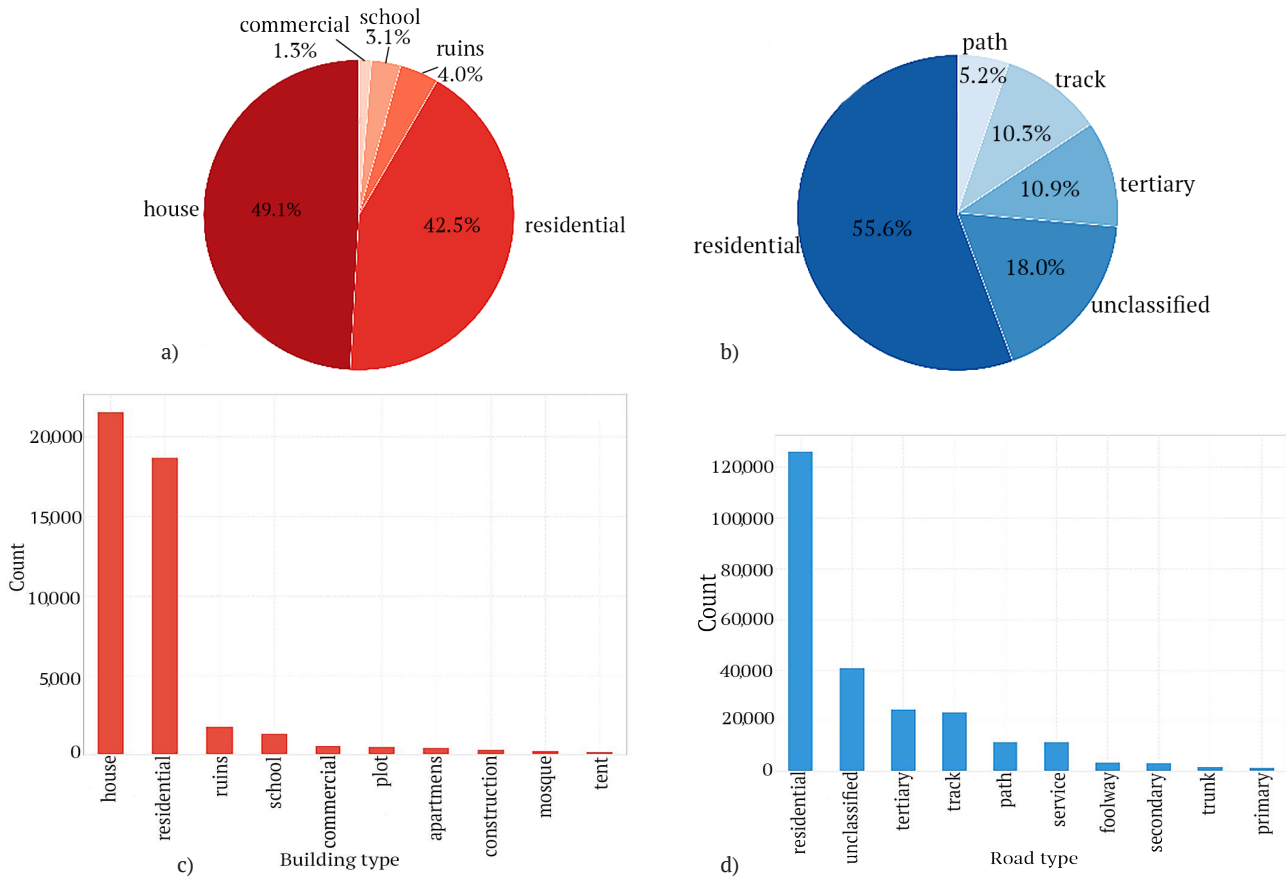


Figure 3. Typological and quantitative analysis of building and road distributions in Kabul City

Note: a – Top 5 building types; b – Top 5 road types; c – Top 10 building types; d – Top 10 road types

Source: OpenStreetMap Data Extracts (n.d.)

Table 3. Quantitative results of Kabul's CVI

Indicator	Red zones (High)	Orange zones (Medium)	Yellow zones (Low)	Green zones (Very low)
Area (km ²)	32.5 (18%)	58.7 (33%)	45.2 (25%)	42.6 (24%)
Critical infrastructure	87 (63%)	32 (23%)	15 (11%)	4 (3%)
Average CVI score	82.5	64.3	42.1	21.8
Building damage (%)	68	45	28	12
Damaged roads (%)	55	28	12	5

Source: OpenStreetMap Data Extracts (n.d.)

The CVI analysis for Kabul revealed stark disparities in urban risk distribution, with Central and Northwestern districts ("Red zones") showing extreme vulnerability – containing 63% of critical infrastructure and 68% of building damage within just 18% of the city's area, while peripheral Green zones remained relatively intact with only 3% of infrastructure and 12% damage. These findings demonstrated that 83% of Kabul's urban challenges concentrated in 51% of its territory, demanding prioritised interventions, including

infrastructure rehabilitation in "Red zones" (requiring 70% of resources), land-use redesign in high-risk areas, and community preparedness programmes, while suggesting that sustainable development models could be piloted in less-affected Green zones, presenting a clear roadmap for efficient post-conflict recovery through spatially-targeted resource allocation. SWOT-analysis of urban planning in Kabul based on 25 semi-structured interviews with urban reconstruction stakeholders demonstrated in Table 4.

Table 4. SWOT analysis of Kabul's urban planning

Category	No.	Factor	Analysis
Strengths	1	Specialised urban planners	Skilled professionals for modern projects
	2	NGO participation	Access to international resources
	3	Local leaders' awareness	Understanding socio-cultural challenges



Table 4. Continued

Category	No.	Factor	Analysis
Weaknesses	1	Lack of urban data	Hinders GIS utilisation
	2	Institutional overlap	Causes management inefficiencies
	3	Administrative corruption	Obstructs transparent implementation
	4	Lack of training	Deficiency in spatial analysis skills
Opportunities	1	GIS/PGIS adoption	Enhances transparency
	2	Inter-agency coordination	Improves institutional cohesion
	3	Capacity building	Reduces structural weaknesses
	4	Participatory planning	Builds community trust
Threats	1	Political instability	Disrupts long-term planning
	2	Security threats	Limits project accessibility
	3	Political interference	Biases resource allocation
	4	Ethnic divisions	Creates conflict-area challenges

Source: developed by the author

The SWOT analysis concerning the urban planning of the city of Kabul outlined a dynamic conjunction of internal strengths and weaknesses as well as external opportunities and threats shaping urban growth. On the strengths aspect, the specialised urban planners, coupled with active participation from NGOs and local leaders that were aware of socio-cultural, had sharpened the growing capacities for implementing infrastructure development. On the other hand, an insufficient urban data, overlapping institutions, administrative corruption, lack of skilled personnel, and deficient technical know-how were multiple systemic hurdles to socio-economic development programme implementation. At the same time, there were critical gaps such as the use of geospatial data and technologies, better inter agency collaboration, enhancement of local skills, fostering appreciation for participatory planning, inclusiveness, and effective and cooperative planning (Kozhobaeva *et al.*, 2024).

However, these regions tended to be overshadowed by external dangers, such as political violence, ethnic division, political bullying, security threats, violence, and instability, which heavily compromised programme sustainability and overall stability. This type of analysis led to conclude

that effective urban planning in Kabul must: 1) deploy and maximise available strengths; 2) strategically diminish identified weaknesses; 3) maximise fragilities; 4) passively negotiate vulnerabilities. A mix of socio-political and technical elements bolstered with institutional strength could bring about urban change that was both transformative and enduring for this region. Analysis of stakeholder interviews indicated that the city's strengths were primarily related to technical capacity, with 84% of respondents confirming the availability of technical expertise as a key asset. Regarding weaknesses, 92% of participants identified data deficiencies and 76% cited corruption as major constraints. In terms of opportunities, 68% emphasised the potential for GIS adoption, while 81% highlighted the benefits of participatory planning for improving urban processes. Concerning threats, 88% of stakeholders expressed concern about the impact of political instability on long-term planning. Research underscored the necessity for context-sensitive, multi-stakeholder approaches in post-conflict urban reconstruction, with particular emphasis on institutional capacity building and community engagement mechanisms. Identification of key themes in stakeholder interviews was presented in Table 5.

Table 5. Thematic analysis coding of stakeholder interviews

Main code	Subcodes	Frequency
Institutional barriers	Administrative overlap, resistance	6
Technical deficiencies	Lack of GIS training, outdated systems	5
Social challenges	Ethnic divisions, distrust	5
Corruption	Corruption, lack of transparency	4
Instability	Political instability	4
Planning issues	Short planning cycles	4

Source: developed by the author

The thematic analysis of interviews with Kabul's urban reconstruction stakeholders revealed five major challenges in the urban planning process. Institutional barriers emerged as the most frequently cited issue (6 occurrences), primarily involving organisational redundancy and resistance to change. Technical deficiencies and social challenges

followed closely (5 occurrences each), reflecting both skill gaps (particularly in GIS applications) and deeper societal issues like ethnic divisions and public distrust.

Administrative corruption and political instability (4 occurrences each) represented additional significant obstacles to effective urban reconstruction. Notably, the



repeated emphasis on short planning cycles (4 occurrences) highlighted the modern impossibility of long-term

strategic planning in the existing environment. Figure 4 showed possible areas for reconstruction in Kabul.

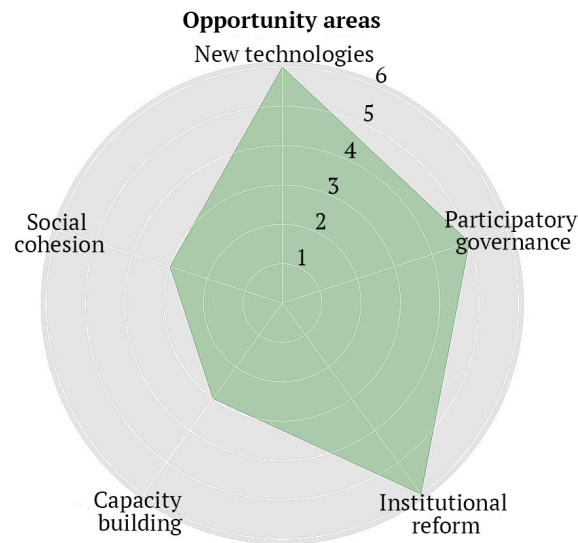


Figure 4. Opportunity areas for reconstruction in Kabul

Source: developed by the author

The findings highlighted that the most significant opportunities for Kabul's reconstruction fall into three key areas: new technologies (6 mentions), institutional reform (6 mentions), and participatory governance (5 mentions). Together, these three domains account for over 70% of identified opportunities. The radar chart visually reinforced this concentration, with the axes for technology

and institutional reform showing the widest spans, indicating their prominence. In contrast, capacity building and social cohesion (each with 3 mentions) appeared less emphasised but remained relevant. The stakeholder matrix analysis of Kabul's urban reconstruction revealed significant differences in how various groups perceived challenges and opportunities (Table 6).

Table 6. Matrix of codes and roles of interviewees

Role	Institutional barriers	Corruption	Data weakness	Social challenges	Participatory opportunities
Urban planner	High	Low	High	Low	Medium
Municipal official	Medium	Medium	Low	None	Low
NGO rep	Medium	None	None	High	High
Local leader	Low	None	Low	High	Medium

Source: developed by the author

So, urban planners, as technical experts, showed the highest sensitivity to institutional barriers and data deficiencies, while municipal officials assessed corruption and institutional issues as moderate challenges. In contrast, NGO representatives and local leaders strongly emphasised social challenges and participatory opportunities, but remained indifferent to corruption and data shortcomings. Based on the word cloud analysis of the interview texts, it can identify three core thematic clusters concerning Kabul's urban reconstruction discourse (Fig. 5). The institutional factors stood out as the focal area of concern, as the terms "institutions" and "planning" appeared as the largest ones. This spoke to the acute governance and decision-making challenges on the dual governance and planning levels. At the same time, social factors came into view with the recurrent appearance of "trust" and "security",

capturing the human dimensions of post-conflict recovery. The technical aspects also formed one of the other three key clusters, where "GIS" and "data" signaled the increasing attention to the role of technology in reconstruction. Particularly, striking was the visual prominence of "overlap" next to "institutions", which highlighted long-standing problems with bureaucratic overlap. At the same time, the association between "people", "trust", and "security" indicated the predominant view among the stakeholders. It was also striking to note the recurrence of "coordination" in conjunction with "change", suggesting that many people shared the idea that a reconstruction system overhaul was essential. Taken together, the texts suggested that reconstruction was a multi-layered problem that required a combination of governance shift to address fragmentation, instill social trust, and integrate modern technology.



Figure 5. Word cloud analysis

of Kabul urban reconstruction stakeholder interviews

Source: developed by the author

The results of this research showed substantial methodological and contextual congruence with studies on informal settlements and urban planning challenges in Afghanistan. Revelation of extremely concentrated vulnerability within particular “Red zones” of Kabul supported the findings of A. Hanif *et al.* (2024) in Herat, who also reported the clustering of physical and infrastructural problems within high-density informal areas. The spatial focusing of damage and vulnerability within this study CVI analysis supported their results concerning the uneven nature of urban problems. The GIS-informed study of informal settlement challenges within Kabul’s Thirteenth district conducted by A.K. Stanikzai *et al.* (2024) supported results of this research concerning institutional fragmentation and data dearth. Their observation of governance voids within informal settlements complements of this research SWOT results, wherein 92% of stakeholders identified institutional overlap and data credibility as major constraints. This convergence across various districts of Kabul highlighted the systemic nature of these problems. In the context of urban development planning, W. Wafa *et al.* (2023) documented integrated planning deficits in Kabul New City’s waste systems, repeating the institutional coordination challenges discussed in stakeholder interviews conducted in this study. The congruent findings implied concentrated planning strategies cross-specific sectors and constituted an intrinsic property of post-conflict Afghan cities’ governance. The Kandahar urban resilience study of B.A. Karimi *et al.* (2024) exposed institutional and infrastructural weaknesses similar to what was found within this study on Kabul, and indicated such weaknesses were not unique to Kabul, but rather a property of several major Afghan cities. This inter-city validation highlighted the rationale for regionally transferable reconstruction templates. In terms of public participation, the decision support systems study of J. Haqbeen *et al.* (2021) at the municipality of Kabul supported finding of this study that 81% of stakeholders deemed participatory planning an important opportunity. Their successful application of crowd-sourced issue identification exemplified the practical, real-world applicability of the participatory approaches. J. Cifuentes-Faura (2023) discussed the Ukrainian scenario, claiming efficient post-conflict urban planning should engage complex risk management

tools and intense socio-cultural considerations to reduce long-run susceptibilities. Parallel understanding came from A. Alkazei & K. Matsubara (2021), who reported Beirut’s attempts to harmonise modernity and cultural heritage maintenance through identity-driven urban regeneration efforts, albeit not without intense conflicts and neoliberal doses. B.A. Kazimee & A.W. Najimi (2017) emphasised that Kabul’s recovery cannot be limited to physical reconstruction but must also address the protection of its historical urban fabric and cultural heritage as a foundation for social resilience. V. Chaturvedi *et al.* (2020), through high-resolution spatial analyses, demonstrated how post-2001 urban growth in Kabul followed highly fragmented and unbalanced patterns, reinforcing the necessity for spatially guided, data-driven recovery models. In addition, P.A. Calogero (2011) provided a historical-political insight into Kabul’s urban planning, showing that political fragmentation and inconsistent governance had long hindered coordinated urban strategies. These perspectives collectively supported this study’s argument that effective post-conflict urban frameworks must integrate spatial intelligence, institutional reform, and socio-cultural sensitivity.

CONCLUSIONS

This study illustrated that in a post-conflict scenario, the holistic and sustainable rebuilding of Kabul needed the establishment and execution of a multi-layered, integrated strategic framework addressing physical, spatial, institutional, and social aspects simultaneously. The “Red zones” covered 18% of the city but accounted for 63% of critical infrastructure, 68% of structural damages, and the highest population density. As a result of the semi-structured interview, it was determined that among stakeholders, 92% cited institutional overlapped and lacked of credible information as major challenges, while 68-81% supported geospatial technologies, governance reform, and participatory planning as key opportunities.

The proposed conceptual model was built on three core pillars: passive defense, focusing on resilient spatial networks, protective materials, and supporting infrastructure; sustainable development, emphasising reconstruction of critical infrastructure in high-risk areas, mixed land uses, and green, energy-efficient rebuilding; and local participation, ensuring continuous community involvement, empowerment of civil society, and skill-building workshops. Together, these pillars provided a concise framework for guiding post-conflict urban reconstruction. Successful implementation of this framework will require enhanced inter agency collaboration, development of spatial and social grounded longterm frameworks, and strong counter-corruption oversight and transparency frameworks. Such an approach enabled not just swift and effective restoration of infrastructure and services, but fortified lasting social and institutional resiliency, which served as a replicable reconstruction model for sustainable and responsible recovery in other war affected cities. Future research should examine the framework’s adaptability across diverse post-conflict urban



contexts and explore advanced digital tools to enhance resilient, participatory, and sustainable reconstruction. None.

FUNDING

ACKNOWLEDGEMENTS

None.

CONFLICT OF INTEREST

None.

REFERENCES

- [1] Alkazei, A., & Matsubara, K. (2021). Post-conflict reconstruction and the decline of urban vitality in downtown Beirut. *International Planning Studies*, 26(3), 267-285. doi: [10.1080/13563475.2020.1839388](https://doi.org/10.1080/13563475.2020.1839388).
- [2] Al-Samurai, A.A.R.M., & Al-Qaraghuli, A.S.R. (2021). Adopting sustainable development in reconstruction post war city of Mosul: Architecture-case study. *IOP Conference Series: Earth and Environmental Science*, 754, article number 012001. doi: [10.1088/1755-1315/754/1/012001](https://doi.org/10.1088/1755-1315/754/1/012001).
- [3] Amini, M., Deng, L., Hassan, W., Nawaz, M.N., Zidane, F.Z., & Fang, R. (2024). Integrative geospatial analysis: Unveiling insights through GIS modeling and statistical evaluation of SPT-N and soil types data of New Kabul City, Afghanistan. *Advances in Civil Engineering*, 2024, article number 9925038. doi: [10.1155/2024/9925038](https://doi.org/10.1155/2024/9925038).
- [4] Amiryar, M.R., Niazi, A.J., & Sediq, S.P. (2022). [Urban development through participatory approach: Contemporary methods of urban planning in Kabul City](#). *KPU International Journal of Engineering & Technology*, 2(2), 35-46.
- [5] Barabash, M., Kostyra, N., & Maksymenko, V. (2024). Modeling of building structures resistance to collapse failure from explosive impact. *Advances in Science and Technology*, 156, 65-74. doi: [10.4028/p-CSaY06](https://doi.org/10.4028/p-CSaY06).
- [6] Calogero, P.A. (2011). [Planning Kabul: The politics of urbanization in Afghanistan](#). (Doctoral dissertation, University of California, Berkeley, USA).
- [7] Chaturvedi, V., & de Vries, W.T. (2025). Residential location preferences in a post-conflict context: An agent-based modeling approach to assess high-demand areas in Kabul New City, Afghanistan. *Land*, 14(7), article number 1502. doi: [10.3390/land14071502](https://doi.org/10.3390/land14071502).
- [8] Chaturvedi, V., Kuffer, M., & Kohli, D. (2020). Analysing urban development patterns in a conflict zone: A case study of Kabul. *Remote Sensing*, 12(21), article number 3662. doi: [10.3390/rs12213662](https://doi.org/10.3390/rs12213662).
- [9] Cifuentes-Faura, J. (2023). Ukraine's post-war reconstruction: Building smart cities and governments through a sustainability-based reconstruction plan. *Journal of Cleaner Production*, 419, article number 138323. doi: [10.1016/j.jclepro.2023.138323](https://doi.org/10.1016/j.jclepro.2023.138323).
- [10] Dimelli, D., & Kotsoni, A. (2023). The reconstruction of post-war cities – proposing integrated conservation plans for Aleppo's reconstruction. *Sustainability*, 15(6), article number 5472. doi: [10.3390/su15065472](https://doi.org/10.3390/su15065472).
- [11] Ebrahimi, M.H., Devillers, Ph., & Garcia-Diaz, E. (2022). Sustainable construction for affordable housing program in Kabul. *Journal of Contemporary Urban Affairs*, 6(1), 23-35. doi: [10.25034/ijcua.2022.v6n1-3](https://doi.org/10.25034/ijcua.2022.v6n1-3).
- [12] Hanif, A., Barak, T., Loodin, N., Duque, C., Zakeri, J.A., Mirzahi, S., & Nadeem, G.F. (2024). Physical features of unplanned settlements in Herat City, Afghanistan. *Frontiers of Urban and Rural Planning*, 2, article number 18. doi: [10.1007/s44243-024-00044-z](https://doi.org/10.1007/s44243-024-00044-z).
- [13] Haqbeen, J., Sahab, S., Ito, T., & Rizzi, P. (2021). Using decision support system to enable crowd identify neighborhood issues and its solutions for policy makers: An online experiment at Kabul municipal level. *Sustainability*, 13(10), article number 5453. doi: [10.3390/su13105453](https://doi.org/10.3390/su13105453).
- [14] Jahani, A.S. (2023). Zoning ordinance as a development method for Kabul City. *Open Access Library Journal*, 10, article number e9724. doi: [10.4236/oalib.1109724](https://doi.org/10.4236/oalib.1109724).
- [15] Japan International Cooperation Agency, Dehsabz City Development Authority, & Ministry of Urban Development. (2009). [The study for the development of the master plan for Kabul Metropolitan Area in the Islamic Republic of Afghanistan](#). Tokyo: RECS International Inc.; Yachiyo Engineering Co., Ltd.; CTI Engineering International Co., Ltd.; Sanyu Consultants Inc.
- [16] Karimi, B.A., Hayat, A., Dandautiya, R., & Ulfat, S. (2024). Urban resilience assessment of Kandahar City, Afghanistan. In N.V.C. Menon, S. Kolathayar, H. Rodrigues & K.S. Sreekesava (Eds.), *Recent advances in civil engineering for sustainable communities* (Vol. 459, pp. 471-483). Singapore: Springer. doi: [10.1007/978-981-97-0072-1_41](https://doi.org/10.1007/978-981-97-0072-1_41).
- [17] Kazimee, B.A., & Najimi, A.W. (2017). Urban heritage of Kabul and post-war recovery efforts. *International Journal of Heritage Architecture*, 1(1), 60-67. doi: [10.2495/HA-V1-N1-60-67](https://doi.org/10.2495/HA-V1-N1-60-67).
- [18] Kozhobaeva, S., Omurova, A., & Barkalbasov, A. (2024). [Analysis of structural changes in residential space in modern conditions of architectural development](#). *Architecture. Construction*, 1(1), 4-12.
- [19] LatLong.net. (n.d.). *Kabul, Afghanistan*. Retrieved from <https://www.latlong.net/place/kabul-afghanistan-3827.html>.
- [20] Mushkani, R.A., & Ono, H. (2022). Urban planning, political system, and public participation in a century of urbanization: Kabul, Afghanistan. *Cogent Social Sciences*, 8(1), article number 2045452. doi: [10.1080/23311886.2022.2045452](https://doi.org/10.1080/23311886.2022.2045452).
- [21] OpenStreetMap Data Extracts. (n.d.). Retrieved from <https://download.geofabrik.de/>.
- [22] Sarwari, F., & Ono, H. (2022). An analysis of urban ethnic inclusion of master plans – in the case of Kabul City, Afghanistan. *Urban Science*, 7(1), article number 3. doi: [10.3390/urbansci7010003](https://doi.org/10.3390/urbansci7010003).





- [23] Stanikzai, A.K., Sadeq, M.S., & Halimee, M.K. (2024). Spatial analysis of the challenges of informal settlements using geographic information systems (GIS): A case study of the Thirteenth district, Kabul. *Journal of Natural Sciences – Kabul University*, 7(2), 19–42. [doi: 10.62810/jns.v7i2.37](https://doi.org/10.62810/jns.v7i2.37).
- [24] The Declaration of Helsinki. (2013). Retrieved from <https://www.wma.net/what-we-do/medical-ethics/declaration-of-helsinki/>.
- [25] UN-Habitat. (2022). *Urban recovery framework. An enabling institutional and policy framework to support resilient urban recovery at scale and the renewal of the social contract in urban crisis contexts*. Bruxelles: European Union.
- [26] Vishnevsky, D. (2024). Risk management strategies of urban planning projects in the framework of post-war reconstruction. *IOP Conference Series: Earth and Environmental Science*, 1376, article number 012048. [doi: 10.1088/1755-1315/1376/1/012048](https://doi.org/10.1088/1755-1315/1376/1/012048).
- [27] Wafa, W., Sharaai, A.H., Mukhtar, S., Sahak, K., & Afghan, F.R. (2023). Urban development and waste management planning in Kabul New City, Afghanistan: A case study. *Planning Malaysia*, 21(5), 96–109. [doi: 10.21837/pm.v21i29.1358](https://doi.org/10.21837/pm.v21i29.1358).
- [28] World Bank Group. (2021). *Afghanistan development update. Setting course to recovery*. Washington: The World Bank.

Мохаммад Саєд Фарахза

Аспірант

Віденський технічний університет

1040, вул. Карлсплац, 13, м. Відень, Австрія

<https://orcid.org/0009-0004-0878-4353>

Стратегічна урбаністична концепція відновлення міст пошкоджених війною: дослідження міста Кабул

Анотація. Повоєнна урбаністична реконструкція стала однією з найскладніших проблем сучасного просторового планування, у межах якої поєднувалися фізичні втрати, інституційний колапс і соціальна вразливість, що суттєво ускладнювало процес післявоєнного відновлення. Кабул – столиця Афганістану – стала показовим прикладом міста, в якому наслідки війни призвели до ослаблення міської інфраструктури та управлінських інституцій. Метою цього дослідження стала розробка стратегічного урбаністичного плану відновлення Кабула, що інтегрує принципи стійкості, сталого розвитку та участі громадян у післявоєнній реконструкції. Результати дослідження засвідчили наявність глибоких просторових нерівностей у рівні пошкоджень міського середовища на території Кабула. Аналіз даних про руйнування показав, що район Дашт-е-Барчі зазнав найбільших втрат – зруйновано близько 60 % будівель, тоді як найбільші пошкодження транспортної мережі, зокрема 18 ключових магістралей, зафіксовано вздовж коридору дороги Джалалабад. Моделювання композитного індексу вразливості виявило, що лише 18 % території міста, визначені як «червоні зони», зосереджували 63 % ключової інфраструктури Кабула та 68 % загальних втрат забудови й потребували першочергового втручання. Інтерв'ю зі стейкхолдерами також засвідчили системні інституційні проблеми: 92 % респондентів назвали дефіцит даних і дублювання повноважень інституцій основними перешкодами, а 76 % – корупцію як постійний стримувальний чинник. Водночас, як ключові можливості було визначено впровадження геоінформаційних технологій (68 %), партисипативних моделей планування (81 %) та посилення міжвідомчої координації (68 %). Тематичне кодування інтерв'ю підтвердило фрагментацію управління, етнічні розмежування та короткострокові планувальні горизонти як типові виклики. Запропонована концептуальна рамка ґрунтувалася на трьох взаємопов'язаних опорах: пасивній обороні (просторове планування та стійкі мережі), сталому розвитку (відновлення на основі зеленої, критичної та соціально справедливої інфраструктури) та локальній участі (механізми підзвітності й планування, орієнтоване на громади). Отримані результати довели, що відновлення Кабула є залежним від просторово спрямованого розподілу ресурсів, інституційних реформ та репрезентативного врядування. Практична цінність дослідження полягає у запропонованні прикладної моделі післяконфліктної урбаністичної реабілітації, яка може бути використана для формування стійких і ефективних стратегій відновлення міст, постраждалих від збройних конфліктів

Ключові слова: урбаністичне планування; післявоєнна реконструкція; сталий розвиток територій; урбаністична стійкість; післяконфліктне міське відновлення

Anastasiia Mudra*

Postgraduate Student
Lviv Polytechnic National University
79013, 12 Stepan Bandera Str., Lviv, Ukraine
<https://orcid.org/0000-0002-6899-7594>

Traditional and innovative approaches to landscaping and principles of their implementation in the context of urban space harmonisation

Abstract. Intensive urbanisation processes require solutions that combine the socio-psychological features of the development of urban fabric with modern technologies in order to preserve the connection of man with nature even in conditions of compacted development. The purpose of the study was to analyse traditional and innovative approaches to landscaping and determine the principles of their implementation to create a safe and comfortable space. A historical and comparative analysis was carried out, which showed the evolution of landscaping elements. It was revealed that before the growth of the role of cities, landscaping was an integral part of human life, a kind of intermediary between it and the environment. In addition, using the provisions of psychology and sociology, the study identified the main mechanisms of space perception, which helped to comprehensively assess the impact of nature on the quality of human life. Modern examples of integration of landscaping elements into dense development of cities in Europe (France, Denmark, Germany), Asia (China, Singapore), and the USA were analysed. Two groups of approaches to gardening were identified and summarised – traditional and innovative, each of which was represented by a 3D diagram of the main structural components. It was established that innovative technologies – green roofs, terraces and walls, vertical farms with hydroponic, aquaponics, and aeroponic systems, mobile landscaping – do not contradict historically established models, but transform and complement them in accordance with new spatial constraints and needs of cities. Based on this, three principles of urban landscaping were proposed: extensive – focused on the use of large areas with minimal resources; intensive – focused on less space, but more technological solutions and costs; combined – combined the advantages of both principles. For each of them, the characteristic forms of landscaping and their impact on different levels of human comfort were determined: physical, psychological, and social. It was noted that effective integration of landscaping into dense buildings was possible only if there was a balance between technological innovations and basic mechanisms of space perception. The results obtained can become the basis for developing strategies for sustainable development of Ukrainian cities aimed at harmonising urban space and increasing the sense of security of residents

Keywords: housing; building density; planning; landscape architecture; urban landscaping; urban agricultural production

INTRODUCTION

Intensive urbanisation has led to denser development and a reduction in green spaces, weakening people's connection with nature and negatively affecting their physical, psychological and social well-being. Advanced technologies for integrating natural elements into urban space

often did not consider historically formed mechanisms of spatial perception, which is why there was a need for approaches that can combine traditional human behavioural models with the capabilities of the latest solutions. The ecological and architectural approach continued the

Suggested Citation:

Mudra, A. (2025). Traditional and innovative approaches to landscaping and principles of their implementation in the context of urban space harmonisation. *Architectural Studies*, 11(4), 53–63. doi: 10.56318/as/4.2025.53.

Journal homepage: <https://arch-studies.com.ua/en>

Architectural Studies, 11(4), 53–63

Received: 26.06.2025 Revised: 12.11.2025 Accepted: 19.12.2025 Published: 29.12.2025

*Corresponding author



Copyright © The Author(s). This is an open access article distributed under the terms of the Creative Commons Attribution License 4.0 (<https://creativecommons.org/licenses/by/4.0/>)



tradition of considering green spaces as part of architecture, which shaped not only the appearance, but also the quality of urban space. In 2020-2025, attention was focused on improving the ecological balance based on modern technologies – green roofs and facades, hydroponic, aquaponic, and aeroponic systems. F. Barriuso & B. Urbano (2021) analysed the extent to which green roofs and walls can mitigate climate change in cities by comparing their effectiveness in different continental conditions. The researchers determined that such systems reduce the impact of the urban heat island effect, reduce greenhouse gas emissions, improve storm drain management, reduce noise, and support urban biodiversity. This study organically complemented the paper by V. Marsaglia (2024), who detailed the differences between different types of innovative landscaping. The author proposed a broader typology of solutions – for example, living walls, roof gardening. O. Oleshko & Yu. Petrovska (2020) focused on the concept of phytodesign and its functional content, emphasising the role of plants in the development of both comfortable exteriors and interiors. Research by Å.O. Sang *et al.* (2022) focused on another aspect – the impact of green roofs and walls on human health. The researchers found that lowering the temperature using vegetation helped to reduce the risk of heart disease, while air purification improved the state of the respiratory system.

The socio-psychological approach to gardening was based on the ideas of the influence of nature on humans, considering it as an important element of everyday comfort. In the contemporary interpretation, this approach has acquired innovative content due to concepts that combined architecture and psychology. Nature was considered as a basic need of an urban resident – one that helps to reduce stress levels and maintain social connections. The study by A. Schwartz *et al.* (2023) emphasised that the impact of landscaping on the psychological state is not unified: much depends on individual perception, the level of environmental awareness, and other factors. Scientists emphasised that there was no universal formula like “the more plant species, the better for everyone”. S. Šćepanović *et al.* (2025) proposed a new classification of green spaces, highlighting “on-road” – green elements that people see every day, when moving around the city, and “off-road” – places that required special visits. Their research showed that it was “on-road” landscaping that had a more pronounced impact on human health, which emphasised the importance of green areas integrated into hiking routes as a factor of socio-psychological comfort. G.N. Bratman *et al.* (2021) specified the mechanisms, by which people perceive space, and analysed how landscaping can work in two key areas: reduce the impact of harmful factors and simultaneously promote well-being. F. Beute *et al.* (2023) compared different types of green spaces in terms of mental health benefits and emphasised the need for an interdisciplinary approach – a combination of natural, social, and medical sciences together with specialists in spatial design. C. Wan *et al.* (2021) proposed a model for conceptualising the relationship

between landscape elements and community cohesion. In the Ukrainian scientific discourse, this area was developed by O. Kosyk & K. Letik (2021), who identified key aspects of the organisation of urban space by means of landscaping that were primarily focused on human comfort. Thus, the contemporary paradigm of urban landscaping relied on the continuity of ideas and also updated them in accordance with new challenges. Tradition here does not limit development, but becomes the basis for an innovative understanding of the natural element in architecture.

The purpose of the study was to investigate traditional and innovative approaches to urban landscaping and formulate the principles of their practical application in the context of improving the quality of urban space and the comfort of life of residents. To achieve this goal, a comprehensive approach to the development of scientific literature and sources was applied. Using the historical and comparative method, the evolution of landscaping in urban space was traced. Due to the variety of aspects of the topic, the research was expanded with an interdisciplinary approach involving the provisions of psychology and sociology. This helped to comprehensively assess the role of landscaping in the development of a safe and comfortable space. At the next stage of the study, architectural objects with integrated elements of landscaping were analysed – multi-apartment residential buildings in Bordeaux (France) and Copenhagen (Denmark), a community centre in Singapore, an administrative building in Oberhausen (Germany), a park in Taichung (China), and the Glasir landscaping system in New York (USA). Graphic materials for the study were obtained from specialised electronic resources ArchDaily (n.d.), Dezeen (n.d.), and Landezine (n.d.). Methods of comparative analysis and generalisation helped to form a sample of various buildings and urban spaces that differed in geographical location, place in the urban structure, functions and methods of applying landscaping. Based on this sample, two main approaches to the organisation of landscaping were identified. To organise materials, the authors applied the formalisation method using ArchiCAD and Adobe Photoshop programmes. Each of the approaches was presented as 3D diagrams in a unified format, which helped to demonstrate differences in the use of green elements. At the last stage of the study, three principles of implementing urban landscaping were proposed, and their main features were formulated – recommended forms of landscaping and the impact on human comfort.

Historical prerequisites for the development of urban landscaping and its extensive principle of implementation

The planning of the first settlements depended on natural conditions – climate, topography, water, and the need for protection. These factors determined the first spatial decisions, in which nature was not just a background, but an active element of space formation. Where there was a lot of land, people used extensibility: they developed large areas for arable land and expanded settlements



without restrictions. In the Mayan civilisation, this strategy led to resource depletion and an environmental crisis, which forced a switch to more efficient land use methods – reducing crops, introducing new technologies, and creating house plots. In mountainous areas, such as the Andes, on the contrary, rational solutions were applied from the very beginning – terracing, irrigation, economical use of each plot (Lentz *et al.*, 2014). Thus, the prerequisites for intensive farming models were born. As the complexity of socio-economic structures increased, urban planning also changed. The gradual increasing dominance of the city over the countryside did not correspond to the usual picture of the world. For example, to preserve a connection with nature, suburban villas combining elements of decorative parks and kitchen gardens – the prototypes of modern summer cottages – appeared around Rome (Jashemski *et al.*, 2017). The Middle Ages were a period of return to the utilitarian logic of urban planning. The establishment of cities took place against the background of famine and wars, so people looked for safe places near castles and abbeys, adapting the surrounding space to life. This was how settlements with spontaneous terrain-dependent development emerged, where most of the territories were allocated for gardening (Leslie, 2016).

The Renaissance was a new stage in the development of urban landscaping: nature was perceived as a universal source of beauty and harmony. Courtyards and inter-house spaces were combined into green cells for communication and plant care. It was then that landscape art – a combination of architecture, landscape, and humans – was actively developing (Mosser & Teyssot, 1991). The Industrial Age brought drastic changes. Industrial urbanisation reduced agricultural land, so cities began to allocate land plots to workers for their own farms. During the world wars, “victory gardens” were actively created – in all possible places – vacant lots, school yards, stadiums – to provide people with food

(Gowdy-Wygant, 2013). After the war, with the growth of prosperity, the need for urban gardening decreased. Its function was partially adopted by suburban settlements, which preserved a deep connection between humans and nature. Thus, the historical development of spatial organisation has demonstrated a natural evolution of human interaction with landscaping. When there was enough space, simple, low-cost models of green spaces prevailed – extensive ones. With the growing density of buildings, there was a need for careful planning, technologisation, and intensive use of each site. And where the conditions were intermediate – with moderate restrictions, but without a critical shortage of territories – transitional, combined options were formed. These three ideas – extensive, intensive, and combined – can be distinguished as the main principles of implementing urban landscaping.

The extensive principle was developed at a time, when cities still had enough space, but resources for care remained limited. It was based on the use of the existing natural potential of the territories – favourable climate and terrain conditions, soil fertility, access to water. After the expansion of multi-storey residential areas and the destruction of a significant part of the estate development in the 1960s and 1970s, traditional forms were preserved in the form of significant green areas – urban forests, parks, as well as garden and country plots and adjacent parts of the countryside (fields, meadows), which were within the city in the process of its expansion. An example of the modern recreation of this logic was Ilot Queyries, a multi-apartment residential building in the city of Bordeaux in France, designed by the architectural firm MVRDV. A distinctive feature of the project was the shared courtyard, which, due to its area of 5,200 m², not only physically complements the neighbouring park, but also served as its visual extension in the eyes of the public. Thus, a characteristic feature of the traditional approach shown in the 3D diagram was the maximisation of the vegetation area in the horizontal dimension (Fig. 1).

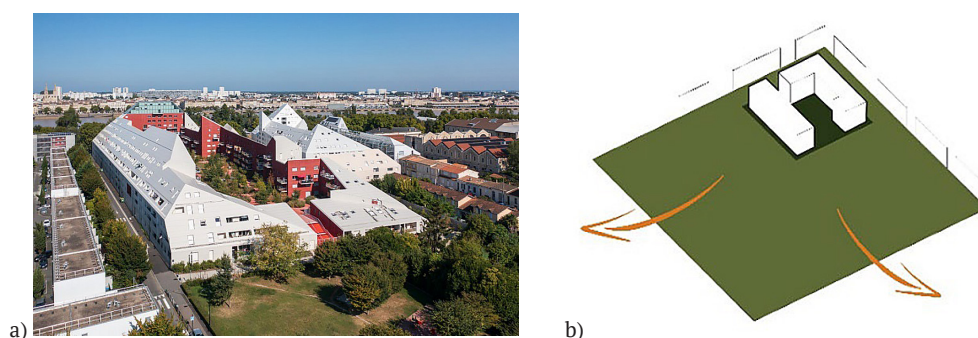


Figure 1. Traditional approach to urban landscaping in the context of an extensive principle of its implementation

Note: a – courtyard as part of a park area in Bordeaux, France; b – 3D diagram of the main structural elements of extensive traditional landscaping

Source: based on H. Abdel (2021)

At the basic level of urban comfort, i.e., physical safety, such spaces played the role of a natural barrier between

humans and adverse environmental factors. Large green areas mitigated the effects of urbanisation – it purified the





air, reduced noise levels, and reduced overheating of the city. M. Žuvela-Aloise *et al.* (2016) and R. Staniszewski *et al.* (2025) determined that increasing the area of green spaces by 10-20% can reduce the average air temperature in the city by 0.45-2.0°C, and the noise load level – by 2-10 dB. The value of extensive gardening was not limited only to physical comfort; it had a significant psychological dimension that affected both the emotional state and cognitive processes of a person (Kellert, 2018). Even the papers by scholars of the 19th and 20th centuries, C. Sitte (1922), E. Howard & F.J. Osborn (1965) and I.L. McHarg (1969), traced the idea of a harmonious combination of nature and urban space – it became the basis for further research on the role of natural elements in the structure of the city. One of the key steps in this area was taken by R.S. Ulrich (1984), proving that people, who contemplate natural landscapes recover faster – both physically and psychologically. Based on his findings, a theory of attention recovery emerged (Kaplan & Kaplan, 1989), which emphasised that excessive visual overload of urban space drains cognitive resources, while nature, on the contrary, activates involuntary attention and gives the brain the opportunity to rest. Large green areas are perceived without tension-the gaze

moves easily, and the feeling of space becomes softer and calmer. This is the main advantage of extensive gardening: it returns a person to the natural rhythm of life, reduces stress levels, and increases psychological stability.

This tradition has been transformed, adapting to modern conditions: if once extensive gardening was associated mainly with horizontal spaces, now it was actively mastering the vertical. Green roofs, terraces, and facades (Manso & Castro-Gomes, 2015; Giacomello, 2021) not only increased the area of human contact with nature, but also returned to dense buildings the feeling of free, dispersed view that previously gave extensive urban green areas. An example of this was the three-dimensional solution of the Oasis Terraces community centre, located in Singapore. In order to offset the disadvantages of dense development, the London bureau used such a technique as terracing – this helped to lighten the mass of the building and its perception from street level and apartments of neighbouring residential complexes. The green roof was designed as a place for joint urban gardening, which was intended to strengthen ties in the community. Using a 3D diagram, the main difference between the innovative approach was shown – the shift from the horizontal of urban space to the building vertical (Fig. 2).

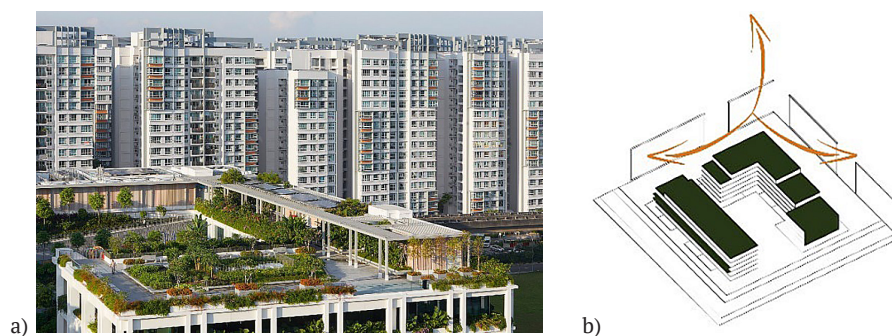


Figure 2. Innovative approach to urban landscaping in the context of an extensive principle of its implementation

Note: a – green roofs and terraces in Singapore, Asia; b – 3D diagram of the main structural elements of extensive innovative landscaping

Source: based on A. Griffiths (2019)

Equally important was the social dimension of this tradition. As noted by E. Fromm (1973), excessive population density in cities activates defensive responses – from alienation and loneliness to manifestations of aggression. A person was evolutionarily adapted to life in small communities – families and neighbouring communities, where emotional connection and mutual support were maintained. It was this need that has long been met by garden

and suburban cooperatives – spaces that combined caring for nature with informal communication and a sense of belonging. In the modern city, their role was gradually being taken over by new “green nodes” – galleries, corridors, bridges-transitions between buildings, which became places of spontaneous meetings and short social contacts. Table 1 summarised the main approaches to the extensive principle of implementing landscaping in the city.

Table 1. Extensive principle of urban landscaping implementation

Traditional approach		Innovative approach
Forms of landscaping	Green parks and urban forests. Territories of garden and suburban cooperatives and parts of rural areas (fields, meadows) within the city limits	Large layers of landscaping in the structure of the building – roofs, terraces, walls. Green transit spaces in the building structure
Impact on human comfort	Psychological safety (distribution of attention), social safety (informal communication), physical safety (reducing temperature, noise, pollution, ensuring air circulation)	

Source: developed by the author



The integration of extensive landscaping into the building structure changes the perception of multi-storey buildings, giving them a density of human scale. In this context, the transition from tradition to innovation appears as an opportunity to make the space work more efficiently, while maintaining concern for human needs.

Intensive principle of urban landscaping implementation

Intensive farming had traditionally been established based on the idea of maximum efficiency in the use of space. It occurred, where the territory was limited, but the need for yield remained high. That was why people invested more resources – time, labour, and finances – to achieve results, compensating for the lack of space by increasing productivity. For this purpose, fertilisers, chemicals, irrigation systems, and special equipment

were used, which allowed using every square metre of land efficiently. An important element was greenhouses, which provided the possibility of growing plants throughout the year, regardless of climatic conditions. This can be seen in the example of the inner courtyard in Copenhagen, Denmark, created in collaboration with residents, designers, and the municipality to solve the problem of flooding. Rainwater from the roofs did not go into the sewers, but collected in the lake and streams, unloading the city system and simultaneously forming a space for recreation and children's games. In the centre was a greenhouse, the glass facades of which accumulated heat and extended the season of stay in the yard for almost a third of the year. The 3D diagram reproduces the typical placement of intensive traditional landscaping in the structure of urban fabric – in city gardens and vegetable gardens, and on adjacent territories (Fig. 3).



Figure 3. Traditional approach to urban landscaping in the context of an intensive principle of its implementation

Note: a – beds and greenhouses in the courtyard in Copenhagen, Denmark; b – 3D diagram of the main structural elements of intensive traditional landscaping

Source: Landezine International Landscape Award (n.d.)

Gradually, intensive farming began to play not only an economic role: its presence in urban space created a sense of predictability and control. One of the aspects of psychological security was the recognition of space: in monotonous buildings, unusual objects – greenhouses, glass pavilions, open vegetable gardens – became landmarks. The brain remembered them as “anchors” that helped to create mental maps of the area. This reduced stress levels, as people felt confident knowing, where they were and how to return to familiar places. The tradition of intensive farming has not disappeared, but has been transformed into new technological models. The main principle remained rational use of space, which since the beginning of the 2000s, when sustainable development was established as a systematic approach in urban planning, was gradually supplemented by the desire to preserve natural resources – water, soil, and energy. Thus, vertical trusses appeared, which, combined with glazed facades and open structural elements, turned not only into production sites, but also into architectural dominants that enriched the urban landscape and simultaneously enhanced the sense of order.

The most common methods of modern intensive gardening were hydroponics, aquaponics, and aeroponics.

Hydroponics involved growing plants without soil, when the roots were submerged in nutrient-rich water. Instead of soil, substrates were used – both natural (expanded clay, crushed stone, sand) and artificial (mineral wool). Aquaponics combined the cultivation of plants and fish in one system, where fish produced waste that served as fertiliser for plants, and plants purified water for fish, creating an environmentally friendly and interdependent ecosystem. Aeroponics was a system, in which plant roots were suspended in the air and periodically sprayed with a nutrient solution that provided them with the necessary elements for growth (Harwood & Martin, 2014). One of the most significant cases of using innovative landscaping was the project of an administrative building in Oberhausen, Germany. The main component was a vertical truss that ran through all the floors and led to a greenhouse on the roof, where hydroponic systems were located. Part of this landscaping was used as a research area for the Fraunhofer Institute for Environmental, Safety and Energy Technology. The 3D diagram illustrated the possibilities of this innovative approach: the focus of the design solution shifted to compactness in terms of building volume (Fig. 4).

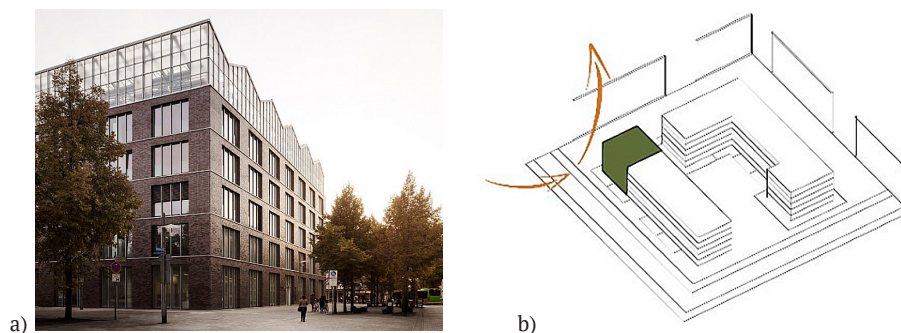


Figure 4. Innovative approach to urban landscaping in the context of an intensive principle of its implementation

Note: a – vertical roof truss in Oberhausen, Germany; b – 3D diagram of the main structural elements of intensive innovative landscaping

Source: based on J. Astbury (2019)

The social aspect of intensive farming also had significant potential. Traditional urban gardens and vegetable gardens had always served several functions simultaneously: it was places for work, recreation and communication, helping to avoid the appearance of dangerous, monofunctional areas. As noted by J. Jacobs (1961), the security of space was ensured not only by the presence of the police,

but also by its active use. If the place was filled with people, who work, relax, or study, it automatically became safer due to “eyes on the street”. A modern modification of this idea was urban agricultural production, integrated into buildings that combined social, commercial, and educational functions. Table 2 summarised the main approaches to the intensive principle of implementing landscaping in the city.

Table 2. Intensive principle of urban landscaping implementation

	Traditional approach	Innovative approach
Forms of landscaping	City gardens/vegetable gardens and adjacent territories with greenhouses	Vertical trusses with elements of hydroponics, aquaponics, aeroponics
Impact on human comfort	Psychological security (orientation in space), social security (multifunctionality of space), physical security (independence from weather conditions)	

Source: developed by the author

Saving space in this case allowed several functions to co-exist side by side, enriching the density of buildings with a variety of uses. In turn, the development of different types of activities determined the visual variability of compositional solutions, which created more interesting sensory impressions for a person.

Combined principle of urban landscaping implementation

Combined farming had traditionally emerged, where resources were limited and the need for landscaping was constant. In such circumstances, people were looking for ways to combine utilitarianism and harmony, creating small green cells in the city structure. So, there were linear and dotted street plantings – green corridors, front gardens, apartment courtyards, which formed natural “inclusions” among dense buildings. This was also evident in the planning of the linear park in Taichung, China. The architects reinterpreted the abandoned railway track as the green frame of the city, which not only physically connected individual public spaces, but also maintained the ecological balance of flora and fauna under the pressure of urbanisation. The 3D diagram showed the main compositional axes created by combined traditional landscaping, and its main difference was the location along

pedestrian paths (Fig. 5). In the psychological dimension, this organisation of space had a deep evolutionary basis. J. Appleton (1975) explained a person’s choice of a place to stay because of the instinct to “see, but not be noticed”: a person naturally tended to the perimeter of space, where the ability to see and the ability to hide were combined. This mechanism created a basic sense of security, which was preserved on a subconscious level. Its development was the “savanna” theory (Herwagen, 1993), according to which since primitive times people preferred not open spaces, but small groups of green spaces – groves as shelters that allowed them to observe the environment, while remaining protected. In an urban context, it was small-scale landscaping that reproduced this logic – it structured shapeless areas, created visual landmarks, and formed a sense of protection and control over the space. Since 2010, with the development of the ideas of tactical urbanism, the traditional model of combined economy had evolved, acquiring new forms that meet the challenges of the modern city. Mobile landscaping was an example: unlike stationary green areas, mobile structures can be installed, moved, or completely removed, making them a flexible tool in dense urban areas. Thus, the space acquired dynamics, easily adapted to changes and better met the daily needs of residents. The project of the Glasir urban

landscaping system in New York was indicative. Glasir was a modular construction structure with aeroponic elements that can provide the city and surrounding area with local products throughout the year. The unified block solution allowed creating many configurations from 2x2 modules. The primary factor in choosing a specific shape

and location in the city was the three-dimensional vision of the created space, that was, what kind of visual effect should be obtained from the interaction of the structure with the person and buildings. Therefore, the characteristic features reproduced on the 3D diagram were the variability and variability of space (Fig. 6).

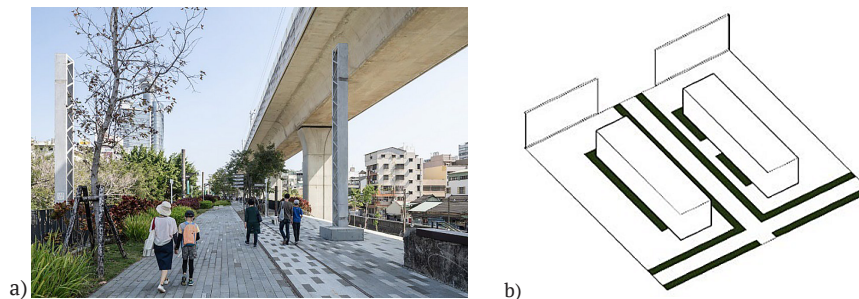


Figure 5. Traditional approach to urban landscaping in the context of the combined principle of its implementation
Note: a – green corridor in Taichung, China; b – 3D diagram of the main structural elements of combined traditional landscaping
Source: based on P. Pintos (2020)

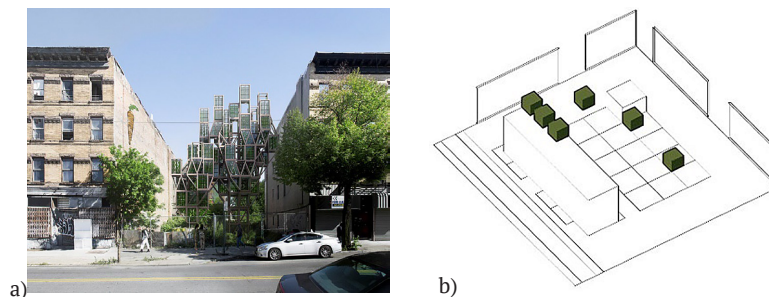


Figure 6. Innovative approach to urban landscaping in the context of the combined principle of its implementation
Note: a – modular landscaping in New York, USA; b – 3D diagram of the main structural elements of combined innovative landscaping
Source: based on C. Harrouk (2020)

The social dimension of the combined principle was to form a culture of belonging to a place. Small green areas in apartment courtyards or front gardens create “transitional” spaces between private and public, where informal contacts arose and a sense of belonging was formed. Mobile landscaping in such areas makes them even more open to communication: passers-by were more likely to stop, when they see some activities (Gehl, 2010). This was how the natural interaction between people and space was gradually formed, which strengthened the sense of community and trust in the city. The educational aspect remained equally important. Traditionally, children learned how to care for plants from their elders – this experience formed ecological

thinking and respect for nature. Mobile gardening can replicate this function in urban spaces: it was increasingly being placed near schools, kindergartens, or other educational spaces. Such constructions became an interactive learning tool that helped to learn about nature in a dynamic, playful way. In the physical dimension, greening lines along roads became barriers between cars and pedestrians, creating protection both on a psychological level (a sense of isolation) and on a practical level (elements of greening restrain transport in the event of a collision). Thus, the space was organised in such a way that a person gains control over the situation, and the flows of transport and pedestrians were separated (Table 3).

Table 3. Combined principle of urban landscaping implementation

Traditional approach		Innovative approach
Forms of landscaping	Green corridors along the streets, front gardens, apartment courtyards	Mobile landscaping
Impact on human comfort	Psychological security (sense of protection and control), social security (belonging to a place-community; elements of learning-games), physical security (development of a protective barrier)	

Source: developed by the author



Given the interdisciplinary nature of the scientific discourse on the introduction of landscaping in urban space, the number of studies in this area was constantly growing. Within the framework of the extensive principle, J. Kingsley *et al.* (2020) analysed the social potential of urban gardens and vegetable gardens based on a sociological study in Melbourne (Australia). The researchers found that urban gardening was perceived as a space for interaction, support, and mutual benefit, which created a sense of community. In turn, P.-Y. Nguyen *et al.* (2021) focused on the impact of the quality of urban landscaping on the physical and psychological state of a person. The researchers identified a number of criteria – comfort, safety, calmness – and determined that high-quality landscaping was associated with a reduction in psychological distress, depressive and anxiety states, and antisocial behaviour. In the context of the intensive principle, R. Gunapala *et al.* (2025) reviewed the social aspect of vertical gardening, emphasising that it can create additional opportunities – from spending time together to education and professional development. M. Artmann *et al.* (2021) investigated the psychological factors of urban agricultural production. Based on the example of gardening in German cities, the authors proposed a model that emphasised the importance of combining physical experience and mental connection with nature for the development of proecological behaviour. The combined principle was represented by Q. Ren *et al.* (2025), who turned to an evolutionary approach to explain psychological comfort. The researchers emphasised the importance of the prospect-refuge parameter as one of the key parameters in the design of green spaces. F. Rosso *et al.* (2024) developed this topic as part of a study of tactical urbanism, analysing the impact of pocket parks on subjective feelings of comfort and on objective microclimatic indicators. S. Rajendran *et al.* (2024) compared hydroponics with traditional soil gardening, emphasising its potential in urban density settings. J. Garzón *et al.* (2023) outlined the key opportunities and challenges of aeroponics, while S.L. Lama *et al.* (2025) analysed aquaponics, especially in terms of its cost-effectiveness. Within the Ukrainian context, researchers' attention also increased. O. Klymchyk (2021) considered the prospects for the use of vertical gardening in the cities of Ukraine, and I. Patseva *et al.* (2022) developed practical recommendations for the implementation of green roof projects, in particular on the example of Zhytomyr. Overall, the scientific discourse remains heterogeneous: most studies have focused on individual aspects – environmental, social or psychological – avoiding a comprehensive interdisciplinary analysis of the effective use of greening opportunities. Simultaneously, this approach has become necessary to achieve the strategic goals of urban development and increase human comfort. This required a broader dialogue between researchers, practitioners from different fields, investors, local authorities, and the public – an

exchange of ideas that will help to ensure the sustainability of urban development.

CONCLUSIONS

As a result of the study, it was found that urbanisation processes change the structure of cities, compacting buildings and reducing the possibilities of human interaction with nature inherent in it throughout human development. In addition, the study revealed that the combination of the latest technologies with the specifics of human perception allowed creating adaptive models of urban space, where nature returns a sense of security – control, belonging to a place, information exchange. Traditional groups of approaches to landscaping, formed in different historical epochs, remained relevant, because it laid the foundations for safety and comfort, while innovative ones developed them in accordance with new spatial and technological challenges. In the context of certain approaches, three principles of urban landscaping implementation were proposed – extensive, intensive, and combined. The extensive principle tends to maximise the possible use of space with minimal labour, time, and finances. Its meaning was to create a favourable microclimate, disperse human attention, and maintain informal social ties. The landscape here works as a spatial background – through green roofs, terraces, walls, and transit spaces. The intensive principle was based on the limited area and provided for its efficient use due to significant investment of resources; its goal was to achieve high food productivity, form a recognisable image of the space, and ensure its versatility. Landscaping in this case acquired a high-tech character and was implemented through vertical farms using hydroponic, aquaponic, and aeroponic systems. The combined principle takes an intermediate position, combining minimal use of space with moderate resource consumption. Its task was to create buffer zones, form a sense of control over space, and strengthen a person's emotional attachment to a place. For this purpose, mobile landscaping elements were used, which easily adapted to different use cases and allowed flexible changes in the spatial organisation without significant interference. For each principle, the recommended forms of landscaping and their impact on physical, psychological, and social security were defined. Further research should focus on combining certain principles into a single multi-level system, while maintaining the idea that the new organically continues the old, which will ensure harmony between man, nature, and urban space.

ACKNOWLEDGEMENTS

None.

FUNDING

None.

CONFLICT OF INTEREST

None.



REFERENCES

- [1] Abdel, H. (2021). Ilot queyries apartment building/MVRDV. *ArchDaily*. Retrieved from https://www.archdaily.com/968597/ilot-queyries-apartment-building-mvrdv?ad_medium=gallery.
- [2] Appleton, J. (1975). *The experience of landscape*. London; New York: Wiley.
- [3] ArchDaily. (n.d.). Retrieved from https://www.archdaily.com/?ad_name=small-logo.
- [4] Artmann, M., Sartison, K., & Ives, C.D. (2021). Urban gardening as a means for fostering embodied urban human-food connection? A case study on urban vegetable gardens in Germany. *Sustainability Science*, 16, 967-981. doi: 10.1007/s11625-021-00911-4.
- [5] Astbury, J. (2019). Kuehn Malvezzi tops brick office with translucent urban greenhouse. *Dezeen*. Retrieved from <https://www.dezeen.com/2019/11/04/kuehn-malvezzi-office-urban-greenhouse/>.
- [6] Barriuso, F., & Urbano, B. (2021). Green roofs and walls design intended to mitigate climate change in urban areas across all continents. *Sustainability*, 13(4), article number 2245. doi: 10.3390/su13042245.
- [7] Beute, F., et al. (2023). How do different types and characteristics of green space impact mental health? A scoping review. *People and Nature*, 5(6), 1839-1876. doi: 10.1002/pan3.10529.
- [8] Bratman, G.N., Olvera-Alvarez, H.A., & Gross, J.J. (2021). The affective benefits of nature exposure. *Social and Personality Psychology Compass*, 15(8), article number e12630. doi: 10.1111/spc3.12630.
- [9] Dezeen. (n.d.). Retrieved from <https://www.dezeen.com/>.
- [10] Fromm, E. (1973). *The anatomy of human destructiveness*. New York: Open Road Media.
- [11] Garzón, J., Montes, L., Garzón, J., & Lampropoulos, G. (2023). Systematic review of technology in aeroponics: Introducing the technology adoption and integration in sustainable agriculture model. *Agronomy*, 13(10), article number 2517. doi: 10.3390/agronomy13102517.
- [12] Gehl, J. (2010). *Cities for people*. Washington D.C.: Island Press.
- [13] Giacomello, E. (2021). *Green roofs, facades, and vegetative systems. Safety aspects in the standards*. Oxford: Butterworth-Heinemann. doi: 10.1016/C2017-0-01917-1.
- [14] Gowdy-Wygant, C. (2013). *Cultivating victory: The women's land army and the victory garden movement*. Pittsburgh: University of Pittsburgh Press. doi: 10.2307/j.ctt9qh5qk.
- [15] Griffiths, A. (2019). Oasis Terraces is a neighbourhood centre built around a stepped garden. *Dezeen*. Retrieved from <https://www.dezeen.com/2019/01/22/ocean-terraces-singapore-serie-architects-multiply/>.
- [16] Gunapala, R., Gangahagedara, R., Wanasinghe, W.C.S., Samaraweera, A.U., Gamage, A., Rathnayaka, C., Hameed, Z., Baki, Z.A., Madhujith, T., & Merah, O. (2025). Urban agriculture: A strategic pathway to building resilience and ensuring sustainable food security in cities. *Farming System*, 3(3), article number 100150. doi: 10.1016/j.farsys.2025.100150.
- [17] Harrouk, C. (2020). Framlab imagines modular vertical urban farms on the streets of Brooklyn. *ArchDaily*. Retrieved from <https://www.archdaily.com/933879/framlab-proposes-modular-vertical-urban-farms-in-brooklyn>.
- [18] Harwood, E.D., & Martin, T. (2014). *Patent No. US 8,782,948, B2. Method and apparatus for aeroponic farming*. Retrieved from <https://patentimages.storage.googleapis.com/41/6e/7a/eb55329756c7d1/US8782948.pdf>.
- [19] Herwagen, J.H. (1993). *Humans, habitats, and aesthetics. The Biophilia Hypothesis*, 138-172.
- [20] Howard, E., & Osborn, F.J. (1965). *Garden cities of to-morrow*. Cambridge: The MIT Press.
- [21] Jacobs, J. (1961). *The death and life of great American cities*. New York: Random House.
- [22] Jashemski, W.F., Gleason, K.L., Hartswick, K.J., & Malek, A.-A. (Eds.). (2017). *Gardens of the Roman Empire*. Cambridge: Cambridge University Press. doi: 10.1017/9781139033022.
- [23] Kaplan, R., & Kaplan, S. (1989). *The experience of nature: A psychological perspective*. Cambridge: Cambridge University Press.
- [24] Kellert, S.R. (2018). *Nature by design: The practice of biophilic design*. New Haven: Yale University Press.
- [25] Kingsley, J., Foenander, E., & Bailey, A. (2020). "It's about community": Exploring social capital in community gardens across Melbourne, Australia. *Urban Forestry & Urban Greening*, 49, article number 126640. doi: 10.1016/j.ufug.2020.126640.
- [26] Klymchyk, O. (2021). Possibilities of application of vertical greening in the cities of Ukraine. *Environmental Sciences*, 7, 51-55. doi: 10.32846/2306-9716/2021.eco.7-34.9.
- [27] Kosyk, O., & Letik, K. (2021). Formation of a comfortable urban environment by means of landscaping. *Theory and Practice of Design*, 23, 134-140. doi: 10.18372/2415-8151.23.16279.
- [28] Lama, S.L., Marcelino, K.R., Wongkiew, S., Surendra, K.C., Hu, Z., Lee, J.W., & Khanal, S.K. (2025). Recent advances in aquaponic systems: A critical review. *Reviews in Aquaculture*, 17(3), article number e70029. doi: 10.1111/raq.70029.
- [29] Landezine International Landscape Award. (n.d.). *The courtyard of the future at Strausvej*. Retrieved from <https://landezine-award.com/the-courtyard-of-the-future-at-strausvej/>.
- [30] Landezine. (n.d.). Retrieved from <https://landezine.com/>.
- [31] Lentz, D.L., et al. (2014). Forests, fields, and the edge of sustainability at the ancient Maya city of Tikal. *Proceedings of the National Academy of Sciences*, 111(52), 18513-18518. doi: 10.1073/pnas.1408631111.





- [32] Leslie, M. (Ed.). (2016). *Cultural history of gardens in the Medieval Age*. London: Bloomsbury Academic.
- [33] Manso, M., & Castro-Gomes, J. (2015). Green wall systems: A review of their characteristics. *Renewable and Sustainable Energy Reviews*, 41, 863-871. doi: [10.1016/j.rser.2014.07.203](https://doi.org/10.1016/j.rser.2014.07.203).
- [34] Marsaglia, V. (2024). Technological greenery. Exploring cutting-edge solutions for performant greenery integration in building envelope design. *Energy and Buildings*, 324, article number 114920. doi: [10.1016/j.enbuild.2024.114920](https://doi.org/10.1016/j.enbuild.2024.114920).
- [35] McHarg, I.L. (1969). *Design with nature*. New York: Garden City.
- [36] Mosser, M., & Teyssot, G. (Eds.). (1991). *The architecture of Western gardens: A design history from the Renaissance to the present day*. Cambridge: MIT Press.
- [37] Nguyen, P.-Y., Astell-Burt, T., Rahimi-Ardabili, H., & Feng, X. (2021). Green space quality and health: A systematic review. *International Journal of Environmental Research and Public Health*, 18(21), article number 11028. doi: [10.3390/ijerph182111028](https://doi.org/10.3390/ijerph182111028).
- [38] Oleshko, O., & Petrovska, Yu. (2020). Phytodesign as a mean of greening and a detailed of the subject-spatial environment. *Problems of Theory and History of Architecture in Ukraine*, 20, 249-258. doi: [10.31650/2519-4208-2020-20-249-258](https://doi.org/10.31650/2519-4208-2020-20-249-258).
- [39] Patseva, I., Alpatova, O., Rybak, O., Tsyganenko-Dziubenko, I., & Medvid, O. (2022). Rooftop gardening as an adaptation measure of the climate changes a case study of Zhytomyr. *Problems of Chemistry and Sustainable Development*, 3, 67-74. doi: [10.32782/pcsd-2022-3-9](https://doi.org/10.32782/pcsd-2022-3-9).
- [40] Pintos, P. (2020). Taichung Green Corridor/Mecanoo. *ArchDaily*. Retrieved from <https://www.archdaily.com/972400/taichung-green-corridor-mecanoo>.
- [41] Rajendran, S., Domalachenpa, T., Arora, H., Li, P., Sharma, A., & Rajauria, G. (2024). Hydroponics: Exploring innovative sustainable technologies and applications across crop production, with emphasis on potato mini-tuber cultivation. *Heliyon*, 10(5), article number e26823. doi: [10.1016/j.heliyon.2024.e26823](https://doi.org/10.1016/j.heliyon.2024.e26823).
- [42] Ren, Q., Weng, Y., & Hu, Z. (2025). A study of space creation for healing landscape design in the post-epidemic era. *Frontiers in Psychology*, 16, article number 1618451. doi: [10.3389/fpsyg.2025.1618451](https://doi.org/10.3389/fpsyg.2025.1618451).
- [43] Rosso, F., Pioppi, B., & Pisello, A.L. (2024). Tactical urban pocket parks (TUPPs) for subjective and objective multi-domain comfort enhancement. *Journal of Environmental Management*, 349, article number 119447. doi: [10.1016/j.jenvman.2023.119447](https://doi.org/10.1016/j.jenvman.2023.119447).
- [44] Sang, Å.O., Thorpert, P., & Fransson, A.-M. (2022). Planning, designing, and managing green roofs and green walls for public health – an ecosystem services approach. *Frontiers in Ecology and Evolution*, 10, article number 804500. doi: [10.3389/fevo.2022.804500](https://doi.org/10.3389/fevo.2022.804500).
- [45] Šćepanović, S., Joglekar, S., Law, S., Quercia, D., Zhou, K., Battiston, A., & Schifanella, R. (2025). Vitamin N: Benefits of different forms of public greenery for urban health. *arXiv*. doi: [10.48550/arXiv.2508.12998](https://doi.org/10.48550/arXiv.2508.12998).
- [46] Shwartz, A., Tzunz, M., Gafter, L., & Colléony, A. (2023). One size does not fit all: The complex relationship between biodiversity and psychological well-being. *Urban Forestry & Urban Greening*, 86, article number 128008. doi: [10.1016/j.ufug.2023.128008](https://doi.org/10.1016/j.ufug.2023.128008).
- [47] Sitte, C. (1922). *The urban planning according to its artistic principles: A contribution to the solution of modern questions of architecture and monumental sculpture with special reference to Vienna*. Vienna: Carl Graeser.
- [48] Staniszewski, R., Podawca, K., Sojka, M., Kacprzak, E., & Karsznia, K. (2025). Analysis of the impact of road noise on urban green spaces: A case study of the dendrological garden in Poznań, Poland. *Miscellanea Geographica*, 29(1), 11-20. doi: [10.2478/mgrsd-2025-0004](https://doi.org/10.2478/mgrsd-2025-0004).
- [49] Ulrich, R.S. (1984). View through a window may influence recovery from surgery. *Science*, 224(4647), 420-421. doi: [10.1126/science.6143402](https://doi.org/10.1126/science.6143402).
- [50] Wan, C., Shen, G.Q., & Choi, S. (2021). Underlying relationships between public urban green spaces and social cohesion: A systematic literature review. *City, Culture and Society*, 24, article number 100383. doi: [10.1016/j.ccs.2021.100383](https://doi.org/10.1016/j.ccs.2021.100383).
- [51] Žuvela-Aloise, M., Koch, R., Buchholz, S., & Früh, B. (2016). Modelling the potential of green and blue infrastructure to reduce urban heat load in the city of Vienna. *Climatic Change*, 135, 425-438. doi: [10.1007/s10584-016-1596-2](https://doi.org/10.1007/s10584-016-1596-2).



Анастасія Мудра

Аспірант

Національний університет «Львівська політехніка»

79013, вул. Степана Бандери, 12, м. Львів, Україна

<https://orcid.org/0000-0002-6899-7594>

Традиційні та інноваційні підходи до озеленення та принципи їх впровадження в контексті гармонізації міського простору

Анотація. Інтенсивні урбанізаційні процеси потребують рішень, які поєднують соціально-психологічні особливості формування міської тканини з сучасними технологіями, щоб зберегти зв'язок людини з природою навіть в умовах ущільненої забудови. Метою статті став аналіз традиційних та інноваційних підходів до озеленення й визначення принципів їхнього впровадження для створення безпечного та комфортного простору. Проведено історико-порівняльний аналіз, який показав еволюцію елементів озеленення. Виявлено, що до зростання ролі міст озеленення було невід'ємною частиною життя людини, своєрідним посередником між нею та навколишнім середовищем. Також, за допомогою положень психології та соціології у дослідженні було визначено основні механізми сприйняття простору, що дозволило комплексно оцінити вплив природи на якість життя людини. Проаналізовано сучасні приклади інтеграції елементів озеленення у щільну забудову міст країн Європи (Франція, Данія, Німеччина), Азії (КНР, Сінгапур) та США. Виокремлено та узагальнено дві групи підходів до озеленення – традиційний та інноваційний, кожен з яких представлено 3D-схемою основних структурних складових. Встановлено, що інноваційні технології – зелені покрівлі, тераси та стіни, вертикальні ферми з гідропонними, аквапонними та аеропонними системами, мобільне озеленення – не суперечать історично сформованим моделям, а трансформують і доповнюють їх відповідно до нових просторових обмежень і потреб міст. На основі цього було запропоновано три принципи впровадження міського озеленення: екстенсивний – орієнтований на використання великих площ із мінімальними ресурсами; інтенсивний – орієнтований на використання менше простору, але більше технологічних рішень і витрат; комбінований – поєднує переваги обох принципів. Для кожного з них визначено характерні форми озеленення та їхній вплив на різні рівні комфорту людини: фізичний, психологічний та соціальний. Наголошено, що ефективна інтеграція озеленення в щільну забудову можлива лише за умови балансу між технологічними інноваціями та базовими механізмами сприйняття простору. Отримані результати можуть стати основою для розроблення стратегій сталого розвитку українських міст, спрямованих на гармонізацію міського простору та підвищення відчуття безпеки мешканців

Ключові слова: житло; щільність забудови; планування; ландшафтна архітектура; міське озеленення; міське агровиробництво



UDC 73.01
DOI: 10.56318/as/4.2025.64

ISSN: 2411-801X
e-ISSN: 2786-7374

Kateryna Didenko*

PhD in Architecture, Associate Professor
Vilnius Gediminas Technical University
LT-10223, 11 Saulėtekio Al., Vilnius, Lithuania
O.M. Beketov National University of Urban Economy in Kharkiv
61002, 17 Chornoglazivska Str., Kharkiv, Ukraine
<https://orcid.org/0000-0003-2567-686X>

Olga Vigdorovich

PhD in Architecture, Associate Professor
O.M. Beketov National University of Urban Economy in Kharkiv
61002, 17 Chornoglazivska Str., Kharkiv, Ukraine
<https://orcid.org/0000-0001-6461-2792>

Typical projects for atypical urban formations: The science city Piatykhvatky

Abstract. Science cities, as specialised scientific production complexes, were a unique phenomenon of Soviet urban planning, formed in the 1950s-1980s. These settlements were planned to provide optimal conditions for the work of scientific institutions and comfortable living for their employees. One of the vivid examples of such formation was the science town Piatykhvatky in Kharkiv, created to maintain the functioning of the Kharkiv Institute of Physics and Technology. The aim of this article was to examine the architectural and urban planning evolution of the Piatykhvatky science city in Kharkiv, identifying stage-based development and analysing unique and standardised features at both urban and building scales. The results of the study demonstrated that the Piatykhvatky area exhibited the key characteristics of a classic science city: a satellite location, a closed structure, individual master planning, a high level of landscaping, and a balanced combination of residential, industrial, and recreational infrastructure. These features emphasised the scientific and state priorities underlying its design. However, the architectural component of the area reflected the characteristic features of mass construction of the era, expressed in the use of standard projects for residential and public buildings. This combination of unique urban status and typical buildings formed contrast, demonstrating a pragmatic approach to architectural solutions in the context of limited resources. Of particular interest was the study of the functional and spatial complex of Piatykhvatky, encompassing social, educational, sports, and transport elements, as well as its potential as a cultural heritage site. This research highlighted the necessity of modernising outdated infrastructure, while preserving valuable spatial and compositional solutions that continue to serve elements of the urban environment

Keywords: research-oriented settlement; mono-industrial town; post-Soviet built legacy; unique urban structure; standard design

INTRODUCTION

From the 1950s through the 1980s, post-war industrialisation and state socialist planning enabled the large-scale

production of functionally specialised, often enterprise-dependent settlements and new districts across the USSR and

Suggested Citation:

Didenko, K., & Vigdorovich, O. (2025). Typical projects for atypical urban formations: The science city Piatykhvatky. *Architectural Studies*, 11(4), 64-75. doi: 10.56318/as/4.2025.64.

Journal homepage: <https://arch-studies.com.ua/en>

Architectural Studies, 11(4), 64-75

Received: 31.07.2025 Revised: 03.11.2025 Accepted: 19.12.2025 Published: 29.12.2025

*Corresponding author



Copyright © The Author(s). This is an open access article distributed under the terms of the Creative Commons Attribution License 4.0 (<https://creativecommons.org/licenses/by/4.0/>)



the broader socialist block. The expansion of industrialised construction coincided with the development of research-oriented urban areas closely linked to strategic scientific institutions. These settlements were characterised by a deliberate planning structure combined with widely replicated building types. One such environment evolved in Kharkiv around a major physics research centre, forming a distinct urban entity within the city's fabric. In the context of contemporary challenges to the preservation of 20th century built environments, systematic academic reflection on these planned formations was essential for understanding their internal organisation, architectural composition, and long-term development.

Scholarly discourse increasingly addressed the urbanistic, architectural, and socio-spatial legacy of post-socialist mass housing estates, industrial legacy and monotowns. A significant contribution to the understanding of post-Soviet residential environments was made by O. Buryak & O. Vigdorovich (2023), who emphasised the importance of protecting the spatial configuration of large-scale industrial housing developments, particularly in Kharkiv, and argued for innovative heritage-oriented approaches to their conservation. H. Antypenko *et al.* (2021) further explored post-1991 transformations of Kharkiv's large housing estates, demonstrating how socio-economic change had reshaped their functional and spatial structures. A foundational overview of mass housing development in Eastern Europe was provided by L. Shevchenko (2022), who examined Ukrainian mass housing of the second half of the 20th century, emphasising its typological uniformity, standardised construction methods, and long-term urban implications.

M. Drémaitė (2023) analysed Lithuanian mass housing estates, focusing on architects' strategies to mitigate monotony within socialist planning frameworks. The author's study highlighted the role of design agency within highly regulated systems, offering insights relevant to the spatial identity of monotowns. Issues of adaptation and functional diversification were further explored by H. Antypenko & M. Benkő (2022), who demonstrated how large housing estates responded to contemporary socio-economic pressures. I. Serhiuk & I. Kalakoski (2023) critically discussed demolition versus adaptation strategies for post-industrial buildings in Ukraine. Processes of decay and renewal were further conceptualised by O. Remizova & K. Bozhko (2025), who analysed ruinisation and revitalisation in modernist industrial architecture. The challenges of aging Soviet-era building stock were addressed by E. Grinevich *et al.* (2021), who analysed reconstruction problems of residential buildings from the 1960s-1970s. Broader post-industrial trajectories were examined by R. Hajduková & A. Sopiřová (2022), who studied Eastern Slovak towns and landscapes, emphasising the spatial consequences of industrial decline.

Also, attention was given to nuclear city in Lithuania: S. Liubimau (2019) framed Visaginas as a multi-scalar infrastructural product of Soviet nuclear urbanisation, arguing its post-1991 trajectory reflects enduring links between infrastructure, sovereignty and urbanity. Researcher

distinguished Cold War, imperial and Soviet-welfare "nuclear" dimensions shaping futures amid decommissioning. Scientists N. Mažeikienė & E. Gerulaitienė (2022) showed how Visaginas' post-nuclear identity was negotiated through tourism as an interpretive practice. Participatory action research on a virtual route revealed tensions between empowerment and commodification, critique of legacies and self-exoticising narratives. L. Kachemtseva *et al.* (2022) identified urban planning characteristics of Ukrainian science cities, including Piatykhatty, while leaving their detailed architectural and urban planning characteristics insufficiently explored, particularly regarding the development stages and unique and standardised components of Piatykhatty science city. The aim of this article was to describe the architectural and urban planning characteristics and features of the Piatykhatty science city in Kharkiv at each stage of its construction, and to identify its unique and standardised components at both the urban planning level and the level of individual buildings.

MATERIALS AND METHODS

To achieve the aim of this study, a systematic, logical, and analytical research approach were employed, enabling the identification of spatial, compositional, and functional characteristics of urban planning solutions, as well as the architectural features of individual buildings within the Piatykhatty science city. The research examined planning approaches at both the urban scale and the scale of individual buildings. The investigations were conducted during the period of 2021-2025. Data were collected through route-based observation and in situ recording and processed through inventory building, categorisation by function/type/condition, and cross-source comparison. Contemporary Google Maps imagery was compared with historical plans to identify continuities and transformations in the residential urban fabric. The research was carried out in several stages: first – the collection and critical review of historical and contemporary sources; second – systematic analysis of urban planning layouts and architectural forms; and third – synthesis and comparison of unique and standardised components across different stages of the city's development. To generalise the findings and ensure methodological rigor, the method of information systematisation was applied, supported by the integration of field observations and archival evidence. This approach enabled a comprehensive understanding of both macro-level urban organisation and micro-level architectural composition, providing a robust framework for evaluating the development patterns and distinctive features of Piatykhatty science city.

Historical publications were used as follows: V. Ashykhmin & V. Stepina (2008) was used as a contextual, publication-based account of the establishment of the scientific-production base associated with Kharkiv Institute of Physics and Technology and the Piatykhatty area, supporting the reconstruction of the project's chronology and institutional factors of its development. V. Tolok (2004) provided a peer-reviewed historical overview of physics in





Kharkiv and the role of the KIPT in the city's scientific system, which was used to form the socio-institutional rationale for the emergence of the Piatykhatty residential area. Archive of NSC KIPT (1963) was examined to extract the phase-I planning scheme and plans of selected buildings; Archive of NSC KIPT (1987) was examined to extract the phase-II block layouts, building plans, and the explanatory note covering the development. Empirical field materials were used as follows: semi-structured interviews with local residents and NSC KIPT (National Science Centre of Kharkiv Institute of Physics and Technology) employees provided narrative evidence on everyday mobility, use of public spaces, and perceived transformations of Piatykhatty (The Declaration of Helsinki, 2013). Field investigations in the Piatykhatty residential area (housing microdistricts, dormitories, retail and everyday services, socio-cultural facilities, and public open spaces) generated systematic photo documentation, field notes, and route maps, enabling the assessment of current building conditions, functional changes, and the comparison of observed urban fabric with archival plans and published accounts.

RESULTS AND DISCUSSION

In the mid-1950s, urban planning in the USSR became centralised. At the 20th CPSU Congress (1956), the sixth five-year plan directives emphasised the industrialisation and standardisation of construction and set ambitious near-term targets for state-funded housing (Communist Party of the Soviet Union, 1956). A key policy instrument was the joint Decree of the CPSU Central Committee and the USSR Council of Ministers of 31 July 1957, which formalised the shift toward industrial mass housing and standardised design principles (Drémaité, 2022). This marked the beginning of a period of mass housing development across the USSR. From that point forward, residential and public construction relied on the industrialised method of building standardised housing designs. Elite architectural projects disappeared, while the primary focus shifted to the location of buildings, logistical convenience, and the inclusion of recreational and cultural zones. These transformations impacted all Soviet republics, including Ukraine. In the 1950s-1960s, unique urban formations known as science cities ("naukogrady") emerged across the Soviet republics. Commonly referred to as "closed cities" or "mailboxes", these settlements were established to facilitate scientific research and development in various fields, including nuclear physics, rocketry, and other high-tech industries. Strictly controlled by the state, these cities were shrouded in secrecy, with access heavily restricted and information about them largely unknown to the general public for an extended period.

One of the defining features of science cities that distinguished them from other urban structures was, for example, that these cities often functioned as satellites of large urban centres, playing a role in metropolitan agglomerations as integral components of current and future settlement patterns (Kachemtseva *et al.*, 2022). When

a science city was situated at a considerable distance from its "parent" city, it was consistently provided with reliable and regular transportation links to ensure connectivity. These cities (or at least their research and experimental centres) were frequently surrounded by controlled zones. It was isolated from other settlements and surrounding areas by forests and often located in picturesque settings, such as along scenic lakeshores or navigable rivers. A distinctive feature emphasising the introverted nature of science cities was their lack of through traffic, making them self-contained and inward-focused. These cities represented a new type of settlement emerging during the era of the scientific and technological revolution, reflecting a qualitative leap in the advancement of science and technology. Their exceptional intellectual potential facilitated the creation of cutting-edge facilities that outpaced broader Soviet trends in areas such as environmental sustainability, services, and culture. Residents of science cities enjoyed a high quality of life, with work, housing, leisure, and services harmoniously integrated. The foundation of science cities comprised research institutes, project bureaus, experimental factories, and testing sites. These cities were equipped with the most advanced technical infrastructure, and their laboratories featured state-of-the-art innovations. These resources were available to highly skilled personnel, including scientists, engineers, and technicians, capable of executing the most complex programmes. Special attention was given to developing a favourable architectural and urban environment, which contributed to the enhancement of the nation's scientific potential. However, despite the emphasis on thoughtful urban planning and a tailored approach, standardised designs for residential and public buildings were frequently employed. It was important to note that, in the case of residential buildings, projects with improved layouts were frequently used, often including mandatory storage rooms for each apartment in the basement. The main components of these cities included: research institution(s) and laboratories; residential quarters with standardised multi-apartment buildings; public buildings: kindergartens, schools, hospitals, and clinics; social infrastructure facilities: stores, cultural centres, sports complexes, recreational areas. Seven key areas of science cities development included aviation, rocket engineering and space research, electronics and radio engineering, automation, machine and instrument engineering, chemistry and physicochemical research for the creation of innovative materials, the nuclear sector, energy, as well as biology and biotechnology.

In Ukraine, there were several cities that have become important centres of innovation and technological progress. However, most of Ukraine's scientific cities have acquired narrow specialisations and belong to the category of so-called "atomograds" – cities built around nuclear energy facilities. These included Pripyat, Enerhodar, Netishyn, Varash, Pivdennoukrainsk, and Slavutych, the latter one was standing apart as it was constructed for the evacuation of Pripyat's residents. A key urban planning feature of this



type of city was the mandatory presence of a water body within the city to provide necessary reactor cooling, as well as the placement of the nuclear power plant at a significant distance from the residential and infrastructure areas. In Ukraine, there were also science cities focused on other scientific disciplines, such as Kyiv's Akademmistechko, which was built on the outskirts of the city in the 1960s-1970s and included more than 15 multidisciplinary research institutions, or the Zhukovsky settlement near Kharkiv Aviation Institute (KhAI), which served as a hub for scientists, educators, and aviation industry workers. An important part of the study was the analysis of the scientific city of Piatykhvatky, home to one of the leading centres for physical research – the National Scientific Centre “Kharkiv Institute of Physics and Technology”.

Although atomograds such as Prip'yat, Slavutych, and Enerhodar held unique significance and specific purposes, their construction predominantly relied on standard Soviet designs. Nevertheless, urban planning at these sites incorporated individualised solutions. Among these cities, Slavutych stood out as the location, where the largest number of atypical architectural approaches were implemented. These ones and mentioned earlier atomograds emerged as a response to the rapid growth of nuclear energy in the USSR during the 1960s-1980s. It was built near nuclear power plants to support the energy complex, offering housing and social services for nuclear power plant workers and their families. Prip'yat, founded in 1970 to accommodate workers of the Chernobyl nuclear power plant, was designed for a population of 50,000, with a focus on establishing comprehensive infrastructure for comfortable living (Wendland, 2020). There were public buildings, commercial facilities, and cultural institutions, surrounded by residential blocks. Enerhodar, also established in 1970 to serve the Zaporizhzhia nuclear power plant, represented another example of an atomic town. Situated on the banks of the Kakhovka reservoir, Enerhodar was planned with functional zoning principles, incorporating industrial, residential, and socio-cultural zones, much like other atomograds. Slavutych was constructed in 1986 following the Chernobyl disaster as a response to the need for relocating power plant workers from the contaminated zone. Its planning adhered to Soviet urban development traditions, while incorporating more modern approaches to ecology and comfort. The city was designed with considerations for environmental safety and radiation protection. Green spaces and parks occupied a significant portion of Slavutych, contributing to an improved ecological environment. Slavutych was organised into microdistricts, each characterised by unique architectural features reflecting the republics of the USSR that contributed to its construction. The architecture of these urban developments adhered to the principles of mass construction and industrialisation. Prip'yat was built using prefabricated panel construction technologies, with multi-story apartment buildings organised into microdistricts that included spaces for recreation and social activities. Similarly, the architectural solutions

in Enerhodar were based on standard Soviet designs. However, its proximity to water bodies and green spaces enhanced the city's aesthetic appeal, featuring numerous parks and public gardens.

Slavutych's districts designs was created by architects from various Soviet republics, including Lithuania, Estonia, Latvia, Georgia, Armenia, Azerbaijan. This approach introduced diversity to the appearance of residential buildings. In Prip'yat, prefabricated panel housing dominated, with series 84, 121, and 111 being the most common, including II-60 designs for residential complexes. The “Prometheus” cinema was constructed following the 264-13-53 project plan. In Enerhodar, typical housing series such as 84, 87, 121, and 125 were prevalent, alongside series 224 schools and series 214 kindergartens. The “Sovremennik” cultural centre was built according to the 264-12-50 project. In Slavutych, standard panel housing series were also employed; however, architects sought to introduce variety through the distinct design of different districts. In these districts, one can observe buildings featuring architectural elements characteristic of the corresponding Soviet republics, such as balconies and façades styled to reflect regional aesthetics. As a result, Slavutych utilised both common Soviet-era housing series (91, 121, 84, 119, 94) and uniquely designed architectural structures (PhotoBuildings, n.d.).

The settlement of Piatykhvatky in Kharkiv served as a prominent example of a science city. Its core institution held a special status and conducted research in nuclear physics, a field of significant military and defense importance. This elevated status necessitated a distinctive approach to the architectural and urban planning framework. While the urban design aligned with the unique stature of a science city, the architectural components reflected standardisation and uniformity. Residential and public buildings in Piatykhvatky were constructed based on standardised designs, albeit occasionally featuring improved layouts. From 2022, one of the foremost priorities was the documentation and scholarly integration of design and archival materials related to Ukraine's architectural and urban planning heritage. Kharkiv, as a border city, has been subjected to relentless and severe bombardment since the early days of the Russian-Ukrainian war (from 2022), with Piatykhvatky emerging as one of the city's most heavily affected districts. The unique urban entity of the Piatykhvatky science city should be documented as a striking example of the interplay between specific urban planning structures and standardised architectural forms. Ensuring the sustainable development of urban structures established during the 1960s-1980s requires a focused effort on identifying and preserving such urban planning and spatial-compositional solutions. While infrastructure modernisation was imperative, it was critical to recognise and safeguard these significant elements as part of the nation's cultural heritage.

Piatykhvatky exemplified a scientific settlement specialising in atomic science, where research and development of nuclear reactors and nuclear weapons were conducted. Its origins date back to the 1930s, and this science



city continued its activities as of 2025. The establishment of the Ukrainian Research Institute under the Supreme Council of the National Economy of the Ukrainian SSR and the approval of its composition and staff schedule were enacted by a Decree of the Council of People's Commissars of the Ukrainian SSR on October 30, 1928. Construction of the main building of the Ukrainian Institute of Physics and Technology, along with residential houses and workshops, was completed on September 1, 1930, in central Kharkiv (Kachemtseva *et al.*, 2022). Work on creating the technical infrastructure for conducting experiments in nuclear physics began in 1931, and an experiment on the "splitting" of the atomic nucleus was conducted as early as 1932 (Ashykhmin & Stepina, 2008). The territory selected for the construction of Piatykhvatky was located in the Northern part of Kharkiv and had previously been a farmstead belonging to the village of Cherkaska Lozova. It was separated from the city by a green belt of forest-park

zone. In the early 1950s, the Ukrainian Institute of Physics and Technology was assigned new tasks related to the development of nuclear weapons, various types of nuclear reactors, and space programmes. This required a significant expansion of the institute's scientific and technical potential, an increase in staff numbers, and the development of its scientific, industrial, and social infrastructure. In the mid-1950s, work began on designing and constructing the Piatykhvatky complex, which included laboratory, industrial, residential, and engineering buildings, as well as socio-cultural facilities. By 1958-1959, the first residents began to settle in the area. During this period, the first kindergarten was opened, and a school was built. In the Northeastern part of this Piatykhvatky territory, the building of the Ukrainian Institute of Physics and Technology was later constructed (Fig. 1). In the 1980s-1990s, additional blocks were developed in the Northeastern part of the settlement.



Figure 1. Piatykhvatky buildings

Note: a – main building of KhIPT, Piatykhvatky; b – residential building, 17 Akademik Kurchatov Avenue; c – school No. 62, 2 Walter Street

Source: photos by the authors

Since its inception, the Kharkiv Institute of Physics and Technology (NSC KIPT) held a special status and was located adjacent to a purpose-built residential area. Data of interview indicated that Piatykhvatky offered a comparatively high standard of living, where stable employment and housing were accompanied by well-supplied local retail; residents noted that people travelled from Kharkiv to buy food and consumer goods that were scarce in the city. The planning and design of such entities were carried out centrally and classified as secret, often referred to as "mailboxes", directives and orders were issued from Moscow. Even when the master plan and design were delegated to a local institute, such as in Kharkiv, where the work was executed by a branch of the State Design Institute in Dniprodzerzhynsk (now DneprodzerzhinskCivilProject, Kamiansk), all documentation was ultimately reviewed and approved by Moscow authorities and subsequently archived there. This process also applied to the design of the NSC KIPT territory. As of 2025, only limited information about the designers and builders can be reconstructed, primarily based on the

testimonies of NSC KIPT employees, who witnessed the planning and early construction of the settlement (Archive of NSC KIPT, 1963; Archive of NSC KhIPT, 1987).

The city featured a unique two-winged structure, with a trapezoidal core block at the intersection and rectangular blocks along the sides. To the Northwest and Southeast of enclosed area were the first and second phases of Piatykhvatky's residential development. The district was characterised by a clear division into residential quarters: the first phase predominantly features low-rise buildings (three-five stories, with occasional nine-story structures, erected in 1970s), while the second phase primarily consisted of nine-story buildings, with the exception of a kindergarten. The street network was predominantly orthogonal, forming a grid of blocks along the main arterial road, which runs along the Southeastern perimeter (Akademik Kurchatov Avenue and Kharkiv Highway). This arterial road had a slight bend, where Kharkiv Highway transitions into Akademik Kurchatov Avenue, creating a trapezoidal core within the first-phase residential area. This core comprised



trapezoidal block at the intersection, and the remaining blocks follow a free-plan layout with rectangular shapes. The wing oriented toward the southeast experienced the most intensive development during the 1980s-1990s, encompassing the second-phase construction. This trapezoidal core, developed in the 1950s-1960s, comprised two trapezoidal sub-blocks, which were the only ones with a perimeter block development pattern. The second phase of development reflected the urban planning trends of the 1970s-1980s, when block structures were replaced by free-plan microdistricts. The intra-block spaces in the first-phase development, as well as the open spaces of the second phase, incorporated green areas. Pedestrian green streets run along all main transport connections, and within the trapezoidal core block, the pedestrian Myru Boulevard connected Akademik Kurchatov Avenue and Akademik Walter Street through a green corridor. Greenery also lined the main arterial road and adjacent streets. Additionally, recreational spaces originally planned for the district were complemented by the presence of a forested area on the opposite side of the main road, contributing to the ecological balance of the district.

Consistent with the characteristics of science cities, a section of Akademik Kurchatov Avenue was a dead-end in the Southwest direction. The district's social infrastructure included schools, kindergartens, commercial buildings, and sports facilities, which were integrated into the residential quarters. These structures were generally free-standing buildings. The blocks, in addition to residential functions, included socio-cultural, domestic, and educational facilities necessary for the autonomous functioning of the city. When discussing master planning, it was

important to note the high level of secrecy that restricted access to original blueprints and their copies, while documentary information about residential and service zones was available in significantly larger volumes. The working blueprints for the master plan and buildings (or rather their integration into the landscape) were developed by Kharkiv's Gorstroyproject in 1957 (Archive of NSC KIPT, 1963). While Piatykhvatky's master plan adhered to the urban planning characteristics typical of science cities the city was constructed with standard buildings for residential and service sectors. Residential buildings followed standard series such as 1-438, 1-258, 87; dormitories used series 1-251-1, kindergartens followed series 2-04-32, and cafeterias used series 9001, among others (Archive of NSC KIPT, 1963; Archive of NSC KIPT, 1987).

The typification and centralisation of standard project development, and their dissemination across the territory of the former USSR, were fully realised there. For example, residential buildings of series 1-438 can be found in the Volyn, Dnipropetrovsk, and Poltava regions, constructed between 1955 and 1960. Series 87 can be found not only in various regions of Ukraine but also in Belarus and Lithuania (Archive of NSC KIPT, 1963; Archive of NSC KIPT, 1987). Therefore, the development of the science city of Piatykhvatky can be divided into two main periods: the Soviet period and the period of independence. The Soviet period was characterised by construction and development, further divided into two stages: the 1950s to 1970s, and the 1980s to 1991. The period of independence began in 1992 and continued to the present day. This period was further divided into two phases: 1992 to 2022, and the period starting from February 2022 (Fig. 2).

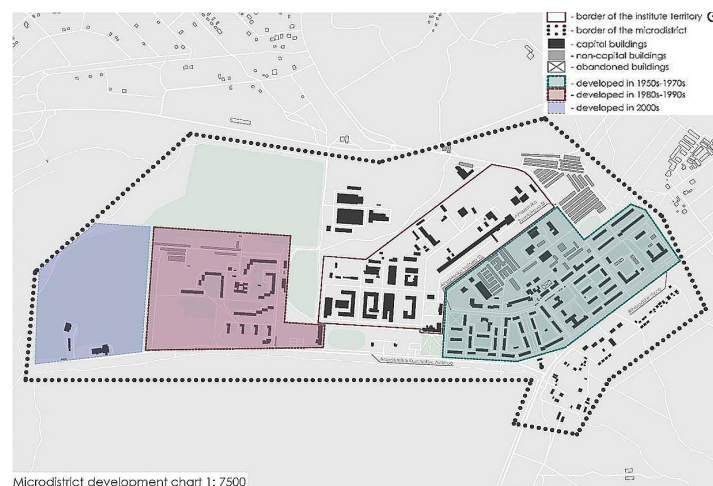


Figure 2. Piatykhvatky master plan with construction stages

Source: developed by the authors

During the 1950s-1960s, 41 buildings were constructed and commissioned in the territory of Piatykhvatky, including 15 laboratory buildings. At the same time, the construction of the residential settlement continued, which was equipped with all the necessary social and cultural

infrastructure. The settlement featured stores, a household services centre, a club with a cinema hall, a post office, a telephone exchange, cafes, a medical centre with a clinic and hospital, a pharmacy, a fire station, a sports complex, and other institutions. By the early 1950s-1960s,



the first phase of construction was completed. Residential blocks were being built, the construction of the Eastern part of the settlement continued into the 1970s. The first area to be developed was Block 3 – the section between Akademichna, Walter, Volkov, and Kurchatov Streets. The construction of this district began among the earliest and was completed by 1963, including 10 residential buildings, 2 kindergartens, and a school. Residential buildings on 7, 9 and 11 Kurchatov Avenue were built according to the

standard design of series 1-424 (Fig. 3), while residential buildings on 1 Akademik Volkov Street, 1 and 2 Yevpatoriya Lane followed the standard design of series 1-258-2. 3 Yevpatoriya Lane and 3 Akademik Volkov Street were built according to the standard design of series 1-258-1, and the residential building on 5 Yevpatoriya Lane followed series 1-438-2. On 5 Kurchatov Avenue, the building followed series 1-438-6, and the school on 2 Akademik Walter Street was built according to series 2-02-19.

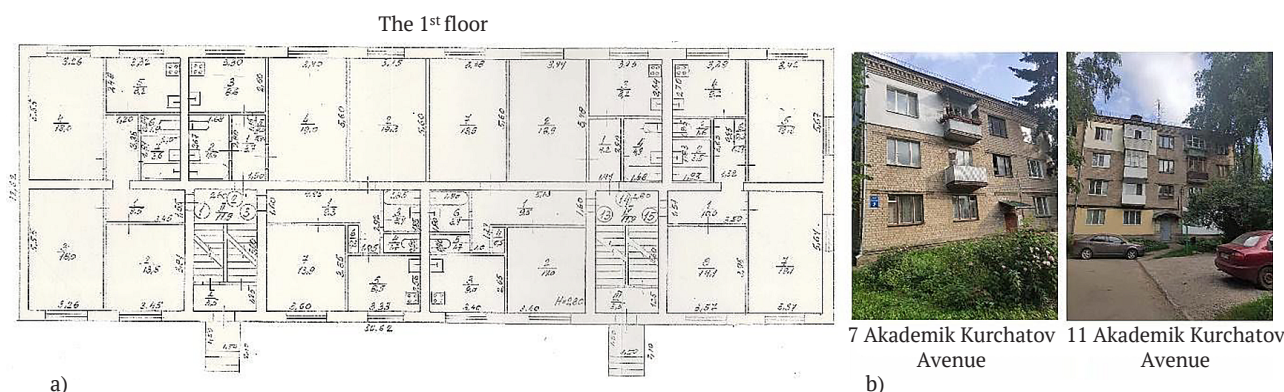


Figure 3. Plan and photos of residential buildings on Akademik Kurchatov Avenue, Piatykhatty

Note: a – plan of the 1st floor of residential buildings on 7 and 11 Akademik Kurchatov Avenue; b – photos of the residential buildings on 7 and 11 Akademik Kurchatov Avenue

Source: Archive of NSC KIPT (1963), photos by the authors

The next phase of development was the construction of Block 2. It was located between Akademik Kurchatov Avenue, Akademik Volkov Street, Akademik Walter Street, and Harkusha Street. By 1963, seven residential buildings and a kindergarten had been completed, while an outbuilding and two residential buildings were under construction, and four residential buildings and an outbuilding were in the design stage. The left half of Block 2 was developed first. As of February 1963, six residential buildings, one dormitory, a kindergarten, and a public-commercial building had been completed. The residential buildings on 13 and 17 Kurchatov Avenue, four stories each, were designed according to series 1-424, and those on 1 and 3 Myru Boulevard, five stories each, followed series 1-438 (project 1-438-9). The dormitory on 6 Volkov Street, three stories, was built according to the standard design 1-251-9. Residential buildings on 2 and 4 Volkov Street, three stories each, followed the standard design 1-258-2. The public and commercial section, three stories, was built according to series 2 on 4 Akademik Walter Street, and the kindergarten on 15 Kurchatov Avenue was designed according to the standard series 2-24-32 (Archive of NSC KIPT, 1963). The buildings in the right half of Block 2, as of February 1963, were either under construction or in the design stage. At the construction stage were residential buildings on 3 Harkusha Street (project 1-438-6) and on 4 Myru Boulevard (project 1-438-9). Six residential buildings and a so-called utility insert or household service facility were planned for this area. As a result, the following were built: a five-story

residential building on 4 Myru Boulevard, project 1-438-9, series 1-438; a five-story residential building on 2 Myru Boulevard, project 1-438-36K, series 1-438A; and later, the nine-story residential building on 21 Akademik Kurchatov Avenue, project 447C-47 (series 1-447C), as well as a food service building, series 2-438U-3-1, 2-438U-3-3 (Archive of NSC KIPT, 1963; PhotoBuildings, n.d.).

The third area to be developed was Block 4, located between Akademik Walter Street, Transportna Street, and Akademik Sinelnikov Street. By 1963, it was more than half built: five residential buildings were constructed along Akademik Walter Street, and six auxiliary buildings were built deeper within the block. The development along Akademik Walter Street consisted of three-story houses. Nine-story building was constructed, specifically, the following buildings were erected: on 17 Akademik Walter Street, three stories – project 1-251-7 (series 1-251); on 15 Akademik Walter Street, three stories – standard project 1-251-9 (series 1-251); on 13 Akademik Walter Street, four stories – project 1-438-4 (series 1-438); on 7 Akademik Walter Street, nine stories – series 87; on 11 Akademik Walter Street, three stories – project 1-251-9 (series 1-251); and on 9 Akademik Walter Street, three stories – project 1-251-7 (series 1-251) (Archive of NSC KIPT, 1963; PhotoBuildings, n.d.). Block 4a included a fire station (planned) and a garage (constructed by 1963). Also, following buildings were added to Block 4a: at 3 Akademik Walter Street, a telecommunications building (formerly ATS No. 335), and at 5 Akademik Walter Street, a residential



building of the 87 series. The fourth area to be developed was Block 1, located between Harkusha Street, Sinelnikov Street, Akademik Walter Street, and Kharkiv Highway. By 1963, plans were in place for the construction of nine residential buildings, a canteen, a children's nursery, a school, workshops, and a sports ground, which were completed in the late 1960s to early 1970s. Specifically, the following buildings were constructed: at 27 Akademik Kurchatov Avenue, five stories – project 1-438-19 (series 1-438); at 25 Akademik Kurchatov Avenue, five stories – project 1-438-9 (series 1-438); at 12 and 10 Akademik Walter Street – projects 1-438-6 and 1-438-6M (series 1-438); at 1 and 3 Akademik Sinelnikov Street (five stories) – project 1-438-16 (series 1-438); at 5 Akademik Sinelnikov Street, five stories – project 1-438-5 (series 1-438); at 25A Akademik Kurchatov Avenue – project 1-438-9; at 10A Akademik Walter Street, five stories – project 1-438-9 (series 1-438); and at 23 Akademik Kurchatov Avenue, a school based on the standard project 2-02-960U.

The territory in the Northeastern part of the district was developed last and was conditionally referred to as Block 5. It was bounded to the Southwest by Akademik Sinelnikov Street, to the southeast by Kharkiv Highway, and was divided by Akademik Walter Street. In the late 1970s and early 1980s, the Eastern-Northern part of the area between Kharkiv Highway, Akademik Sinelnikov Street, and Akademik Walter Street saw the construction of buildings for the Physics and Technology Department of Karazin University, a dormitory, a canteen, and a medical and sanitary unit. The dormitory, with five stories, was built according to project 1-300-2 (series 1-300). On the Northern side of Akademik Walter Street in this block, residential buildings, a store, and a sports ground were constructed. The residential buildings at 19 and 21 Akademik Walter Street, with five stories, were based on project 1U-438A-35K (series 1U-438A), while the building at 19A Akademik Walter Street, with nine stories, was of series 87, and the building at 21A Akademik Walter Street, with five stories, was built according to project 1U-438A-35K (series 1U-438A). In the 1980s, the second phase of construction during the Soviet period began – the design and construction of the Western

part of the settlement, the second stage of development of Piatykhvatky. A master plan was developed, which, unlike the plan for the Eastern part of the settlement, was not fully realised and underwent many modifications. The layout of the Western part was divided into several blocks. In 1987, the graphic part of the architectural and planning task for designing residential Block 2 was released, which was constructed in the late 1980s to early 1990s. According to the master plan, the development of the second stage featured an open layout with residential blocks that were spatially and functionally connected to the social and service facilities of the first and second stages.

According to the "Design proposal for the development of the microdistrict in the Western part of the Piatykhvatky settlement" (Blocks 1 and 2 on Akademik Kurchatov Avenue), it was recommended to use standard designs for residential buildings and other structures, with subsequent site-specific adaptation: 15 residential buildings (standard design No. 87-019/75.2), 24 residential buildings (standard design No. 87-021/75.2), 3 residential buildings (standard design No. 87-094/12), 2 schools (standard design No. 224-1-434.85), a kindergarten-nursery (standard design No. 214-1-285.84), and two swimming pools (standard designs No. 294-3-30 and No. 294-3-37.85). The pools were to be located at the schools and one of the kindergartens-nurseries, which was never built. A large stadium and a vocational-technical school were also planned (Archive of NSC KIPT, 1987; PhotoBuildings, n.d.). In Block 2, the plans included a sports building, a vocational-technical school for 720 students, a thermal distribution point, a dispatch point, public and commercial enterprises according to individual plans, as well as a parking lot and a bus terminal. The design also envisioned a rich green area with coniferous and deciduous trees, shrubs, flowerbeds, climbing plants, and a living hedge. In the end, only part of the planned objects was constructed: nine nine-story residential buildings and one 320-capacity kindergarten-nursery. The remaining facilities were not built, meaning less than 50% of the planned development was realised. The undeveloped areas were used by residents for gardening until a golf club was established during the period of independence (Fig. 4).

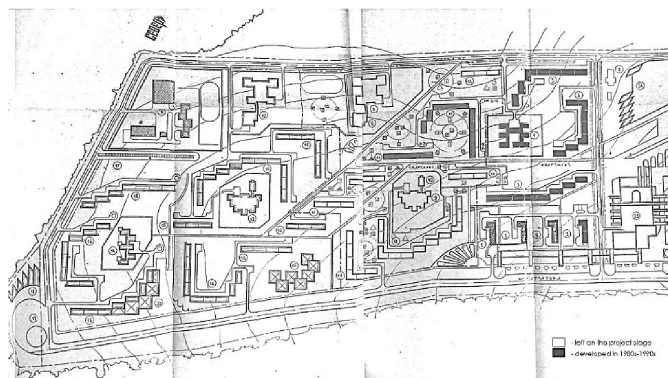


Figure 4. The planned development and the built one, 2nd stage

Note: Piatykhvatky, 1980s-1990s

Source: Archive of NSC KIPT (1987)



The following buildings were eventually constructed and were the typical ones: residential buildings at 4, 6, 8, 8A Akademik Kurchatov Avenue – series 87, sections 87-094 and 87-021; at 10 Akademik Kurchatova Avenue – series 87, sections 87-0120 and 87-019; at 12 Akademik Kurchatov Avenue – series 87, sections 87-021, 87-019, 87-020; at 1, 7, 7A, 7B Gatsev Street – series 87; at 28 Akademik Kurchatov Avenue 28 – series 87, project 114-87-2.75.2; and the kindergarten-nursery at 12A Akademik Kurchatov Avenue 12A – standard project 214-2-72 (Archive of NSC KIPT, 1987). After the collapse of the Soviet Union, funding for science cities was discontinued, forcing them to find alternative methods of operation and financing. As a result, the settlement was not completed as originally planned and, like many other science cities, it went through a crisis during the transitional period. After 1991,

when Ukraine declared its independence, the settlement continued to function as an autonomous residential district of the city, equipped with shops, pharmacies, medical and educational institutions, a library, a gas station, an electric charging station, a fire department, a police station, emergency services, and various household service and equipment repair enterprises. The centre of the settlement remained lively and functionally well-equipped, although abandoned buildings and areas began to appear within the former science city. This primarily concerned the Northeastern part, between the Physics and Technology Faculty of KhNU and Medical Facility No. 13, as well as the Southwestern areas between the newly established golf course in the 2000s and the residential buildings from the second construction phase of the 1980s, including informal residents' allotment gardens (Fig. 5).

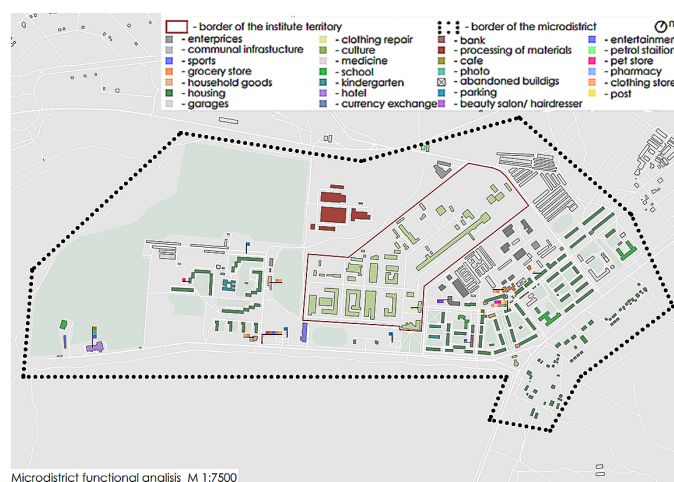


Figure 5. Piatykhatky master plan with functional analysis

Source: developed by the authors

After the outbreak of Russia's full-scale war against Ukraine from 2022, the Piatykhatky suffered significant damage. Buildings at the NSC KPTI, which houses a nuclear facility, were destroyed. While the reactor itself was not damaged, several critical components of the facility were destroyed by the missile shockwave, including the power transformer, which was essential for its continued operation. The residential infrastructure was also affected, with buildings on 7, 11, 19A, 21A Akademik Walter Street, Akademik Kurchatov Avenue, and others being partially destroyed. The Kharkiv specialised school No. 62, located at 23 Akademik Kurchatov Avenue, was partially damaged, as well as were grocery stores and other buildings (Pecherskyi, 2023; Dotsiak, 2023). Thus, the research demonstrated that Piatykhatky was a unique urban formation that reflected key characteristics of a science city: its satellite nature, the presence of a city-forming institution – a large research centre, its enclosed structure, individualised urban planning, a high level of amenities, as well as a harmonious combination of residential, industrial, and recreational infrastructure, which emphasised its state significance and

scientific potential. However, despite the urban uniqueness of Piatykhatky, it predominantly employed standardised designs typical of Soviet construction from the late 1950s to the 1980s. This created a contrast between the innovative status of the science city and the standard approach to architectural objects, reflecting the practical impetus for mass construction in the context of limited resources.

Research on specialised urban formations and science-oriented settlements provided a comparative framework for interpreting the findings of this study. M. Harlov-Csorján & M. Tamáska (2025), in their comparative analysis of Dunaújváros and Paks, showed how technological purpose fundamentally shaped urban structure, reinforcing observation that research-oriented functions were central to Piatykhatky's spatial organisation. K. Stanilov (2007) situated such transformations within broader patterns of postsocialist urban form, supporting the interpretation of historical planning trajectories at Piatykhatky. J. Jaczewska *et al.* (2022) demonstrated how sustainable mobility and densification strategies influenced postsocialist spatial adaptation, which parallels



Piatykhatty's infrastructure distribution. D. Dijokienė & A. Paškauskienė (2022) examined the interaction between urban form, natural environment, and cultural identity, providing a contemporary lens to analyse how Piatykhatty's spatial organisation and design contributed to the city's unique historical and functional identity. S. Berger (2019) emphasised the role of industrial heritage and regional identity in shaping post-industrial urban landscapes, providing insights into Piatykhatty's historical and scientific legacy within Kharkiv's urban context. Scientists V. Kulić *et al.* (2014) discussed the sanctioning of modernist urban forms, highlighting how standardised architectural solutions coexisted with functional specialisation – parallels that were evident in Piatykhatty's combination of research facilities, residential zones, and recreational areas. Socialist new towns as post-utopian urban formations were examined by K. Kissfazekas & M. Benkő (2022), who analysed Dunaújváros as a case of rebranding and symbolic transformation. This theme was expanded in the edited volume by V. Mihaylov & M. Ilchenko (2022), which examined case studies of planned socialist cities in Central Europe and the Balkans undergoing post-socialist transformations. Collectively, these works situated Piatykhatty within an international scholarship on planned scienceoriented urban forms, support findings of this research, and elucidated broader implications for urban regeneration theory and practice.

CONCLUSIONS

Piatykhatty science city was established for KIPT employees and represented a significant monument of Ukrainian scientific culture. Its functional-spatial complex, including social, educational, sports, and transport infrastructure, required thorough analysis and preservation. Piatykhatty represented a unique science city, characterised by its satellite nature, a major research institution, enclosed layout, and integrated infrastructure. Despite its urban distinctiveness, residential and public buildings largely used standardised Soviet designs, highlighting a contrast between the city's scientific significance and practical mass-construction approaches. Ensuring the sustainable

development of 1960s-1980s urban structures required assessing their planning, spatial, and compositional features. While technical upgrades were needed, the city's compositional and spatial elements remained valuable, stable, and worthy of preservation as cultural heritage. After 1991, following the discontinuation of centralised Soviet-era funding for science cities, Piatykhatty was not completed according to the original plan and experienced a crisis, yet it continued to function as an autonomous residential district with an active service core. The settlement's centre remained functionally well-equipped; however, underused areas emerged. In the South-Western sector, some of these areas were subsequently redeveloped for a golf course established in the 2000s, while others were appropriated by residents for informal allotment gardening. Piatykhatty's urban planning offered lessons for modern regeneration, especially in post-industrial and science-driven districts. Its integration of research institutions with residential areas, balanced green spaces, and phased transition from perimeter blocks to open-plan microdistricts illustrated sustainable, flexible urban design. Studying its spatial organisation, street network, and social infrastructure provided strategies for combining scientific, residential, and recreational functions in contemporary urban renewal projects. Future research on Piatykhatty should explore its sustainable development, adaptation to modern environmental and technological standards, preservation of scientific heritage, and its role in fostering high-tech clusters and attracting investment in research and innovation within contemporary urban contexts.

ACKNOWLEDGEMENTS

We express our sincere gratitude to the staff of the NSC KIPT for providing access to archival materials, in particular, Georgiy Yakovlev, Daria Kepova and Iryna Spodenets.

FUNDING

None.

CONFLICT OF INTEREST

None.

REFERENCES

- [1] Antypenko, H., Antonenko, N., & Didenko, K. (2021). Urban transformations of Kharkiv's large housing estates. Novi Budynky and Pavlovo Pole after 1991. *Építés – Építészettudomány*, 50(1-2), 45-63. [doi: 10.1556/096.2021.00017](https://doi.org/10.1556/096.2021.00017).
- [2] Antypenko, H., & Benkő, M. (2022). Architectural and urban transformations of large housing estate related to functional diversification: Case of Kelenföld in Budapest. *Journal of Architecture & Urbanism*, 46(2), 160-170. [doi: 10.3846/jau.2022.17462](https://doi.org/10.3846/jau.2022.17462).
- [3] Archive of NSC KIPT. (1963). Development projects of Piatykhatty settlement (1st stage of construction). *Central State Scientific and Technical Archives of Ukraine*. Retrieved from <https://cdnta.archives.gov.ua/>.
- [4] Archive of NSC KIPT. (1987). Development projects of Piatykhatty settlement (2nd stage of construction). *Central State Scientific and Technical Archives of Ukraine*. Retrieved from <https://cdnta.archives.gov.ua/>.
- [5] Ashykhmin, V., & Stepina, V. (2008). *Establishment of the scientific and production base of the Institute of Solid State Physics Materials Science and Technologies*. *Energy and Electrification*, 12, 51-63.
- [6] Berger, S. (Ed.). (2019). *Constructing industrial pasts: Heritage, historical culture and identity in regions undergoing structural economic transformation*. New York: Berghahn Books.





- [7] Buryak, O., & Vigdorovich, O. (2023). Configuration of urban planning spaces as a subject of protection. Innovative approaches to monuments protection works on the mass industrial development of Kharkiv of the 1960s-1980s. *AIP Conference Proceedings*, 2490(1), article number 030014. doi: [10.1063/5.0123084](https://doi.org/10.1063/5.0123084).
- [8] Communist Party of the Soviet Union. (1956). *20th Congress of the Communist Party of the Soviet Union. 14-25 of February, 1956. Verbatim Report. Volumes 1-2*. M.: State Political Publishing House.
- [9] Dijokienė, D., & Paškauskienė, A. (2022). Identity of historical areas of a city: Interaction between nature and man. *Scientific Journal of Latvia University of Life Sciences and Technologies Landscape Architecture and Art*, 20(20), 7-17. doi: [10.22616/j.landarchart.2022.20.01](https://doi.org/10.22616/j.landarchart.2022.20.01).
- [10] Dotsiak, T. (2023). Kharkiv's Piatykhatty are recovering from the unfortunate shelling. *Fakty ICTV*. Retrieved from <https://www.youtube.com/watch?v=nFYzzLo1JEY>.
- [11] Drėmaitė, M. (2022). Co-operative housing in Lithuania as a field of architectural experimentation (1960s-1980s). *ABE Journal*, 20. doi: [10.4000/abe.13188](https://doi.org/10.4000/abe.13188).
- [12] Drėmaitė, M. (2023). *The role of architects in fighting the monotony of the Lithuanian mass housing estates*. In *Urban planning during socialism* (pp. 134-150). London: Routledge.
- [13] Grinevich, E., Gaevoy, Y., Vyatkin, V., & Karzhinerova, T. (2021). The problems of reconstruction of residential buildings built in the 60s and 70s of the XX century in the city of Kharkiv. *Scientific Bulletin of Construction*, 104(2), 140-146. doi: [10.29295/2311-7257-2021-104-2-140-147](https://doi.org/10.29295/2311-7257-2021-104-2-140-147).
- [14] Hajduková, R., & Sopiřová, A. (2022). Perspectives of post-industrial towns and landscape in Eastern Slovakia – case study Strážske. *Land*, 11(7), article number 1114. doi: [10.3390/land11071114](https://doi.org/10.3390/land11071114).
- [15] Harlov-Csorján, M., & Tamáska, M. (2025). Dunaújváros and Paks: Socialist science and technology cities of Hungary? *Studia Historiae Scientiarum*, 24, 75-103. doi: [10.4467/2543702XSHS.25.004.21842](https://doi.org/10.4467/2543702XSHS.25.004.21842).
- [16] Jaczewska, J., Tarkowski, M., Puzdrakiewicz, K., & Połom, M. (2022). Urban densification and sustainable mobility in a post-socialist city. Reconstruction of the science and business district development in Gdańsk. *Cities*, 127, article number 103739. doi: [10.1016/j.cities.2022.103739](https://doi.org/10.1016/j.cities.2022.103739).
- [17] Kachemtseva, L., Khororian, N., Didenko, K., & Antonenko, N. (2022). Urban planning features of naukogrady (science cities) – centers of innovative activity: The case of Pyatihatky. *Architecture, Civil Engineering, Environment*, 15(1), 19-28. doi: [10.21307/acee-2022-002](https://doi.org/10.21307/acee-2022-002).
- [18] Kissfazezas, K., & Benkő, M. (2022). *Dunaújváros. Transforming and re-branding the largest new town of Hungary's state-socialist era*. In *Post-utopian spaces*. London: Routledge.
- [19] Kulić, V., Parker, T., Penick, M., & Steiner, F. (Eds.). (2014). *Sanctioning modernism: Architecture and the making of postwar identities*. Austin: University of Texas Press.
- [20] Liubimau, S. (2019). *Post-Soviet 'nuclear' towns as multi-scalar infrastructures. Relating sovereignty and urbanity through the perspective of Visaginas*. In T. Tuvikene, W. Sgibnev & C.S. Neugebauer (Eds.), *Post-socialist urban infrastructures* (pp. 90-104). London: Routledge.
- [21] Mažeikienė, N., & Gerulaitienė, E. (2022). Negotiating post-nuclear identities through tourism development in the 'atomic town' Visaginas. *Journal of Baltic Studies*, 53(3), 437-457. doi: [10.1080/01629778.2022.2092163](https://doi.org/10.1080/01629778.2022.2092163).
- [22] Mihaylov, V., & Ilchenko, M. (Eds.). (2022). *Post utopian spaces: Transforming and re-evaluating urban icons of socialist modernism*. London: Routledge. doi: [10.4324/9781003260769](https://doi.org/10.4324/9781003260769).
- [23] Pecherskyi, A. (2023). By shelling Kharkiv's Piatykhatty, the russians deliberately ignored the danger of radioactive contamination. *Army Inform*. Retrieved from <https://armyinform.com.ua/2023/06/14/obstrilyuyuchy-harkivski-pyatyhatky-rosiyany-svidomo-ignoruly-nebezpeku-radioaktyvnogo-zabrudnennya/>.
- [24] PhotoBuildings. (n.d.). Retrieved from <https://photobuildings.com/cities/70/>.
- [25] Remizova, O., & Bozhko, K. (2025). Processes of ruinisation and revitalisation: Kharkiv industrial architecture in the modernist era. *Docomomo Journal*, 74, 59-68. doi: [10.52200/docomomo.74.06](https://doi.org/10.52200/docomomo.74.06).
- [26] Serhiuk, I., & Kalakoski, I. (2023). Demolition or adaptation?: Post-industrial buildings in Ukraine. *Buildings & Cities*, 4(1), 352-368. doi: [10.5334/bc.307](https://doi.org/10.5334/bc.307).
- [27] Shevchenko, L. (2022). Mass housing in Ukraine in the second half of the 20th century. *Docomomo Journal*, 67, 72-79. doi: [10.52200/docomomo.67.08](https://doi.org/10.52200/docomomo.67.08).
- [28] Stanilov, K. (Ed.). (2007). *The postsocialist city. Urban form and transformations in Central and Eastern Europe after socialism*. Dordrecht: Springer. doi: [10.1007/978-1-4020-6053-3](https://doi.org/10.1007/978-1-4020-6053-3).
- [29] The Declaration of Helsinki. (2013). Retrieved from <https://www.wma.net/policies-post/wma-declaration-of-helsinki/>.
- [30] Tolok, V. (2004). *Physics and Kharkiv*. *Physical Surface Engineering*, 2(4), 229-243.
- [31] Wendland, A.V. (2020). Ukrainian memory spaces and nuclear technology: The musealization of Chornobyl's disaster. *Technology and Culture*, 61(4), 1162-1177. doi: [10.1353/tech.2020.0116](https://doi.org/10.1353/tech.2020.0116).



Катерина Діденко

Кандидат архітектури, доцент

Вільнюський технічний університет Гедиміна

LT-10223, алея Саулетекіо, 11, м. Вільнюс, Литва

Харківський національний університет міського господарства імені О.М. Бекетова

61002, вул. Чорноглазівська, 17, м. Харків, Україна

<https://orcid.org/0000-0003-2567-686X>

Ольга Вигдорович

Кандидат архітектури, доцент

Харківський національний університет міського господарства імені О.М. Бекетова

61002, вул. Чорноглазівська, 17, м. Харків, Україна

<https://orcid.org/0000-0001-6461-2792>

Типові проєкти для нетипових містобудівних утворень: наукоград П'ятихатки

Анотація. Наукогради як спеціалізовані науково-виробничі комплекси були унікальним явищем радянського містобудування, сформованим у 1950-1980-х роках. Ці поселення проєктувалися з метою створення оптимальних умов для діяльності наукових установ і комфортного проживання їхніх працівників. Одним із яскравих прикладів такого утворення був наукоград П'ятихатки у Харкові, створений для забезпечення функціонування Харківського фізико-технічного інституту. Метою цієї статті стало дослідження архітектурної та містобудівної еволюції наукограда П'ятихатки у Харкові шляхом визначення етапів його розвитку та аналізу унікальних і стандартизованих рис на містобудівному рівні та на рівні окремих будівель. Результати дослідження показали, що територія П'ятихаток продемонструвала ключові характеристики класичного наукограда: супутникове розташування, закриту структуру, індивідуальне генеральне планування, високий рівень озеленення, а також збалансоване поєднання житлової, виробничої та рекреаційної інфраструктури. Ці риси підкреслили наукові й державні пріоритети, закладені в основу його формування. Водночас архітектурна складова району відображала характерні риси масового будівництва відповідної епохи, що проявлялися у використанні типових проєктів житлових і громадських будівель. Таке поєднання унікального містобудівного статусу та типової забудови сформувало контраст і продемонструвало прагматичний підхід до архітектурних рішень в умовах обмежених ресурсів. Особливий інтерес становило дослідження функціонально-просторового комплексу П'ятихаток, який охоплював соціальні, освітні, спортивні та транспортні елементи, а також аналіз його потенціалу як об'єкта культурної спадщини. Проведене дослідження підкреслило необхідність модернізації застарілої інфраструктури з одночасним збереженням цінних просторових і композиційних рішень, що й надалі формують елементи міського середовища

Ключові слова: науково орієнтоване поселення; моноіндустріальне місто; пострадянська забудована спадщина; унікальна містобудівна структура; типовий проєкт

UDC 721, 72.023, 624:016
DOI: 10.56318/as/4.2025.76

ISSN: 2411-801X
e-ISSN: 2786-7374

Mykola Bevz*

Doctor of Architecture, Professor
Lublin University of Technology
00-511, 31 Nowogrodzka Str., Warsaw, Poland
Lviv Polytechnic National University
79013, 12 Stepan Bandera Str., Lviv, Ukraine
<https://orcid.org/0000-0003-1513-7045>

Maryna Bordun

PhD, Associate Professor
Ukrainian State University of Science and Technologies
49010, 2 Lazaryan Str., Dnipro, Ukraine
Prydniprovsk State Academy of Civil Engineering and Architecture
49005, 24A Architect Oleh Petrov Str., Dnipro, Ukraine
<https://orcid.org/0000-0002-8539-2423>

Svitlana Shekhorkina

Doctor of Technical Sciences, Professor
Ukrainian State University of Science and Technologies
49010, 2 Lazaryan Str., Dnipro, Ukraine
Prydniprovsk State Academy of Civil Engineering and Architecture
49005, 24A Architect Oleh Petrov Str., Dnipro, Ukraine
<https://orcid.org/0000-0002-7799-2250>

Iryna Merylova

PhD in Architecture, Associate Professor
Ukrainian State University of Science and Technologies
49010, 2 Lazaryan Str., Dnipro, Ukraine
Prydniprovsk State Academy of Civil Engineering and Architecture
49005, 24A Architect Oleh Petrov Str., Dnipro, Ukraine
<https://orcid.org/0000-0001-5375-1359>

A sustainable, energy-efficient and eco-friendly wall system for building applications in Ukraine

Abstract. In response to global environmental challenges and the growing demand for energy-efficient solutions in the construction sector, the search for environmentally safe structural systems with a minimal carbon footprint had become increasingly relevant. This study aimed to develop and analyse an external wall enclosure system made of ecological materials, considering its thermal and hygrothermal performance, as well as assessing its environmental impact in terms of carbon footprint. The research results demonstrated that the proposed structure, based on a cross-laminated timber panel with insulation made from grass mats, had a thermal resistance of 4.9 m²·K/W, complying with current building code requirements. The hygrothermal analysis confirmed the internal stability of the wall assembly and the absence of condensation in the coldest month of the year – January (for city Dnipro). The calculated carbon footprint amounted to

Suggested Citation:

Bevz, M., Bordun, M., Shekhorkina, S., & Merylova, I. (2025). A sustainable, energy-efficient and eco-friendly wall system for building applications in Ukraine. *Architectural Studies*, 11(4), 76-90. doi: 10.56318/as/4.2025.76.

Journal homepage: <https://arch-studies.com.ua/en>

Architectural Studies, 11(4), 76-90

Received: 18.06.2025 Revised: 10.11.2025 Accepted: 19.12.2025 Published: 29.12.2025

*Corresponding author



Copyright © The Author(s). This is an open access article distributed under the terms of the Creative Commons Attribution License 4.0 (<https://creativecommons.org/licenses/by/4.0/>)



-23.6 kgCO₂-eq/m², indicating the carbon-negative nature of the system due to the use of bio-based materials capable of sequestering carbon throughout their life cycle. Additionally, the obtained indicators were compared with those of the most common building envelope design solutions, confirming the advantages of the proposed structure. Furthermore, a pilot architectural concept of a rehabilitation centre was developed, demonstrating the practical application of sustainable construction strategies based on the offered solution. The practical significance of this study lies in the potential integration of the developed wall design into the construction of modern buildings with enhanced energy efficiency and environmental performance. This aligns with the principles of sustainable development and contributes to reducing the climate impact of the building sector

Keywords: energy-efficient architecture; wall construction; hydrothermal analysis; bio-based insulation; CLT panels; post-war reconstruction

INTRODUCTION

Global environmental issues have become increasingly evident – air pollution, ozone layer depletion, global warming, glacier melting, ocean contamination, river eutrophication, biodiversity loss, among others. Each of these phenomena was defined and driven by human activity, particularly by the intensive development of industry to meet societal needs. These factors not only impact the natural environment but also directly affect every individual. The construction sector held significant potential in contributing to sustainable development. In 2019, the World Green Building Council (n.d.) estimated that the building sector accounted for 39% of global carbon emissions, with 28% attributed to operational stages (energy consumption for heating and cooling) and 11% resulting from materials and construction processes. According to a study by C. Li *et al.* (2025), under a business-as-usual scenario, construction emissions were projected to more than double by 2050. The challenges posed by global climate change have stimulated new initiatives aimed at preserving and protecting the environment. One such initiative was the European Green Deal, which sought to achieve climate neutrality within the European Union by 2050. For example, in the study G. Ottomano Palmisano *et al.* (2025), eight key areas of the European Green Deal were considered, which involved all the main sectors of the EU economy, including the building sector. This strategy envisions achieving near-zero greenhouse gas emissions by 2050 and fostering economic growth without increasing resource consumption. Meeting these goals was possible through the implementation of innovative construction solutions focused on the sustainable and efficient use of natural resources, transitioning away from non-renewable raw materials, and promoting the adoption of ‘green’ materials and products, as well as energy-saving measures. Such approaches can significantly reduce the consumption of non-renewable resources, lower greenhouse gas emissions, and enhance both the quality and longevity of human life.

Modern sustainability requirements have led to a growing interest in innovative building systems and technologies that promoted the adoption of resource-efficient and environmentally friendly solutions in the construction industry. J. Švajlenka & T. Pošiváková (2023) observed a notable resurgence of interest in wood as a structural

material within the construction sector. This trend was largely driven by advancements in engineered wood products, particularly in the domain of mass timber. M. Schubert *et al.* (2022) highlighted cross-laminated timber (CLT) as the most prominent innovation, alongside the well-established glued laminated timber (glulam). CLT had revolutionised the global building industry, positioning wood – a renewable and readily available natural resource – as a viable choice for the construction of environmentally responsible buildings. This shift in material and technological preferences was primarily motivated by the growing awareness of the environmental impact associated with the concrete and steel industries. O.A. Hegeir *et al.* (2022) demonstrated that timber had a significantly lower environmental impact than reinforced concrete and steel, largely due to the carbon stored in the wood. P. Chen *et al.* (2023) noted that despite their pivotal role in shaping modern urban environments, steel and concrete were associated with high energy consumption and substantial carbon emissions. X. Fang *et al.* (2023) contended that timber-based construction was gaining prominence as a sustainable alternative, driven by escalating environmental concerns and rapid urbanisation.

Thermal insulation systems and materials played a crucial role in the path toward carbon-neutral buildings. The proper selection of insulation materials was essential for ensuring the sustainability of construction projects. It affected not only a building's energy efficiency but also its overall environmental footprint. M. Röck *et al.* (2020) demonstrated that inadequate or absent insulation results in elevated energy demanded for heating and cooling, consequently leading to increased greenhouse gas emissions throughout a building's operational life cycle, which typically exceeded 50 years for standard residential structures. S.M.H. Castro *et al.* (2025) analysed different thermal materials and identified that prevalent synthetic insulation presented challenges, mineral wool was heavy and linked to health concerns, and common petrochemical foams (EPS, XPS, PU) required high production energy, were brittle, and present significant fire hazards. Conventional insulation materials (such as mineral wool and polystyrene-based foams) had an excessive carbon footprint due to the embodied energy in raw material extraction and manufacturing. However, according to research by F. Ye *et al.* (2025),





bio-based insulation materials – including grass-based insulation, cork, straw, mycelium-based insulation (derived from fungal root structures), and hemp fiber boards, as well as recycled wood fiber products – can have a low or even negative carbon footprint. This was because it absorbed CO₂, while growing and required less energy to manufacture than traditional materials. The study by M. Babenko *et al.* (2025) showed that an innovative material, combining mycelium and agricultural waste, was a thermally efficient alternative to traditional insulation materials, such as rock and glass mineral wool, in key sustainability metrics. O. Ranefj rd *et al.* (2024) experimentally demonstrated the high thermal insulation properties of bio-based insulation materials such as eelgrass, grass, and wood fibre. The aim of this research was to develop and theoretically substantiate a structural solution for an energy-efficient building envelope composed of environmentally friendly materials, through a comprehensive analysis of its thermal performance and an assessment of its life-cycle carbon footprint.

MATERIALS AND METHODS

To assess the energy efficiency of building envelope design solutions incorporating ecological natural materials – specifically, CLT panels made of glued multi-layered wood with crosswise lamination, and environmentally-friendly grass-based insulation – the thermal and hygrothermal parameters of an opaque wall envelope structure were examined. The analysis also considered thermal bridges in the form of metallic fasteners. The Ukrainian national building code DBN V.2.6-31:2021 (2023) established the requirements for energy performance indicators of buildings, including thermal characteristics of envelope structures (the thermal insulation envelope) during the design and construction stages. This standard aimed to ensure normative sanitary and hygienic indoor climate conditions and the long-term durability of building enveloped during operation. In accordance with this standard, external envelope structures of buildings that were heated and/or cooled must comply with the requirements presented in equations (1), (2), and (3). The thermal performance of the proposed envelope was evaluated by comparing its calculated thermal parameters with established normative values for enclosing structures, using these equations. The first requirement dealt with the thermal resistance of the envelope structure:

$$R_{\Sigma pr} \geq R_{qmin}, \quad (1)$$

where $R_{\Sigma pr}$ – equivalent thermal resistance of the opaque envelope structure or its opaque section, in m²·K/W; R_{qmin} – minimum permissible value of the equivalent thermal resistance of the opaque envelope structure or its opaque section, in m²·K/W.

The second requirement concerns the difference between the indoor air temperature and the reduced temperature of the inner surface of the envelope structure:

$$\Delta Q_{int-si} \leq Q_{int-si,max}, \quad (2)$$

where ΔQ_{int-si} – difference between the indoor air temperature and the reduced temperature of the inner surface of the envelope structure measured along internal dimensions, in °C; $Q_{int-si,max}$ – maximum permissible difference, according to sanitary and hygienic standards, between the indoor air temperature and the reduced temperature of the inner surface of the envelope structure, in °C.

The third requirement set the minimum temperature of the inner surface in zones with thermal bridges in the envelope structure, which must be above the dew point:

$$\theta_{tb,si,min} > \theta_{si,min}, \quad (3)$$

where $\theta_{tb,si,min}$ – minimum temperature of the inner surface in zones with thermal bridges in the envelope structure, in °C; $\theta_{si,min}$ – minimum allowable temperature of the inner surface under design indoor and outdoor air temperatures, in °C.

The calculation of thermal performance indicators, as well as the modeling of temperature distribution and heat flux in the wall structure, was carried out under steady-state heat transfer conditions using the methodology implemented in the Physibel software suite (DSTU 9191:2022, 2023). Physibel was a software package designed for engineering analysis and two-dimensional and three-dimensional modelling based on the finite element method. Computer-based modelling and numerical analysis in construction allow engineers to avoid costly and time-consuming physical testing, while also accelerating, supplementing, and visualising the design and development process. To investigate the hygrothermal condition of the wall envelope structure, an analysis of water vapour diffusion was conducted for the coldest month of the year – January (for city Dnipro), based on the methodology outlined in Physibel (n.d.). The calculation of the hygrothermal state of the wall was performed under steady-state vapour diffusion conditions using a graphical-analytical method (DSTU-B V.2.6-192:2013, 2014). The following assumptions were adopted: the structure was flat and thermally homogeneous; the vapour transfer resistances of the inner and outer surfaces of the structure were assumed to be zero; and within each homogeneous layer of the structure, the partial pressure of saturated water vapour varies according to a nonlinear (curvilinear) law. The vapour diffusion resistances of each layer R_{ex} and of the entire structure $R_{e\Sigma}$ were determined using the following formulas:

$$R_{e\Sigma} = \sum_{j=1}^n \frac{d_j}{\mu_j}, \quad (4)$$

$$R_{ex} = \sum_{j=1}^n \frac{d_j}{\mu_j} + \frac{\chi - \sum_{j=1}^m d_j}{\mu_{(m+1)}}, \quad (5)$$

where n – total number of layers in the construction; m – number of full layers from the inner surface to the section at distance χ ; d_j – thickness of the j -th layer, in meters (m); χ – distance from the inner surface of the envelope to the reference section, in meters (m); μ_j – vapour diffusion coefficient of the j -th layer material, in mg/(m·h·Pa); $\mu_{(m+1)}$ – vapour diffusion coefficient of the



material, in which the reference section χ was located, in $\text{mg}/(\text{m} \cdot \text{h} \cdot \text{Pa})$.

The partial vapour pressure for the internal e_{int} and external e_{ext} surfaces of the wall structure, Pa, was determined by the formulas:

$$e_{int} = 0.01 \cdot \varphi_{int} \cdot E_{int-surf}; \quad (6)$$

$$e_{ext} = 0.01 \cdot \varphi_{ext} \cdot E_{ext-surf}, \quad (7)$$

where φ_{int} – relative humidity of internal air, in percent (%); $E_{int-surf}$ – partial pressure of saturated water vapour

at the internal surface of the building envelope, in Pascal (Pa); φ_{ext} – monthly average relative humidity of external air, in percent (%); $E_{ext-surf}$ – partial pressure of saturated water vapour at the external surface of the building envelope, in Pascal (Pa).

The assessment of the environmental impact of construction products, buildings, and structures was carried out in accordance with the EN 15978:2011 (2011) (Table 1). The quantitative indicator of environmental impact was the carbon footprint, which represented the total amount of greenhouse gases emitted directly or indirectly throughout the entire life cycle of building materials and products.

Table 1. Stages and informational modules of the building life cycle

Building assessment information														
Life cycle information modules														
Product stage			Construction stage		Use stage					End-of-life stage				Additional information beyond the life cycle
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	C1	C2	C3	C4	D
Raw material extraction	Transportation	Material production	Transportation	Construction and installation works	Operation	Maintenance	Repair	Restoration	Replacement	Deconstruction	Transportation	Recycling	Waste disposal	Post-life cycle benefits
					B6	Energy use								Recycling reuse
					B7	Water use								

Source: EN 15978:2011 (2011)

The integral measure of a building's carbon footprint was the Global Warming Potential (GWP), expressed in terms of carbon dioxide equivalent (CO_2 -eq), measured in kilograms of CO_2 -equivalent (kgCO_2 -eq). In environmental assessments, the life cycle was divided into four main stages (informational modules A to C). Additionally, the potential impacts beyond the life cycle boundaries were assessed separately (informational module D). Module A described the pre-use stage, i.e., emissions during the product manufacturing and construction processes. For convenience in assessment, this module was divided into submodules: A1-A3 – extraction and supply of raw materials, production of building materials, products, and industrial structures; A4-A5 – transportation to the construction site and construction works. Module B included 7 submodules corresponding to the operational stage (B1), including maintenance (B2), ongoing or capital repairs (B3), restoration or reconstruction (B4), partial or full replacement (B5), as well as energy (B6) and water (B7) use for ancillary processes (e.g., lighting adjacent areas, lawns, irrigation systems). Module C described the end-of-life stage and was divided into 4 submodules: demolition (C1), transportation of waste from the site to recycling or disposal (C2), recycling (C3), and disposal (C4) of waste. Module D reflected possible environmental impacts beyond the life cycle of the object. This module included the benefits of reusing or recycling

materials from dismantled structures. The term 'benefits' here referred to the potential reduction of emissions due to converting waste into building or energy raw materials, thus reducing the need for extraction from natural environments. In the case of plant-based materials (wood or grass), additional benefits included the effective 'locking' of greenhouse gases in the elements of the architectural and building environment due to natural processes of carbon absorption and retention from the atmosphere during growth, known as carbon sequestration (Bjånesøy et al., 2023). The methodological basis for determining the GWP was the Environmental Product Declarations (EPD) (International EPD System, n.d.), which provided information about the characteristic values of CO_2 -equivalent emissions across the stages of the product life cycle, based on data obtained from research results using a standardised method. The general model for calculating the GWP in the form of CO_2 -equivalent was as follows:

$$GWP_{life-cycle} = \sum GWP_{i,stage}, \quad (8)$$

where $GWP_{i,stage}$ – the GWP indicator for stage i of the life cycle according to the information modules. The calculation of the global warming potential for a specific stage was reduced to summing up the CO_2 emissions for each element of the building object or structure:



$$GWP_{i,stage} = \sum_{i=1}^n GWP_{i,element} \cdot Q_{i,element}, \quad (9)$$

where n – number of elements; $Q_{i,element}$ – quantitative characteristic of the element; $GWP_{i,element}$ – characteristic value of CO₂-equivalent emissions for the i -th element.

So, the assessment of the carbon footprint of the building envelope construction included the following stages: description of the geometric parameters of the building envelope elements; inventory of materials by elements of the building envelope; determination of the material consumption for each type per 1 m² of surface area; systematisation of characteristic CO₂-equivalent emissions values across the life cycle stages based on the EPD; calculation and comparative analysis of the GWP of the proposed building envelope construction with existing solutions.

RESULTS

The building envelope design solution incorporated ecological natural materials, including CLT panels composed of glued multi-layered wood with crosswise lamination and environmentally-friendly grass-based

insulation, so computer model of the wall structure was analysed to assess the performance of the proposed design. The obtained results characterised the key thermal and hygrothermal parameters of the building envelope, including the thermal transmittance resistance with consideration of thermal bridges, the heat flux along the internal contour of the wall, the temperature of the internal wall surface, and the temperature distribution profile across the thickness of the wall structure. For the calculation of the thermal parameters of the building envelope wall construction using ecological materials, the following initial data were adopted: 1) external air temperature: $\theta_{ext} = -4.7^{\circ}\text{C}$ – the average value for January in the city of Dnipro, corresponding to 268.3 K (DSTU-N B V.1.1-27:2010, 2011); 2) internal air temperature $\theta_{int} = +20^{\circ}\text{C}$, corresponding to 293 K (World Green Building Council, n.d.); 3) calculation values of the heat transfer coefficients for the internal h_{si} and external h_{se} surfaces of the building envelope. The technical characteristics and thicknesses of the layers of the considered building envelope construction were presented in Figure 1.

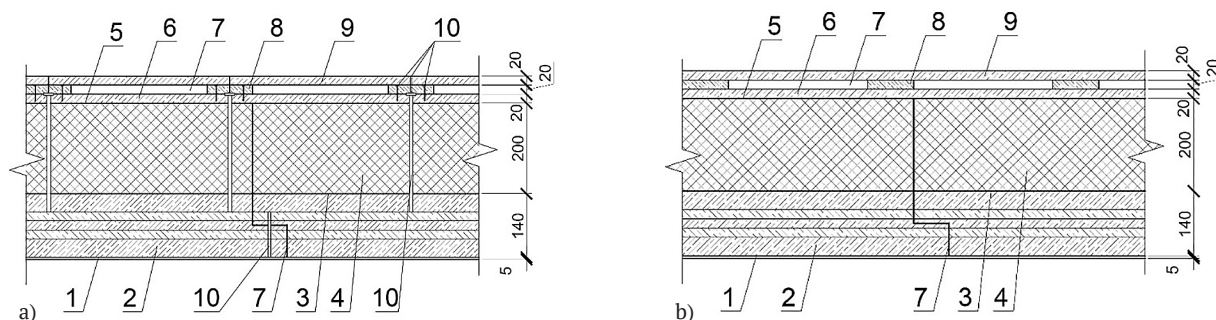


Figure 1. Cross-section diagram of the external enclosing wall structure with identification of layers, components, and their technical characteristics

Note: a – cross-section of the wall structure at the location of thermal bridges; b – cross-section of the wall structure at the location without thermal bridges: 1 – painted MDF panel, $d=0.005$ m, $\lambda=0.19$ W/K·m; 2 – CLT panel, $d=0.14$ m, $\lambda=0.19$ W/K·m; 3 – vapour barrier film (not considered); 4 – insulation with grass mats, $d=0.2$ m, $\lambda=0.04$ W/K·m; 5 – wind and water barrier (not considered); 6 – vertical wooden beam 100x20 mm, $d=0.02$ m, $\lambda=0.35$ W/K·m; 7 – air gap between wooden facade elements, $d=0.04$ m; 8 – horizontal wooden beam 100x20 mm, $d=0.02$ m, $\lambda=0.35$ W/K·m; 9 – wooden facade board, $d=0.02$ m, $\lambda=0.35$ W/K·m; 10 – metal fasteners, $d=0.001$ m, $\lambda=58$ W/K·m

Source: developed by the authors

For a detailed analysis of key thermal performance indicators, two scenarios were examined: a cross-section at a thermal bridge location, where heat loss was intensified (Fig. 1, a), and a cross-section in a homogeneous area without thermal bridges, representing the baseline wall structure (Fig. 1, b). As a result of the simulation, a two-dimensional temperature distribution across the entire wall assembly was generated (Fig. 2). This visualisation illustrated the temperature gradients within the structure, identified areas, where temperature decreased due to the influence of thermal bridges, and provided the corresponding numerical temperature values. The simulation results also provided quantitative

data, including the heat flux density along the internal wall contour and the minimum temperature on the internal wall surface, which were critical for assessing condensation risk. The temperature variation profile across the thickness of the wall structure was presented in Figure 3. The simulation results showed a stable temperature gradient from 292 K (19°C) on the interior surface to 269 K (-4°C) on the exterior surface, with a total temperature difference of 23 K. The temperature decreased gradually across the wall thickness, with the most significant drop observed in the external zone (300-400 mm). The internal surface temperature remained well above the dew point, indicating a minimal risk of condensation.

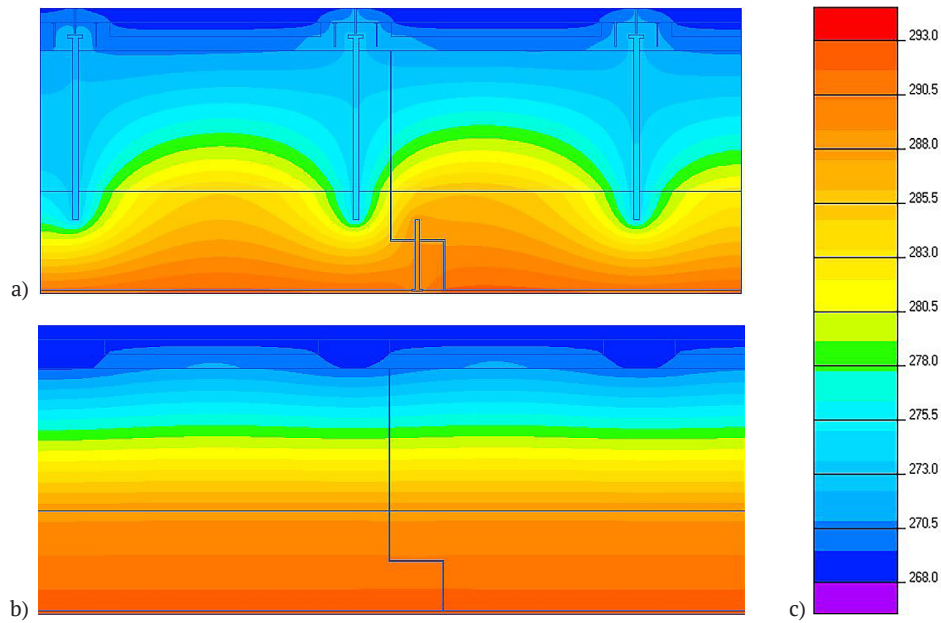


Figure 2. Temperature distribution within the wall structure

Note: a – cross-section of the wall structure at the location of thermal bridges; b – cross-section of the wall structure without thermal bridges; c – temperature on the wall surface

Source: developed by the authors

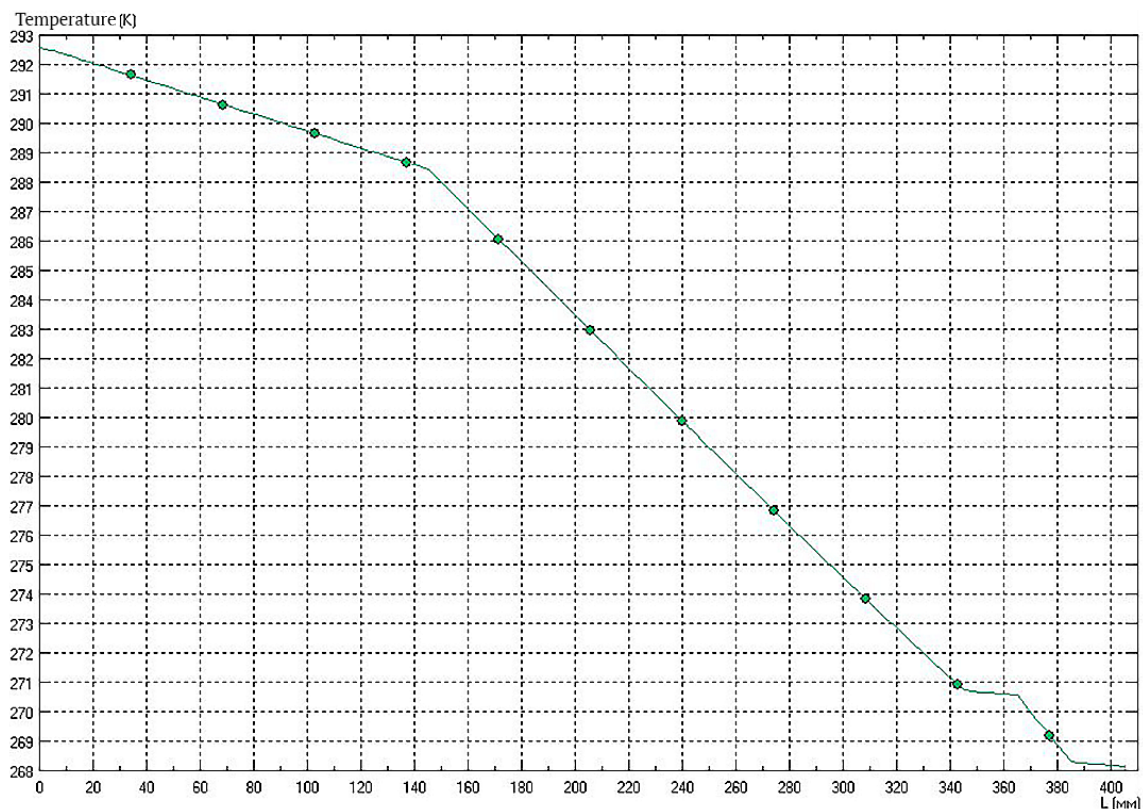


Figure 3. Temperature distribution across the wall structure thickness for January

Source: developed by the authors

The thermal transmittance resistance of the building envelope structure, denoted as the equivalent thermal resistance $R_{\Sigma pr}$ was determined in accordance with, taking

into account point thermal bridges formed by metal fasteners penetrating the insulation layer and the CLT wall panel (DSTU 9191:2022, 2023). Each metal fastener had a thickness





of 8 mm and a length of 260 mm, connecting the façade finishing elements to the wall panel. According to the adopted technical solution, four metal fasteners per 1 m² of the wall

envelope were considered. The calculated equivalent thermal resistance was $R_{spr} = 4.9 \text{ m}^2\text{K/W}$. The results of the thermal performance calculations were presented in Table 2.

Table 2. Thermal performance characteristics of the external wall envelope structure

Indicator	Values for the wall cross-section with thermal bridging elements	Values for the wall cross-section without thermal bridging elements
Average temperature of the internal surface of the structure, $\theta_{int-surf}$, K	291.6	292.7
Minimum temperature on the internal surface of the structure, $\theta_{th,si,min}$, K	290.54	292.56
Temperature difference on the internal surface of the structure, $\Delta\theta_{int-surf}$, K	0.74	0.002
Heat flux, q , W/m ²	11.92	3.75

Source: developed by the authors

The comparative analysis of thermal performance indicators showed clear differences between the wall sections with and without thermal bridging elements. The homogeneous section maintained a higher average surface temperature (292.57 K) than the thermally bridged section (291.60 K). A difference was also observed in the minimum surface temperatures: 292.56 K for the homogeneous section versus 290.54 K for the thermally bridged section,

indicating a 2.02 K reduction. The heat flux in the thermally bridged area reached 11.92 W/m², while in the homogeneous section it was only 3.75 W/m², clearly demonstrating the substantially increased energy losses caused by thermal bridges. Nevertheless, all obtained values remained within the permissible limits. The calculated thermal parameters were compared with established normative values, and the results were presented in Table 3.

Table 3. Analysis of thermal performance of the external enclosure wall made of ecological natural materials

Designation of the construction	R_{pr} , m ² ·K/W	R_{qmin} , m ² ·K/W	ΔQ_{int-si} , °C	$Q_{int-si,max}$, °C	$\theta_{th,si,min}$, °C	$\theta_{si,min}$, °C
Section of the wall construction at the location of heat-conductive inclusions	4.9	4.0	1.4	4.0	17.54	10.7
Section of the wall construction at the location without heat-conductive inclusions	6.3	4.0	0.4	4.0	19.56	10.7

Source: developed by the authors

The analysis of the calculation results confirmed that the proposed design solution for the building wall enclosure structure met the necessary conditions established by the national standard (DBN V.2.6-31:2021, 2023). However, it should be noted that at the locations of the metal connections between the elements of the enclosure structure, heat losses were more intense, leading to a decrease in the overall thermal resistance of the structure. For the calculation of the thermal-moisture state of the wall enclosure structure, the

following initial data were used: 1) monthly average relative humidity of external air in January for Dnipro city: $\varphi_{ext} = 86\%$ (DSTU-N B V.1.1-27:2010, 2011); 2) relative humidity of internal air: $\varphi_{int} = 55\%$ (DBN V.2.6-31:2021, 2023). Elements of the wall structure, such as the external finish with wooden facade boards and wooden beams for fastening the external finish, were not included in this calculation as it was in contact with external air. The results of the vapour permeability resistance calculation were presented in Table 4.

Table 4. Vapour permeability resistance of the wall enclosure structure

Layer of the wall enclosure structure	Layer thickness, d_p , m	Vapour permeability coefficient μ_p , mg/m·h·Pa	Vapour permeability resistance, R_e , (m ² ·h·Pa)/mg
Laminated MDF panel	0.005	0.4	0.0125
CLT wall panel	0.14	0.3	0.47
Vapour barrier film	0.00016	0.000022	7.27
Insulation – grass mats	0.2	2	0.1
R_{ex}			7.85

Note: MDF – medium-density fibreboard

Source: developed by the authors

So, it was indicated that the wall enclosure structure had a total vapour permeability resistance of $R_{ex} = 7.85 \text{ (m}^2\text{·h·Pa)/mg}$, indicating a high level of vapour resistance. The vapour barrier film provided the

dominant contribution ($R_e = 7.27$), accounting for more than 90% of the total resistance. The CLT wall panel offers moderate vapour resistance, while the laminated MDF panel and grass mat insulation were highly



vapour-permeable layers. Overall, the vapour resistance was correctly concentrated on the warm side of the structure, which was favourable for moisture protection. The temperature distribution across the thickness of the structure was adopted according to Figure 4. The saturated vapour pressure on the internal E_{int} and external E_{ext} surfaces of the enclosure structure, Pa, and the

distribution of the partial saturated vapour pressure across the thickness of the structure E_x , based on the temperature distribution at the boundary of each layer, was presented in Table 5. For constructing the distribution curve E_x , 11 points per 1°C temperature gradient across the layer thickness were used in the calculation, in accordance with the requirements of Physibel (n.d.).

Table 5. Values of temperature and partial saturated vapour pressure at the boundary of each layer of the wall structure

Temperature at the boundaries of the wall structure layers, θ_p , °C	Partial vapour pressure E, Pa
$\theta_{int-surf} = 19.6$	$E_{int-surf} = 2,283$
$\theta_1 = 19.45$	$E_1 = 2,261$
$\theta_2 = 15.5$	$E_2 = 1,762$
$\theta_3 = 15.5$	$E_3 = 1,762$
$\theta_{ext-surf} = -2.4$	$E_{ext-surf} = 501$

Source: developed by the authors

So, the temperature gradually decreased from the internal to the external surface of the wall, with the most pronounced drop occurring in the outer part of the structure. This temperature reduction led to a corresponding continuous decrease in partial vapour pressure across the wall thickness. The vapour pressure gradient was directed from the interior toward the exterior, which confirmed outward vapour diffusion under heating conditions. In the middle layers, both temperature and vapour pressure remained nearly constant, indicating similar thermal and

vapour diffusion properties of these layers. Based on the temperature-dependent saturated vapour pressure distribution, the partial vapour pressure does not exceed the saturated vapour pressure at any layer boundary. Therefore, the wall structure can be considered resistant to interstitial condensation under the given conditions. The partial vapour pressures for the internal and external surfaces of the wall structure were: $e_{int} = 1,256 \text{ Pa}$ and $e_{ext} = 431 \text{ Pa}$, respectively. The distribution of partial pressures across the thickness of the wall structure was presented in Figure 4.

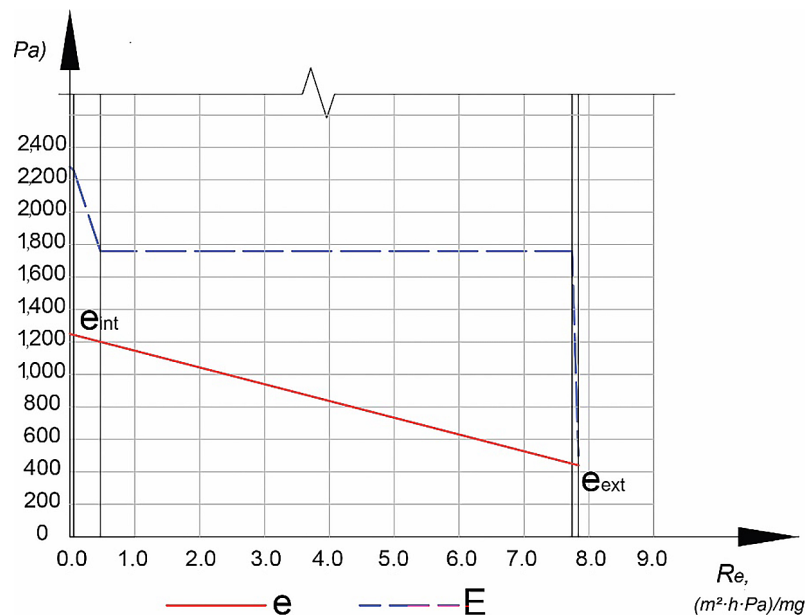


Figure 4. Distribution of partial pressures across the thickness of the wall structure

Source: developed by the authors

According to the distribution of partial pressures in Figure 4, it was established that in this design of the external wall structure, made from wooden CLT panels and insulation from grass mats, condensation of water vapour does not occur. The next step was to justify the proposed

solution from the standpoint of environmental impact. For this purpose, an inventory of the wall construction components was carried out and, based on the geometric parameters, the material consumption per 1 m² was determined, as shown in Table 6.



Table 6. Inventory results, geometric parameters and material consumption per 1 m² of external wall surface area

No.	Material name	Geometric parameters	Consumption per 1 m ² surface area
1	Painted MDF panel	t = 5 mm	0.005 m ³
2	CLT panel	t = 140 mm	0.14 m ³
3	Vapour barrier film	not considered	
4	Insulation – grass mats	t = 200 mm	0.2 m ³
5	Wind and moisture barrier	not considered	
6	Vertical wooden beam	100x20 mm, step 400 mm	0.006 m ³
7	Air gap between wooden facade elements	not considered	
8	Horizontal wooden beam	100x20 mm, step 400 mm	0.006 m ³
9	Wooden facade board	t = 20 mm	0.02 m ³
10	Metal fasteners	not considered	

Source: developed by the authors

The wall structure combined structural, insulating, and protective layers with a total material volume of 0.377 m³ per 1 m² of surface area. The material composition was dominated by the load-bearing CLT panel and the thermal insulation layer, which together accounted for the majority of the volume. Interior and exterior finishing layers made a relatively small contribution (0.005 m³ and 0.02 m³, respectively), while timber substructure elements added a limited

amount (0.012 m³/m² in total). Functional layers such as membranes, air gaps, and fasteners were essential for performance but had negligible material volume and were excluded from the calculation. An essential component for determining the GWP of the wall structure was the characteristic CO₂ emission values of the materials used. These data, systematised from open databases of environmental declarations for construction products, were provided in Table 7.

Table 7. Characteristic values of CO₂-equivalent emissions by life cycle stages based on EPD

Material name	Unit of measurement	GWP by life cycle stages (kg CO ₂ eq)							
		A1-A3	A4	A5	C1	C2	C3	C4	D
Painted MDF panel	1 m ³	-1.40	0.30	0.49	0.00	0.14	4.91	0.00	-2.88
CLT panel	1 m ³	-708.0	25.90	5.38	4.01	2.05	782.00	0.00	-268.0
Grass mat insulation	1 m ³	-5.01	0.13	0.62	0.00	0.09	8.77	0.35	-1.66
Wooden beam	1 m ³	-752.0	43.10	1.70	0.34	6.93	800.00	0.00	-299.0

Source: International EPD System (n.d.)

So, the life-cycle GWP results showed that all timber-based materials had strongly negative impacts at the production stage (A1-A3) due to biogenic carbon storage. The most significant carbon storage was observed for wooden beams and CLT panels, while grass-mat insulation showed a smaller but still negative value. Transport and construction stages (A4-A5) contributed relatively minor positive emissions, remaining below 50 kg CO₂eq/m³ for all materials. In contrast, the end-of-life stage (C3) generated

substantial emissions for timber products, reaching approximately 800 kg CO₂eq/m³ for CLT panels and wooden beams. Module D provided significant environmental credits, particularly for structural wood products, partially offsetting end-of-life impacts. Overall, the results highlighted the importance of carbon storage and reuse potential in bio-based materials, with structural timber elements having the largest influence on the total GWP balance. Also, these results were summarised in Table 8.

Table 8. Results of GWP determination by materials and life cycle stages of the proposed enclosure construction

Material Name	GWP according to information modules of life cycle stages and total, (kg CO ₂ eq)							
	A1-A3	A4	A5	C1	C2	C3	C4	D
Painted MDF panel	-0.007	0.0015	0.0025	0.00	0.0007	0.0246	0.00	-0.014
CLT panel	-99.12	3.6260	0.7532	0.56	0.2870	109.48	0.00	-37.52
Grass mat insulation	-1.0024	0.0264	0.1240	0.00	0.0170	1.754	0.071	-0.332
Wooden beam	-9.024	0.517	0.0204	0.0041	0.0832	9.60	0.00	-3.588
Total GWP by stages	-109.15	4.17	0.90	0.565	0.388	120.85	0.071	-41.45

Source: developed by the authors

To assess the energy and environmental efficiency of the proposed enclosure structure, a comparative analysis was conducted using data from the most popular existing wall constructions, which were obtained by S. Shekhorkina *et al.* (2023). In addition, the GWP of the selected

materials was evaluated across all life cycle stages, including production, transportation, construction, end-of-life processes, and potential benefits beyond the system boundary. The results demonstrated that timber-based elements such as CLT panels and wooden



beams showed significant negative emissions at the production stage due to carbon storage, although impacts increase during disposal stages. Overall, the total GWP values highlighted the environmental advantages of

bio-based materials compared to conventional wall assemblies, supporting the sustainability of the proposed design. Table 9 provided data on the enclosing structure with existing solutions.

Table 9. Comparative analysis of the proposed enclosure structure with existing solutions

Code	Description	$R_{\Sigma pr}$, $m^2 \cdot K/W$	ΣGWP , $kgCO_2\text{-eq}$
EW	Proposed enclosure structure	4.9	-23.6
CT1	Brick masonry with external insulation of expanded polystyrene and plaster	4.17	987.8
CT2	Brick masonry with external insulation of mineral wool and ceramic brick facing	4.03	3,234.9
CT3	Gas concrete block masonry with external insulation of expanded polystyrene	4.57	571.4
CT4	Gas concrete block masonry with external insulation of mineral wool and facing	4.56	2,804.0
CT5	Panel of light steel thin-walled constructions (LSTK) with an internal layer of mineral wool insulation	4.91	2,132.4
CT6	Frame-sheathing panel with a wooden frame and an internal layer of mineral wool insulation	4.23	121.9
CT7	SIP-panel with two cladding plates and expanded polystyrene between them	4.56	184.6

Source: developed by the authors

Figure 5 illustrated the superior environmental performance of the proposed solution (EW), which boasted a negative GWP value in addition to its high thermal resistance. The application of the proposed wall construction based on CLT panels and natural insulation made of grass mats was particularly relevant for construction in recreational zones of Ukraine, in accordance with the General scheme for planning the territory of Ukraine (Dipromisto, 2015). These areas required a delicate approach to design, considering their environmental protection status and the need to preserve ecosystems. The low carbon footprint of the structure (total GWP -23.6 $kgCO_2\text{-eq}/m^2$) made it an environmentally safe alternative to traditional construction solutions. Natural materials not only reduce anthropogenic load but also contribute to the harmonious visual and functional integration of buildings into the natural environment. Thanks to its high thermal insulation properties, the structure ensured energy efficiency, which was especially important for autonomous or seasonal facilities in remote areas.

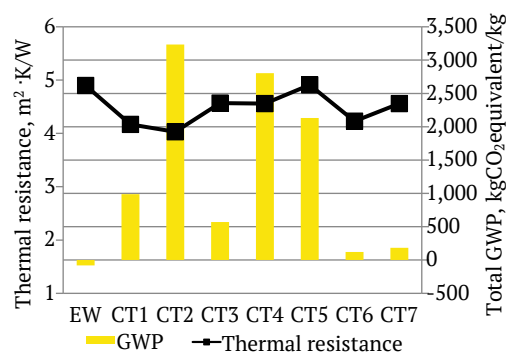


Figure 4. GWP and thermal resistance

Source: developed by the authors

Additionally, the advantages included the speed of installation and the possibility of dry construction, which minimised intervention in the landscape. This opened up broad prospects for the application of such solutions in the construction of eco-tourism facilities, campsites, rec-

reation centres, holiday homes, and other structures in the Carpathian region, Polissia, the Southern coast, and protected areas of Ukraine. Within the framework of the research project “Scientific and practical principles of designing biopositive rehabilitation facilities for veterans and civilians affected by the russian-Ukrainian war” (Grant for Fundamental and Applied Research and R&D by Young Scientists, Ministry of Education and Science of Ukraine) (Ministry of Veterans Affairs of Ukraine, n.d.), a pilot architectural concept of a rehabilitation centre was developed, demonstrating the practical application of sustainable construction strategies based on CLT technology (Fig. 6).

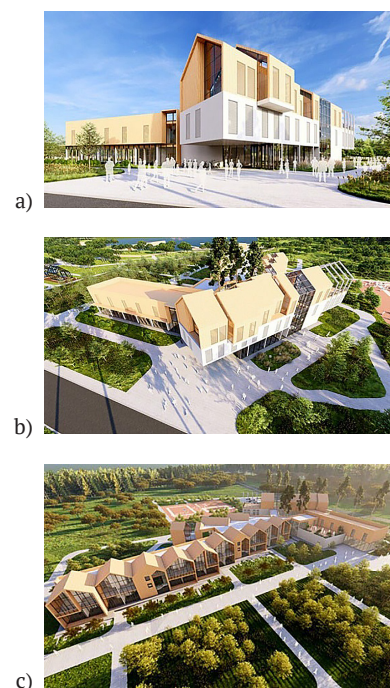


Figure 6. Architectural concept of a rehabilitation centre
Note: a – entrance area with barrier-free access; b – overall perspective; c – view of the residential modules of the rehabilitation centre

Source: developed by the authors



The project was based on three core principles of sustainable architecture: the use of local and renewable materials, the strengthening of sensory and visual connection with nature, and spatial flexibility in support of rehabilitation processes. CLT, as the primary structural and finishing material, enabled the creation of an environmentally responsible and energy-efficient building system, while simultaneously shaping a biophilic and contemporary architectural identity. The centre followed a modular, block-based composition: individual buildings were visually and functionally interconnected, while remaining structurally independent. This approach ensured adaptability, ease of transformation, and spatial separation – critical for rehabilitation facilities that required privacy, controlled circulation, and differentiated therapeutic zones (Merylova *et al.*, 2024). The building volumes were organised with varied heights and reinterpret traditional pitched roof forms in a modern architectural language, fostering an associative link to residential architecture and reinforcing users' sense of safety and comfort. Wood was prominently featured not only in the load-bearing structure but also in exterior and interior finishes, enhancing the biophilic effect. The natural texture of CLT panels remained exposed, contributing to a visually warm and emotionally stable environment. The façades were designed based on principles of rhythm and transparency: vertical wooden panels alternate with deep glazed sections, ensuring ample natural light and visual connection with the surrounding landscape. This not only improved the psychological well-being of occupants but also reduced reliance on artificial lighting, thereby contributing to energy efficiency. Thus, the implementation of wooden multi-layered constructions with plant-based insulation was entirely reasonable and meets modern requirements for sustainable construction in Ukrainian natural-recreational zones.

DISCUSSION

The analysis revealed that the proposed wall structure demonstrated a paradigm shift in environmental performance, achieving a net-negative GWP of $-23.6 \text{ kgCO}_2\text{-eq/m}^2$. This result stood in contrast to the findings of S. Shekhorkina *et al.* (2023) for conventional constructions. For instance, while solutions like brick masonry with EPS insulation (CT1: $987.8 \text{ kgCO}_2\text{-eq}$) or gas concrete with EPS (CT3: $571.4 \text{ kgCO}_2\text{-eq}$) showed a significantly positive carbon footprint, and even other timber-based systems like the wooden frame panel (CT6: $121.9 \text{ kgCO}_2\text{-eq}$) and SIP-panel (CT7: $184.6 \text{ kgCO}_2\text{-eq}$) remained carbon positive, its solution acted as a carbon sink. This superior performance can be directly attributed to the strategic selection of bio-based materials with high biogenic carbon storage capacity, specifically the CLT panels and grass mat insulation, which negative GWP in the product stage (A1-A3) effectively offset the emissions from other life cycle stages. The proposed structure successfully reconciled this exceptional environmental profile with high energy efficiency, attaining a thermal resistance (R-value) of $4.9 \text{ m}^2\text{-K/W}$. This performance was on par with the most

thermally efficient solution identified by S. Shekhorkina *et al.* (2023), the LSTK panel (CT5: $4.91 \text{ m}^2\text{-K/W}$), yet with a GWP that was two orders of magnitude lower. This underscored a critical advantage: while modern industrial materials can achieve high insulation values, it often do so at a substantial carbon cost. The results aligned with and extend the principles discussed by I. Merylova *et al.* (2024), demonstrating that the use of CLT and natural materials was not merely an aesthetic or philosophical choice but a technically viable strategy for creating buildings that were simultaneously energy-efficient and climate-positive, a crucial combination for sustainable development in ecologically sensitive regions.

The presented results significantly advanced the international discourse on carbon-negative construction. Finding of this research of a net-negative GWP of $-23.6 \text{ kgCO}_2\text{-eq/m}^2$ for the CLT and grass mat assembly resonated strongly with the work of F. Pittau *et al.* (2018), who demonstrated that timber-based buildings can act as carbon sinks due to biogenic carbon storage. However, this study provided a more granular life-cycle perspective, showing that even, when considering modules A4-A5 and C1-C4, the high biogenic carbon stored in the primary materials (CLT and wooden beams) not only compensated for emissions from other components but also secured a negative balance for the entire wall system. This finding was more pronounced than the scenarios modeled by A. Amiri & S. Junnila (2025), which comparative LCA of timber and mineral-based walls often showed timber as carbon neutral or slightly positive, but rarely achieving the significant negative GWP demonstrated here, underscoring the critical impact of combining CLT with other bio-based insulations like grass mats.

The comparative advantage over conventional materials was consistent with global trends but revealed a greater magnitude of benefit. For example, V. Cascione *et al.* (2022) in their review of exterior wall systems, confirmed that brick and concrete solutions typically exhibit a high values of GWP, which corroborated CT1-CT4 scenarios (987.8 to $3,234.9 \text{ kgCO}_2\text{-eq/m}^2$). The fact that proposed in this research solution (EW) not only avoided these emissions but also achieved a negative footprint highlighted a transformative potential. Moreover, results of this research challenged the efficiency of some modern industrial systems. The high GWP of the LSTK (CT5: $2,132.4 \text{ kgCO}_2\text{-eq}$) aligned with the findings of X. Zhong *et al.* (2021), who noted the significant embodied carbon of steel, even in well-insulated assemblies. This positions of bio-positive solution not just as an alternative, but as a necessary evolution beyond both traditional mass-based and modern lightweight industrial systems to meet ambitious decarbonisation targets in the building sector.

From an architectural design standpoint, the proposed wall system offered significant advantages that extended beyond its technical performance. The use of CLT as a primary structural material enabled a high degree of prefabrication, which accelerated the building process



and allowed for greater precision. Furthermore, the inherent aesthetic and tactile qualities of exposed wood foster a strong biophilic design connection, a principle emphasised by S.R. Kellert *et al.* (2013) to enhance occupant well-being through a direct and visual connection to natural materials. This approach allowed architects to create spaces, where the structure itself contributed to a sensory-rich and psychologically beneficial environment. The system's flexibility supported the creation of modular, adaptable spaces, aligning with the concept of "design for adaptability" promoted by sustainable building theorists, such as C.S. Goh *et al.* (2023), demonstrating that environmental sustainability and innovative, human-centered architectural design were mutually reinforcing goals. A comprehensive review on the performance and benefits of CLT as an alternative to concrete and steel in modern construction was performed by J. Abed *et al.* (2022), G.Y. Jeong (2024), and F. Ljunggren *et al.* (2025). The authors highlighted significant environmental advantages, such as a lower carbon footprint and carbon sequestration, as well as economic benefits, including faster construction times and reduced labour costs. Additionally, researchers emphasised human-centric benefits, including improved indoor air quality, noise reduction, and enhanced fire and seismic resistance. Experimental research by M. Babenko *et al.* (2018) also confirmed the high thermal properties of flax straw both as a raw material and as a lightweight, environmentally-friendly insulation made from a two-component mixture of flax straw and liquid glass. These ecological materials offered thermal performance comparable to traditional insulation products, while offering significant advantages in reducing environmental impact and contributing to healthier indoor environments. N. Ijjada & R.R. Nayaka (2022) conducted a review on eco-friendly thermal insulation materials and highlighted the benefits to curtail heat ingress, CO₂ emission, embodied energy, and safety for health. But wide adoption of natural, sustainable materials for thermal insulation remained limited. A. Ali *et al.* (2024) considered that key barriers to their use were their susceptibility to moisture and low fire resistance. Compounding this was a notable scarcity of research dedicated to their effective use.

CONCLUSIONS

The study confirmed the effectiveness of the developed enclosure structure, made of ecological materials, from

both a thermotechnical and ecological perspective. The thermal performance analysis confirmed that the proposed wall system, based on CLT panels and grass mat insulation, complied with Ukrainian building code requirements for heat protection. The thermal resistance for the proposed wall system was calculated taking into account the thermal bridges formed by metal fasteners and was 4.9 m²·K/W. The calculation of the thermal-moisture state of the wall enclosure structure demonstrated that in this design of the external wall structure, condensation of water vapour does not occur. An especially important advantage was the low carbon footprint of the structure: the total GWP was -23.6 kgCO₂-eq/m², which was significantly lower than the similar indicators of traditional constructions, for example, brick masonry with external insulation of expanded polystyrene and plaster (GWP of 987.8 kgCO₂-eq/m²) or gas concrete block masonry with external insulation of expanded polystyrene (GWP of 571.4 kgCO₂-eq/m²). This was achieved by using plant-based materials that can sequester carbon throughout their life cycle, as well as the low energy intensity of their production and potential for reuse. In the context of implementing sustainable development principles, the European Green Deal objectives, and the requirements of Ukraine's post-war reconstruction, the proposed structural solution was a promising option for designing modern, energy-efficient buildings with minimal environmental impact. Building on these results, future research will focus on the experimental validation of the developed theoretical models under controlled laboratory conditions that simulate real-world operating environments. Further architectural investigations will address the scaling and adaptation of the offered wall system across different building typologies and climatic requirements.

ACKNOWLEDGEMENTS

The authors would like to express their sincere gratitude to Professors Mykola Savitskyi, Mykola Bevz, and Tamara Panchenko for their valuable guidance and continuous support throughout this research. Their expertise and encouragement have been instrumental in the successful completion of this study.

FUNDING

None.

CONFLICT OF INTEREST

None.

REFERENCES

- [1] Abed, J., Rayburg, S., Rodwell, J., & Neave, M. (2022). A review of the performance and benefits of mass timber as an alternative to concrete and steel for improving the sustainability of structures. *Sustainability*, 14(9), article number 5570. [doi: 10.3390/su14095570](https://doi.org/10.3390/su14095570).
- [2] Ali, A., Issa, A., & Elshaer, A. (2024). A comprehensive review and recent trends in thermal insulation materials for energy conservation in buildings. *Sustainability*, 16(20), article number 8782. [doi: 10.3390/su16208782](https://doi.org/10.3390/su16208782).
- [3] Amiri, A., & Junnila, S. (2025). How much upfront-embodied GHG emissions can wooden buildings save – displacement factors for wooden buildings. *Environmental Research: Infrastructure and Sustainability*, 5(2), article number 025012. [doi: 10.1088/2634-4505/addc16](https://doi.org/10.1088/2634-4505/addc16).





- [4] Babenko, M., Estokova, A., Savytskyi, M., & Unčík, S. (2018). Study of thermal properties of lightweight insulation made of flax straw. *Slovak Journal of Civil Engineering*, 26(2), 9-14. doi: 10.2478/sjce-2018-0008.
- [5] Babenko, M., Klitou, T., Klumbyte, E., & Fokaides, P.A. (2025). Environmental assessment of mycelium based straw insulation composite: A sustainability analysis at building material level. *Case Studies in Construction Materials*, 22, article number e04572. doi: 10.1016/j.cscm.2025.e04572.
- [6] Bjånesøy, S., Kinnunen, A., Einarsdóttir, H., & Heinonen, J. (2023). Carbon storage in the built environment: A review. *Environmental Research: Infrastructure and Sustainability*, 3(4), article number 042003. doi: 10.1088/2634-4505/ad139f.
- [7] Cascione, V., Roberts, M., Allen, S., Dams, B., Maskell, D., & Shea, A. (2022). Life cycle assessment of circular bio-based construction. *Construction Technologies and Architecture*, 1, 124-134. doi: 10.4028/www.scientific.net/CTA.1.124.
- [8] Castro, S.M.H., Rodríguez, R.C., López Arquillo, J.D., & Álvarez de Eulate, M.P. (2025). Comparative evaluation of construction insulation materials: Environmental performance across production, end-of-life, and beyond system boundaries. *Journal of Building Engineering*, 99, article number 111570. doi: 10.1016/j.jobe.2024.111570.
- [9] Chen, P., Zhang, S., Meng, J., Lei, T., Li, B., & Coffman, D. (2023). Technological solutions to China's carbon neutrality in the steel and cement sectors. *Earth's Future*, 11(9), article number e2022EF003255. doi: 10.1029/2022EF003255.
- [10] DBN V.2.6-31:2021. (2023). *Thermal insulation and energy efficiency of buildings*. Retrieved from https://e-construction.gov.ua/laws_detail/3075196638495507996.
- [11] Dipromisto. (2015). General scheme for planning the territory of Ukraine. *Facebook*. Retrieved from <https://lnk.ua/J4ZRMEQ4E>.
- [12] DSTU 9191:2022. (2023). *Thermal insulation of buildings. Method for choosing insulation material for building insulation*. Retrieved from <https://surli.cc/nmsjal>.
- [13] DSTU-N B V.1.1-27:2010. (2011). *Building climatology*. Retrieved from https://dbn.co.ua/load/normativy/dstu/dstu_b_v_1_1_27_2010/5-1-0-929.
- [14] DSTU-N B V.2.6-192:2013. (2014). *Manual of design evaluation of heat and humidity conditions of building envelopes*. Retrieved from <https://teplovizor-plus.lviv.ua/wp-content/uploads/2019/11/dstu-v-2-6-192.pdf>.
- [15] EN 15978:2011. (2011). *Sustainability of construction works – assessment of environmental performance of buildings – calculation method*. Retrieved from <https://surl.it/hrsovy>.
- [16] Fang, X., Li, J., & Ma, Q. (2023). Integrating green infrastructure, ecosystem services and nature-based solutions for urban sustainability: A comprehensive literature review. *Sustainable Cities and Society*, 98, article number 104843. doi: 10.1016/j.scs.2023.104843.
- [17] Goh, C.S., Ting, J.N., & Bajracharya, A. (2023). Exploring social sustainability in the built environment. *Advances in Environmental and Engineering Research*, 4(1), article number 010. doi: 10.21926/aeer.2301010.
- [18] Hegeir, O.A., Kvande, T., Stamatopoulos, H., & Bohne, R.A. (2022). Comparative life cycle analysis of timber, steel, and reinforced concrete portal frames: A theoretical study on a Norwegian industrial building. *Buildings*, 12(5), article number 573. doi: 10.3390/buildings12050573.
- [19] Ijjada, N., & Nayaka, R.R. (2022). Review on properties of some thermal insulating materials providing more comfort in the building. *Materials Today: Proceedings*, 58, 1354-1359. doi: 10.1016/j.matpr.2022.02.230.
- [20] International EPD System. (n.d.). *EPD library*. Retrieved from <https://www.environdec.com/library>.
- [21] Jeong, G.Y. (2024). Status of CLT building construction from 2004 to 2023. *Construction and Building Materials*, 449, article number 138496. doi: 10.1016/j.conbuildmat.2024.138496.
- [22] Kellert, S.R., Heerwagen, J., & Mador, M. (2013). *Biophilic design: The theory, science, and practice of bringing buildings to life*. Hoboken: Wiley.
- [23] Li, C., Pradhan, P., Chen, G., Kropp, J.P., & Schellnhuber, H.J. (2025). Carbon footprint of the construction sector is projected to double by 2050 globally. *Communications Earth & Environment*, 6, article number 831. doi: 10.1038/s43247-025-02840-x.
- [24] Ljunggren, F., Fredriksson, M., Johansson, N., & Sasik Kalagasidis, A. (2025). Cross-laminated timber: A state-of-the-art review of moisture, fire, acoustics, and energy-related aspects. *Wood Material Science & Engineering*, 1-23. doi: 10.1080/17480272.2025.2507145.
- [25] Merylova, I., Shekhorkina, S., Panchenko, T., Zakharov, M., & Talash, A. (2024). Methodological approaches to designing biophilic rehabilitation buildings. *E3S Web of Conferences*, 534, article number 01014. doi: 10.1051/e3sconf/202453401014.
- [26] Ministry of Veterans Affairs of Ukraine. (n.d.). Draft Resolution of the Cabinet of Ministers of Ukraine "Certain Issues Related to the Implementation of an Experimental Project on Providing Extended Palliative Medical Care Services for Combat Injuries and care, as well as Long-Term Inpatient Rehabilitation Assistance to Certain Categories of Persons, who Defended the Independence, Sovereignty, and Territorial Integrity of Ukraine". Retrieved from <https://surl.lu/xgjbcs>.



- [27] Ottomano Palmisano, G., Rocchi, L., Negri, L., & Piscitelli, L. (2025). Evaluating the progress of the EU countries towards implementation of the European Green Deal: A multiple criteria approach. *Land*, 14(1), article number 141. doi: [10.3390/land14010141](https://doi.org/10.3390/land14010141).
- [28] Physibel. (n.d.). *2D & 3D thermal simulation*. Retrieved from <https://www.physibel.be/en/products>.
- [29] Pittau, F., Krause, F., Lumia, G., & Habert, G. (2018). Fast-growing bio-based materials as an opportunity for storing carbon in exterior walls. *Building and Environment*, 129, 117-129. doi: [10.1016/j.buildenv.2017.12.006](https://doi.org/10.1016/j.buildenv.2017.12.006).
- [30] Ranefj rd, O., Strandberg-de Bruijn, P.B., & Wads , L. (2024). Hygrothermal properties and performance of bio-based insulation materials locally sourced in Sweden. *Materials*, 17(9), article number 2021. doi: [10.3390/ma17092021](https://doi.org/10.3390/ma17092021).
- [31] R ck, M., Saade, M.R.M., Balouktsi, M., Rasmussen, F.N., Birgisdottir, H., Frischknecht, R., Habert, G., L tzkendorf, T., & Passer, A. (2020). Embodied GHG emissions of buildings – the hidden challenge for effective climate change mitigation. *Applied Energy*, 258, article number 114107. doi: [10.1016/j.apenergy.2019.114107](https://doi.org/10.1016/j.apenergy.2019.114107).
- [32] Schubert, M., Panzarasa, G., & Burgert, I. (2022). Sustainability in wood products: A new perspective for handling natural diversity. *Chemical Reviews*, 123(5), 1889-1924. doi: [10.1021/acs.chemrev.2c00360](https://doi.org/10.1021/acs.chemrev.2c00360).
- [33] Shekhorkina, S., Zinkevych, O., & Kovtun-Horbachova, T. (2023). Revealing timber structures potential in decarbonization of low-rise residential buildings. *Modern Structures of Metal and Wood*, 27, 28-34. doi: [10.31650/2707-3068-2023-27-28-34](https://doi.org/10.31650/2707-3068-2023-27-28-34).
- [34]  vajlenka, J., & Po iv kov , T. (2023). Innovation potential of wood constructions in the context of sustainability and efficiency of the construction industry. *Journal of Cleaner Production*, 411, article number 137209. doi: [10.1016/j.jclepro.2023.137209](https://doi.org/10.1016/j.jclepro.2023.137209).
- [35] World Green Building Council. (n.d.). Retrieved from <https://worldgbc.org/>.
- [36] Ye, F., Wei, H., Xiao, Y., Berardi, U., Quaranta, G., & Demartino, C. (2025). Bio-based insulation materials in sustainable constructions: A review of environmental, thermal and acoustic insulation, durability, and mechanical performances. *Renewable and Sustainable Energy Reviews*, 223, article number 115872. doi: [10.1016/j.rser.2025.115872](https://doi.org/10.1016/j.rser.2025.115872).
- [37] Zhong, X., Hu, M., Deetman, S., Steubing, B., Lin, H.X., Hernandez, G.A., Harpprecht, C., Zhang, C., Tukker, A., & Behrens, P. (2021). Global greenhouse gas emissions from residential and commercial building materials and mitigation strategies to 2060. *Nature Communications*, 12, article number 6126. doi: [10.1038/s41467-021-26212-z](https://doi.org/10.1038/s41467-021-26212-z).



Микола Бевз

Доктор архітектури, професор
Державний університет «Люблінська політехніка»
00-511, вул. Новгородська, 31, м. Варшава, Польща
Національний університет «Львівська політехніка»
79013, вул. Степана Бандери, 12, м. Львів, Україна
<https://orcid.org/0000-0003-1513-7045>

Марина Бордун

Доктор філософії, доцент
Український державний університет науки і технологій
49010, вул. Лазаряна, 2, м. Дніпро, Україна
Навчально-науковий інститут «Придніпровська державна академія будівництва та архітектури»
49005, вул. Архітектора Олега Петрова, 24А, м. Дніпро, Україна
<https://orcid.org/0000-0002-8539-2423>

Світлана Шехоркіна

Доктор технічних наук, професор
Український державний університет науки і технологій
49010, вул. Лазаряна, 2, м. Дніпро, Україна
Навчально-науковий інститут «Придніпровська державна академія будівництва та архітектури»
49005, вул. Архітектора Олега Петрова, 24А, м. Дніпро, Україна
<https://orcid.org/0000-0002-7799-2250>

Ірина Мерилова

Кандидат архітектури, доцент
Український державний університет науки і технологій
49010, вул. Лазаряна, 2, м. Дніпро, Україна
Навчально-науковий інститут «Придніпровська державна академія будівництва та архітектури»
49005, вул. Архітектора Олега Петрова, 24А, м. Дніпро, Україна
<https://orcid.org/0000-0001-5375-1359>

Стійка, енергоефективна та екологічно чиста стінова система для будівельного застосування в Україні

Анотація. У відповідь на глобальні екологічні виклики та зростаючий попит на енергоефективні рішення у будівельному секторі пошук екологічно безпечних конструктивних систем із мінімальним вуглецевим слідом стає актуальним. Метою цього дослідження було розроблення та аналіз системи зовнішньої стінової огорожувальної конструкції з екологічних матеріалів з урахуванням її теплотехнічних і гігротеплотехнічних характеристик, а також оцінка її екологічного впливу за показником вуглецевого сліду. Результати дослідження показали, що запропонована конструкція на основі панелі з перехресно-клеєної деревини з утепленням із трав'яних матів має термічний опір $4,9 \text{ м}^2\text{К/Вт}$, що відповідає чинним вимогам будівельних норм. Гігротеплотехнічний аналіз підтвердив внутрішню стабільність стінового вузла та відсутність конденсації у найхолоднішому місяці року – січні (для міста Дніпро). Розрахований вуглецевий слід становив $-23,6 \text{ кгCO}_2\text{-екв./м}^2$, що свідчило про вуглецево-негативний характер системи завдяки використанню біоматеріалів, здатних акумулювати вуглець протягом усього життєвого циклу. Крім того, отримані показники було порівняно з найпоширенішими рішеннями огорожувальних конструкцій, що підтвердило переваги запропонованої структури. Також, було розроблено пілотну архітектурну концепцію реабілітаційного центру, яка демонструє практичне застосування стратегій сталого будівництва на основі запропонованого рішення. Практична значущість дослідження полягає в потенційній інтеграції розробленої конструкції стіни у сучасне будівництво з підвищеною енергоефективністю та екологічними показниками. Це відповідає принципам сталого розвитку та сприяє зменшенню кліматичного впливу будівельної галузі

Ключові слова: енергоефективна архітектура; стінові конструкції; гігротеплотехнічний аналіз; біоізоляція; CLT-панелі; післявоєнна відбудова

UDC 711.4:72:614:4
DOI: 10.56318/as/4.2025.91

ISSN: 2411-801X
e-ISSN: 2786-7374

Ihor Gnes*

Doctor of Architecture, Associate Professor
Lviv Polytechnic National University
79013, 12 Stepan Bandera Str., Lviv, Ukraine
<https://orcid.org/0000-0003-0810-7681>

Lubov Soloviy

PhD in Architecture, Assistant
Lviv Polytechnic National University
79013, 12 Stepan Bandera Str., Lviv, Ukraine
<https://orcid.org/0000-0002-1627-030X>

Vasyl Matsola

Postgraduate Student
Lviv Polytechnic National University
79013, 12 Stepan Bandera Str., Lviv, Ukraine
<https://orcid.org/0009-0002-7339-8841>

The impact of epidemics and pandemics on architectural and urban transformations of cities

Abstract. The aim of study was to identify and systematise architectural and urban transformations of cities, urban engineering infrastructure and the residential environment that occurred in response to epidemics and pandemics. The research methodology was based on an interdisciplinary approach that combined historical-retrospective, comparative, and spatial-analytical methods with the use of contemporary urban and epidemiological studies. The study showed that from the earliest water supply and sewage systems in the cities of the Ancient East and Antiquity to the comprehensive sanitary reforms of the 19th century and modernist ideas of the “healthy city”, architectural and planning solutions have been consistently used as a tool to counter the spread of infectious diseases. The article provided a historical and analytical overview of the transformations of urban space under the influence of epidemics, as well as focusing on the modern stage associated with the COVID-19 pandemic. It showed that the modern stage had been characterised by a shift in focus from basic sanitary and engineering solutions to the morphological parameters of the living environment, in particular the density and number of storeys of buildings, the configuration of common spaces and the effectiveness of natural ventilation. Particular attention was paid to the analysis of the spatial parameters of residential buildings that indirectly influenced epidemiological risks, in particular the number of storeys and density of buildings. Based on modern interdisciplinary empirical studies, statistically confirmed correlations between increased density, number of storeys of housing and more intensive spread of infection were analysed. The role of aerosol transmission routes through common engineering systems of multi-storey buildings was emphasised. Design-relevant conclusions were summarised regarding acceptable levels of space utilisation intensity, as well as the role of open and semi-open spaces in reducing the risk of infection transmission and psychological stress during prolonged quarantine. Emphasis was also placed on the importance of effective natural and mechanical ventilation, the organisation of air exchange in common areas (stairwells, corridors, lift halls) and the prevention of stagnant air zones. The practical significance of the work lies in the formation of architectural and urban planning

Suggested Citation:

Gnes, I., Soloviy, L., & Matsola, V. (2025). The impact of epidemics and pandemics on architectural and urban transformations of cities. *Architectural Studies*, 11(4), 91-100. doi: 10.56318/as/4.2025.91.

Journal homepage: <https://arch-studies.com.ua/en>

Architectural Studies, 11(4), 91-100

Received: 29.05.2025 Revised: 30.10.2025 Accepted: 19.12.2025 Published: 29.12.2025

*Corresponding author



Copyright © The Author(s). This is an open access article distributed under the terms of the Creative Commons Attribution License 4.0 (<https://creativecommons.org/licenses/by/4.0/>)



recommendations aimed at increasing the pandemic resilience of the living environment, in the range of “district – multi-apartment residential building”

Keywords: viral infection transmission; residential environment; engineering infrastructure; building height; pandemic resilience; health architecture

INTRODUCTION

The COVID-19 pandemic (2019-2025), caused by the SARS-CoV-2 virus, brought renewed attention to the relationship between epidemics and architectural and urban planning solutions as key non-medical mechanisms for containing the spread of infectious diseases. In the context of global urbanisation and high population mobility, cities have once again found themselves at the centre of epidemiological risks, which has led to a growing interest in the historical experience of creating a “healthy” urban environment. Researchers X. Jiang *et al.* (2024) proposed an analytical framework for assessing the impact of urban planning on public health, identifying key spatial factors in the spread of infections: building density and morphology, street network configuration, water supply and sewage systems, building ventilation, and functional zoning. The Health Impact Assessment model proposed by the authors demonstrated the possibility of integrating health issues into the early stages of architectural and urban design. A review of pandemics and their spatial consequences was conducted by A.E. Sumanti *et al.* (2023), showing that even in ancient and early medieval times, epidemics stimulated the emergence of specialised types of buildings and urban spaces, including military hospitals, isolated medical complexes, and open spaces for ventilation of the urban environment. The authors emphasised that architecture and urban planning have historically developed as tools for adapting to biological threats, even in the absence of modern scientific understanding of the nature of infections. A. Carbone (2022) traced how repeated outbreaks of plague, cholera, and yellow fever in Buenos Aires in 1867-1871 sparked debates about population control, social inequalities, and the need for spatial reforms in urban planning. These became catalysts for the transformation of engineering infrastructure, regulatory norms, and the spatial organisation of cities, including quarantine zones and the creation of open spaces and green spaces as elements of urban sanitary ventilation. M. Satam (2022) illustrated how the Spanish flu pandemic prompted the development of medical infrastructure in Bombay (now Mumbai). The author examined political decisions and social conflicts in the financing of hospitals and sanitation systems, emphasising that epidemics shaped urban health policy.

In the context of contemporary challenges, M. Amirzadeh *et al.* (2023) developed the concept of urban “pandemic resilience”, which encompassed four spatial levels, from housing to the urban and national scales. The researchers emphasised the importance of the living environment, access to green spaces, flexible planning solutions and social inclusion in reducing both the physical and psychological

consequences of pandemics. K. Mouratidis & A. Yiannakou (2022) used the cities of Athens and Thessaloniki as examples to show that during the COVID-19 pandemic, better psychophysical health indicators were associated with larger living spaces, lower building density, and access to green areas. X. Zhu & J. Xu (2023) noted that the pandemic has been a catalyst for rethinking the basic priorities of urban planning – from building techniques and density to the role of public spaces and medical infrastructure. R. Florida *et al.* (2020) analysed how the COVID-19 pandemic has affected the spatial concentration of population, jobs, mobility and social interactions. Researchers explained how the pandemic has changed the role of cities as centres of innovation and interaction, requiring the adaptation of spatial models of residential and commercial development to adequately respond to new priorities of safety and pandemic resilience. The study by M. Kang *et al.* (2020) analysed the relationships between built environment characteristics and COVID-19 transmission in megacities. Scientists focused on the role of building density, housing types, and shared engineering systems. The study highlighted the need to rethink architectural standards, particularly ventilation systems and the organisation of shared spaces, in the context of epidemic safety. X. Zhang *et al.* (2022) investigated the effects of crowding and density in urban environments on the spread of COVID-19. The authors analysed data from various urban contexts, demonstrating that cramped living conditions, limited common spaces and enclosed interiors significantly increased the risk of respiratory infection transmission. Based on the results, the researchers proposed urban development and planning measures aimed at reducing space density, developing open areas, and improving the sanitary quality of the living environment. Thus, contemporary research has confirmed that pandemics were factors in the transformation of architecture and urban planning. At the same time, historical experience accumulated from ancient civilisations to modernism has not been sufficiently integrated into contemporary approaches to residential area design. The aim of this article was to identify and systematise architectural and urban planning transformations in cities that have taken place in response to epidemics and pandemics, as well as to trace the transition from empirical and administrative anti-epidemic practices to scientifically based spatial solutions that laid the foundation for contemporary approaches to the formation of the urban living environment.

The research was based on an interdisciplinary approach that combined historical and urban planning analysis, comparative analysis, and elements of spatial



interpretation of architectural and urban solutions. The methodological framework was aimed at identifying patterns of the impact of epidemics and pandemics on the transformation of urban residential areas in different historical periods. Urban residential areas were analysed as spatial structures formed in conditions of epidemiological threats and architectural and urban planning principles of residential area organisation, which changed under the influence of epidemics and pandemics. The study used retrospective analysis, which made it possible to trace the evolution of urban planning approaches from ancient and medieval cities to industrial and post-industrial urbanisation. Historical examples were considered not as typological models, but as representative cases that illustrated the general patterns of spatial transformations. Comparative analysis was used to compare historical urban planning responses to epidemics with contemporary approaches shaped by the COVID-19 pandemic. Attention was also paid to analysing the scale of spatial changes, parameters of building density and height, and the configuration of open and green spaces.

Historical epidemics as a catalyst for urban transformation.

Sanitary reform and reconstruction of the industrial city

The urban environment has always been closely linked to infectious diseases, and outbreaks of epidemics have been catalysts for profound spatial transformations. C.E. Rosenberg (1992) and F.M. Snowden (2019) noted that it was cities, as forms of high population concentration and social contact, that created conditions for the spread of epidemics, but at the same time became laboratories for spatial responses to these threats. From the 8th century BC, ideas about the connection between public health and the quality of the urban environment began to take shape. Hippocrates' concept of "air, water and place" laid the foundation for the further perception of the city as a factor in the aetiology of disease. M.V. Melosi (1999) and P. Juuti *et al.* (2007) confirmed that in the major centres of the ancient world – Babylon, the cities of the Indus civilisation, Rome – there were already elements of a purposeful organisation of water supply and sewage disposal aimed at minimising sanitary risks. However, in the Middle Ages, much of this knowledge was lost, and European cities developed in the direction of extremely dense construction, due to the requirements of minimising the perimeter of city defensive walls, functional mixing and unsanitary conditions. It was in this context that the bubonic plague of the 14th–17th centuries reached catastrophic proportions, causing not only demographic losses but also radical shifts in spatial thinking (Cipolla, 1992; Alfani & Murphy, 2017).

One of the key spatial responses to epidemics was the practice of quarantine, which developed in the port cities of the Mediterranean and later spread throughout Europe. Quarantine should be seen not only as a medical measure, but as a specific form of spatial management that combined mobility regulation, population segregation, and

control over city boundaries. P. Baldwin (2009) analysed quarantine regimes, sanitary borders, systems of movement restriction control, and institutional mechanisms for combating epidemics of cholera, plague, and typhus. The author demonstrated that medical measures always had a spatial dimension and directly influenced the formation of urban boundaries, infrastructure, and regulatory practices – quarantine as a form of spatial management. M. Foucault (1995) analysed the evolution of spatial control practices in society and showed how the concept of "disciplinary space" was widely used to analyse quarantine regimes, sanitary zoning and control of the urban population during epidemics, how space is used as an instrument of behaviour regulation. The architectural embodiment of this logic was quarantine facilities, isolation hospitals and sanitary cordons, which effectively laid the foundations for the further development of infectious disease hospitals and epidemiological zoning systems. As B. Colomina (2019) pointed out, it was epidemics that forced architecture to work with the concepts of invisible threat, sterility, and distance for the first time, which later became fundamental to modernist spatial thinking. In this sense, the quarantine practices of the early modern period (15th–18th centuries) should be seen as predominantly empirical and administrative mechanisms for responding to the epidemic threat, which were not yet based on a scientific understanding of the transmission of infections, but already formed the preconditions for the institutionalisation of spatial control in the city. It was important to note that quarantine measures were never purely technical. They were accompanied by social tension, ethical conflicts, and unequal impact on different population groups. This highlighted the need to consider historical examples not as direct models for replication, but as a source of understand.

The period of early industrialisation in the 19th century was a turning point in the formation of the modern city. As C. Hamlin (1998) noted, rapid population growth, industrial development and mass housing construction during this period led to an exacerbation of sanitary problems and new waves of epidemics, particularly cholera and typhoid. These challenges gave rise to a large-scale sanitation movement that brought together doctors, engineers, architects and city administrators. The author noted that sanitary reforms in Great Britain in the 19th century were closely linked to issues of social justice, housing conditions and urban management and ultimately led to a transition from fragmented, reactive measures to a conscious approach that laid the foundations for modern urban planning and public health. R.J. Evans (2005) conducted a study using the German city of Hamburg as an example, demonstrating how repeated outbreaks of disease stimulated the development of water supply, sewage and regulatory mechanisms for controlling the urban environment. Particular attention was paid to the role of medical knowledge and statistics in shaping causal ideas about the spread of infections. The author showed how epidemics became a catalyst for the transition to scientifically based,





systematic urban planning. In other words, unlike periods when there was no modern scientific understanding of the nature of infections, in the 19th century, the fight against epidemics was increasingly based on the results of medical research, statistical observations and the formation of cause-and-effect ideas about the spread of diseases, which led to the transition to systematic urban planning.

The reconstruction of Paris, London, Berlin, and New York in the second half of the 19th century demonstrated how the fight against epidemics became the driving force behind radical changes in the planning structure of cities. D.S. Barnes (2006), tracing the transformations of Paris in the second half of the 19th century under the influence of epidemics and sanitary crises, showed how the fight against “miasmas”, pollution, and the spread of infections stimulated the creation of modern city-wide sewerage systems, water purification, and the reconstruction of the street network. The expansion and paving of streets and pavements, and the formation of a network of parks and open spaces had not only infrastructural but also ideological significance – they reinforced the new idea of a “healthy city” as a space of light and air. An article by M. Gandy (2004) provided a critical analysis of the development of engineering infrastructure in North American and European cities in the 19th century through the concept of “urban metabolism”. The author showed that water supply, sewerage and sanitation networks became key tools for overcoming epidemics and, at the same time, means of spatial transformation of the city. Particular attention was paid to the relationship between infrastructure, social inequality and power, which allowed to interpret sanitation reforms as an ambiguous process of modernisation. A. Sutcliffe (1981), analysing planned urban development in Europe and the United States during the industrialisation period, showed that street widening, zoning, demolition of dense historic buildings and the creation of green spaces were a response to public health problems. At the same time, the implementation of these sanitary reforms was accompanied by social conflicts, the displacement of poor populations, and increased spatial polarisation of cities. Thus, historical experience has demonstrated the ambivalence of urban planning responses to epidemics, combining progress in health with new forms of spatial inequality. P. Hall (1998), using examples from the evolution of large cities in Europe and North America in the context of cultural, technological and social change, confirmed that epidemics played a significant role in transforming the planning structure of cities, stimulating the development of sewerage, parks, boulevards and water supply systems. The author concluded with the idea of a “healthy city” as the result of a combination of engineering solutions, social reforms and urban planning ideology, which became important for the historical analysis of pandemic transformations.

It is important to note that at the end of the 19th century, as a result of advances in medical science and the emergence of epidemiology as an independent field of knowledge, anti-pandemic measures gradually transformed from

practices based primarily on centuries-old empirical experience into a system of consciously formulated architectural and urban planning solutions aimed at reducing the risks of spreading infectious diseases in the urban environment. At the turn of the 19th and 20th centuries, the accumulated experience of sanitary reforms was transformed into a comprehensive architectural and urban planning paradigm, in which health became one of the key design objectives (World Health Organization, n.d.). The spread of tuberculosis and, later, the Spanish flu pandemic contributed to the establishment of the principles of insolation, natural ventilation, functional zoning, and access to green spaces as basic criteria for the quality of the urban environment. In this context, modernism emerged not only as an aesthetic movement, but also as a response to the medical and social challenges of the industrial city. The architecture of residential areas, public buildings, and recreational spaces began to take shape with disease prevention in mind, laying the foundation for the further development of normative urban planning in the 20th century (Verderber, 2003). It was this historical evolution – from empirical sanitary measures to systematic environmental design – that created the methodological basis for analysing contemporary pandemic challenges, particularly COVID-19, which brought to the fore issues of density, floor space, the quality of open spaces and the social sustainability of residential areas.

Transformation of the principles of urban residential area development:

COVID-19 as a new type of pandemic challenge for cities

The COVID-19 pandemic was the first global epidemiological crisis to unfold in conditions of mature urbanisation, high informatisation and mobility of the population, and the dominance of megacities as forms of life. Unlike the epidemics of the 19th and early 20th centuries, it unfolded in cities, where basic sanitary and engineering systems already function as a mandatory standard and were not subject to debate (Sharifi & Khavarian-Garmsir, 2020). COVID-19 did not call into question the fundamental principles of sanitary infrastructure, but it did highlight other, less formalised aspects of the urban environment – the spatial organisation of residential areas, the nature of development, the quality of ventilation and the availability of safe recreational spaces. The pandemic has revealed the limitations of the modern compact city model, which is primarily focused on economic efficiency and intensive land use (Florida *et al.*, 2020).

One of the central issues raised by COVID-19 has been the role of urban density in the spread of infections. R. Ewing & S. Hamidi (2015) and C.J. Neiderud (2015) showed that density itself is not a direct factor in increasing epidemic risks; instead, the decisive factor is overcrowding – the overload of the living environment, the lack of open spaces and unequal access to infrastructure. In many cities, the pandemic has shown that residential areas with high building density, increased floor space, minimal inter-building spaces, and insufficient green areas have proven to be less



adaptable to lockdowns and mobility restrictions. In such environments, not only did the risks of physical infection increase, but so did the level of psychological stress and social tension (Mouratidis & Yiannakou, 2022). This again returned attention to historical experience, in which the fight against epidemics prompted a reconsideration of acceptable density parameters and spatial separations between buildings. However, unlike the sanitary reforms of the nineteenth century, the contemporary challenge lies not in the radical reconstruction of cities, but in adjusting the principles for forming new residential districts and renovating existing ones. The COVID-19 pandemic has brought to the fore a rethinking of the role of density and height of residential buildings not only as urban planning or economic parameters, but as spatial variables that indirectly influence the intensity and mechanisms of the spread of infectious diseases. Unlike classic engineering and sanitary measures (water supply, sewerage), which have become mandatory and regulated in modern practice, the parameters of building height and area have remained a sphere of design compromises between developer efficiency and the epidemiological sustainability of the residential environment.

In modern interdisciplinary studies, the term “density” has been used not as a universal indicator, but as a set of interrelated spatial characteristics (population density, building density, floor area ratio, residential crowding). S.J. Hejazi *et al.* (2023) and M. Amirzadeh *et al.* (2023) demonstrated that the relationship between density and morbidity is contextual, but densely built-up residential environments are more likely to provide conditions for the rapid formation of local clusters of infection. A study by Y. Chen *et al.* (2022), conducted on several large agglomerations using machine modelling methods, found statistically significant correlations between the morphological characteristics of residential buildings (number of storeys, compactness of buildings, proportion of open spaces) and the prevalence of COVID-19 at the urban district level. Although the authors emphasised the indirect nature of these relationships, the results confirmed that building density can serve as a proxy indicator of a combination of spatial and social risks. Vertical density, i.e. the number of storeys in residential buildings (Fig. 1), has demonstrated specific epidemiological risks in the context of the pandemic.



Figure 1. Multi-unit residential development with vertical density in Vancouver

Source: Traveling Canuks (n.d.)

Contrary to the traditional view that the risk of infection increases only in proportion to population density, a number of studies have shown that the very fact of vertical housing organisation can create additional mechanisms for the spread of the virus. For example, M. Kang *et al.* (2020) found that the infection of residents of apartments in Hong Kong located on different floors (within the same vertical cluster) did not occur as a result of direct contact, but through aerosol transmission mediated by shared sewage and ventilation shafts: the number of infections within a single “vertical column” of flats was statistically significantly higher than in buildings with fewer floors or with a different type of engineering systems. A comprehensive study by S.Z. Chong *et al.* (2025), which combined epidemiological analysis with CFD modelling of air flows, showed that the risk of SARS-CoV-2 transmission between apartments in high-rise buildings can increase by tens of percent compared to low-rise housing types, given unfavourable ventilation configuration and high population density. In particular, in the cases studied, the probability of infection of residents of apartments located more than two floors above the primary source remained statistically significant.

The author P. Zhao (2022) investigated the spatial patterns of infection spread within urban planning and analysed a series of COVID-19 outbreaks in high-rise residential buildings in Hong Kong (Fig. 2). The results showed the existence of so-called vertical transmission clusters, which cannot be explained by either direct social contacts or typical scenarios of household infection. It was found that infected residents lived on different floors of the same building, occupied apartments with the same layout, located one above the other within a single vertical “column” of the building (e.g., apartment type A on the 5th, 12th and 18th floors). At the same time, the epidemiological investigation did not find any direct social contact between them: the residents did not interact with each other, used the lifts at different times and did not occupy common spaces at the same time. The only common spatial and technical factor for these flats was their connection to shared vertical engineering systems, primarily ventilation and sewer shafts. It was these systems that created the conditions for indirect transmission of the virus between floors, allowing the infection to spread without human contact.



Figure 2. Panorama of high-rise residential buildings in Hong Kong

Source: based on K. Zhuk (2021)





An analysis of possible mechanisms of viral transmission in high-rise buildings made it possible to identify several key processes. First, there is aerosol transmission through ventilation ducts, particularly kitchen and bathroom exhausts, where airflows could transport viral aerosols between flats (Wang *et al.*, 2022). Second, an important role was played by transmission through sewerage systems (the faecal aerosol route), the mechanism of which was confirmed during the SARS outbreak of 2003 and later recorded again for SARS-CoV-2 (Kang *et al.*, 2020). Third, a significant factor was the stack effect, in which warm air from lower floors rises upward through microcracks, facilitating the vertical transport of aerosols inside the building. The case examined demonstrated that, under conditions of multi-storey residential development, building height created a specific epidemiological risk linked to the very spatial and engineering organisation of the structure. In this sense, vertical density functions not only as a quantitative indicator of development intensity, but also as a qualitative factor capable of creating hidden pathways of infection spread, invisible within traditional approaches to evaluating the residential environment.

The COVID-19 pandemic revealed the high vulnerability of apartment housing with shared spatial components. A study by W. Luo *et al.* (2022) showed that living in buildings with shared entrances, lift lobbies, and corridors was associated with an increased risk of within-building transmission, even when basic quarantine restrictions were observed. In this context, building height and development intensity act not as direct causes of infection, but as structural factors that shape: the intensity of shared-space use; the frequency of indirect contacts between residents; and dependence on enclosed vertical circulation systems. These findings correspond with the data of D. Duval *et al.* (2022) on the aerosol transmission of SARS-CoV-2 in interiors, which demonstrated that limited air volume, insufficient ventilation, and high user concentration significantly increase epidemiological risks.

Spatial interpretations for architectural and urban planning practice during epidemics

From the standpoint of architectural design of multi-family housing, the results obtained made it possible to interpret building height and density as factors of potential epidemiological vulnerability, which should be considered alongside the social and psychological aspects of the residential environment. It was important to emphasise that this does not imply a rejection of dense development as such, but rather a limitation of its uncritical intensification, especially under conditions dominated by a developer-driven logic of maximising building height and area. The research results reflected contextual relationships rather than universal threshold values, making their direct use as regulatory

design parameters impossible. At the same time, they convincingly demonstrated the need to integrate epidemiological knowledge into the process of urban-planning and architectural decision-making, particularly in the segment of multi-storey residential construction, which was likely to be most sensitive to future pandemic challenges.

Building height and residential density have formed not only quantitative indicators of land-use intensity, but also qualitatively new epidemiological risks associated with patterns of spatial interaction and engineering systems within buildings and residential districts. These risks cannot be eliminated solely by technical or organisational measures and require spatial compensation at the level of architectural and urban-planning solutions. One of the least regulated factors in the pandemic resilience of residential districts has been the quality of natural aeration of urban development. At the district scale, this is linked to the orientation of the street network, the width of inter-building spaces, the presence of continuous green corridors, and open public spaces (Samuelsson *et al.*, 2020). Planning configurations of residential development have produced significantly different conditions of natural ventilation. In particular, open or semi-open layouts of residential buildings demonstrated 30-60% higher average airflow speeds in pedestrian zones compared with enclosed perimeter blocks, while the level of air exchange in the inner courtyards of semi-open schemes was 40-50% lower (Fig. 3).

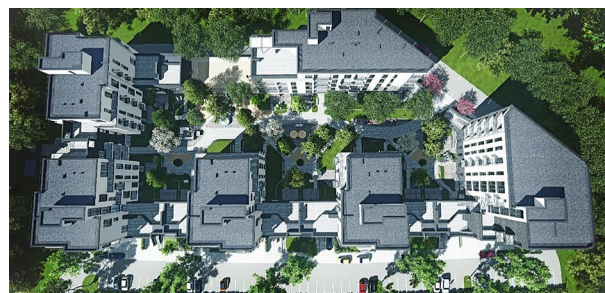


Figure 3. Semi-open placement of residential buildings

Note: the Villa Magnolia quarter, Lviv

Source: photo by I. Gnes

In block development options with through openings or partially open perimeters, the air stagnation zone was reduced by approximately 35-45%, indicating better conditions for the dispersion of aerosol pollutants (Zhang *et al.*, 2022). These effects were complemented by green corridors and open spaces: the presence of continuous green areas was associated with a 20-30% reduction in the time aerosols remain in open spaces, as well as opportunities for safe recreation under quarantine restrictions (Ugolini *et al.*, 2020). An example of a closed residential development scheme was the residential blocks in Barcelona, Spain (Fig. 4).



Figure 4. Enclosed perimeter blocks of Barcelona

Source: Lifestyle 24 (2019)

One particular consequence of the COVID-19 pandemic has been the sharp rise in social isolation, especially among older people, single-person households and socially vulnerable groups. The period of quarantine restrictions revealed the critical role of green and semi-open spaces near homes as a compensatory element of isolation during lockdown. J. Honey-Rosés *et al.* (2021) noted that residents of areas with access to parks, courtyards and boulevards coped better with mobility restrictions, had better psycho-emotional well-being and higher physical activity levels. Thus, the green infrastructure of residential areas emerged not only as a recreational or environmental element, but as an important component of the public health system that needed to be integrated into urban planning decisions at the early stages of design (UN-Habitat, 2021). Quarantine restrictions transformed residential areas from places of transit to the main space of everyday life, which placed new demands on their functional richness (Buffel *et al.*, 2021). The concept of accessibility of basic services within walking distance, which was previously considered mainly from the perspective of convenience and sustainable development, has become a factor of safety and resilience in the context of the pandemic. Local commercial, domestic and recreational functions have reduced the need for travel while maintaining social ties at the neighbourhood level. E. Klinenberg (2018) emphasised that well-developed neighbourhood infrastructure promoted social cohesion among city dwellers and reduced the vulnerability of the population during crises, such as pandemics and heat waves. Scientist formed a theoretical basis for understanding the residential area as a key spatial level, where social interaction and safety can be combined in conditions of limited mobility. The analysis of the impact of the COVID-19 pandemic on residential areas allowed to formulate a number of generalised provisions relevant to contemporary urban planning theory and practice. This was not about revising basic sanitary standards, but about refining the spatial principles of shaping the residential environment, taking into account potential epidemic risks. These principles included: controlled density and height of buildings, ensuring effective natural ventilation, forming a hierarchical

system of open and green spaces, and strengthening the role of residential areas as spaces for everyday support and social stability.

CONCLUSIONS

The study confirmed that epidemics and pandemics throughout the history of urbanisation were not random crises, but systemic triggers of architectural and urban transformations. From early forms of water supply and sanitation control in the cities of the ancient world to large-scale reconstructions of industrial cities in the 19th century, threats to public health have consistently influenced the rethinking of density, spatial structure, and functional organisation of the urban environment. Sanitary infrastructure solutions have shaped the basic level of urban safety, but at the same time have been accompanied by social and spatial contradictions. The COVID-19 pandemic has revealed a qualitatively new type of epidemiological challenge, characteristic of conditions of mature urbanisation, global mobility and regulated engineering systems. The pandemic in the 21st century did not call into question basic sanitary standards, but it did highlight issues that had previously remained on the periphery of urban planning discourse. These issues included the number of storeys and density of buildings, spatial congestion, the quality of natural ventilation, and the availability of open and green spaces in residential areas.

It has been determined that epidemiological risks in the residential environment increase with the height and density of buildings. Vertical organisation of space and shared engineering systems can create hidden mechanisms for the spread of infections that are not controlled by the individual behaviour of residents. Recorded cases of contactless infection of residents of vertical clusters in high-rise residential buildings indicate the need for a critical rethinking of the uncontrolled increase in the building height and area in the interests of developers. This practice contradicts the requirements for adapting the residential environment to pandemic challenges. It was also determined that open and semi-open planning configurations of residential buildings demonstrated 30-60% higher natural ventilation rates and 35-45% fewer areas of air stagnation. This confirmed the increased epidemiological risks of excessive densification without spatial compensators. The limitations of the study are related to its focus on the district and city scales, without a detailed analysis of the typology of multi-apartment residential buildings, their internal living spaces and apartments. Prospects for further research lie in supplementing existing regulatory requirements with scientifically based recommendations for architectural and urban planning practices aimed at creating pandemic-resistant housing.

ACKNOWLEDGEMENTS

None.





FUNDING

None.

CONFLICT OF INTEREST

None.

REFERENCES

- [1] Alfani, G., & Murphy, T.E. (2017). Plague and lethal epidemics in the pre-industrial world. *The Journal of Economic History*, 77(1), 314–343. [doi: 10.1017/S0022050717000092](https://doi.org/10.1017/S0022050717000092).
- [2] Amirzadeh, M., Sobhaninia, S., Buckman, S.T., & Sharifi, A. (2023). Towards building resilient cities to pandemics: A review of COVID-19 literature. *Sustainable Cities and Society*, 89, article number 104326. [doi: 10.1016/j.scs.2022.104326](https://doi.org/10.1016/j.scs.2022.104326).
- [3] Baldwin, P. (2009). *Contagion and the state in Europe, 1830-1930*. Cambridge: Cambridge University Press. [doi: 10.1017/CBO9780511497544](https://doi.org/10.1017/CBO9780511497544).
- [4] Barnes, D.S. (2006). *The Great Stink of Paris and the nineteenth-century struggle against filth and germs*. Baltimore: Johns Hopkins University Press.
- [5] Buffel, T., Yarker, S., Phillipson, C., Lang, L., Lewis, C., Doran, P., & Goff, M. (2021). Locked down by inequality: Older people and the COVID-19 pandemic. *Urban Studies*, 60(8), 1465–1482. [doi: 10.1177/00420980211041018](https://doi.org/10.1177/00420980211041018).
- [6] Carbone, A. (2022). Epidemics, the issue of control and the grid: A nineteenth-century perspective from Buenos Aires. *Planning Perspectives*, 37(1), 9–26. [doi: 10.1080/02665433.2021.2002184](https://doi.org/10.1080/02665433.2021.2002184).
- [7] Chen, Y., Zheng, L., Song, J., Huang, L., & Zheng, J. (2022). Revealing the impact of urban form on COVID-19 based on machine learning: Taking Macau as an example. *Sustainability*, 14(21), article number 14341. [doi: 10.3390/su142114341](https://doi.org/10.3390/su142114341).
- [8] Chong, S.Z., Ooi, C.C., Bin Abdul Malek, M.I., Ge, Z., Low, D., Kang, C.W., Chiew, C.J., Chae, S.-R., Teoh, Y.L., & Tan, K.B. (2025). Assessing vertical transmission of SARS-CoV-2 in high-rise apartments via a joint epidemiologic and modeling investigation. *Frontiers in Public Health*, 13, article number 1694554. [doi: 10.3389/fpubh.2025.1694554](https://doi.org/10.3389/fpubh.2025.1694554).
- [9] Cipolla, C.M. (1992). *Miasmas and disease: Public health and the environment in the pre-industrial age* (Translated by E. Potter). New Haven: Yale University Press.
- [10] Colomina, B. (2019). *X-ray architecture*. Zurich: Lars Müller Publishers.
- [11] Duval, D., Palmer, J.C., Tudge, I., Pearce-Smith, N., O'Connell, E., Bennett, A., & Clark, R. (2022). Long distance airborne transmission of SARS-CoV-2: Rapid systematic review. *BMJ*, 377, article number e068743. [doi: 10.1136/bmj-2021-068743](https://doi.org/10.1136/bmj-2021-068743).
- [12] Evans, R.J. (2005). *Death in Hamburg: Society and politics in the cholera years*. New York: Penguin Publishing Group.
- [13] Ewing, R., & Hamidi, S. (2015). Compactness versus Sprawl: A review of recent evidence from the United States. *Journal of Planning Literature*, 30(4), 413–432. [doi: 10.1177/0885412215595439](https://doi.org/10.1177/0885412215595439).
- [14] Florida, R., Rodriguez-Pose, A., & Storper, M. (2020). Cities in a post-COVID world. *Papers in Evolutionary Economic Geography* 20.41. Retrieved from <https://ideas.repec.org/p/egu/wpaper/2041.html>.
- [15] Foucault, M. (1995). *Discipline and punish: The birth of the prison* (Translated by A. Sheridan). Vancouver: Vintage Books.
- [16] Gandy, M. (2004). Rethinking urban metabolism: Water, space and the modern city. *City*, 8(3), 363–379. [doi: 10.1080/1360481042000313509](https://doi.org/10.1080/1360481042000313509).
- [17] Hall, P. (1998). *Cities in civilization*. New York: Pantheon.
- [18] Hamlin, C. (1998). *Public health and social justice in the age of Chadwick: Britain*. Cambridge: Cambridge University Press.
- [19] Hejazi, S.J., Arvin, M., Sharifi, A., & Lak, A. (2023). Measuring the effects of compactness/sprawl on COVID 19 spread patterns at the neighborhood level. *Cities*, 132, article number 104075. [doi: 10.1016/j.cities.2022.104075](https://doi.org/10.1016/j.cities.2022.104075).
- [20] Honey-Rosés, J., et al. (2021). The impact of COVID-19 on public space: An early review of the emerging questions – design, perceptions and inequities. *Cities & Health*, 5, 263–279. [doi: 10.1080/23748834.2020.1780074](https://doi.org/10.1080/23748834.2020.1780074).
- [21] Jiang, X., Ye, D., Lan, W., & Luo, Y. (2024). Epidemic, urban planning and health impact assessment: A linking and analyzing framework. *Buildings*, 14(7), article number 2141. [doi: 10.3390/buildings14072141](https://doi.org/10.3390/buildings14072141).
- [22] Juuti, P., Katko, T., & Vuorinen, H. (Eds.). (2007). *Environmental history of water – global views on community water supply and sanitation*. London: IWA Publishing. [doi: 10.2166/9781780402277](https://doi.org/10.2166/9781780402277).
- [23] Kang, M., et al. (2020). Probable evidence of fecal aerosol transmission of SARS-CoV-2 in a high-rise building. *Annals of Internal Medicine*, 173(12), 974–980. [doi: 10.7326/M20-0928](https://doi.org/10.7326/M20-0928).
- [24] Klinenberg, E. (2018). *Palaces for the people: How social infrastructure can help fight inequality, polarization, and the decline of civic life*. New York: Crown.
- [25] Lifestyle 24. (2019). *Barcelona, the one tourists don't see: An unexpected view of the capital of Catalonia*. Retrieved from <https://surl.it/bwfosb>.
- [26] Luo, W., Baldwin, E., Jiang, A.Y., Li, S., Yang, B., & Li, H. (2022). Effects of housing environments on COVID-19 transmission and mental health revealed by COVID-19 participant experience data from the All of Us Research Program in the USA: A case-control study. *BMJ Open*, 12(12), article number e063714. [doi: 10.1136/bmjopen-2022-063714](https://doi.org/10.1136/bmjopen-2022-063714).



- [27] Melosi, M.V. (1999). *The sanitary city: Urban infrastructure in America from colonial times to the present (creating the North American landscape)*. Baltimore: The Johns Hopkins University Press.
- [28] Mouratidis, K., & Yiannakou, A. (2022). COVID-19 and urban planning: Built environment, health, and well-being in Greek cities before and during the pandemic. *Cities*, 121, article number 103491. doi: [10.1016/j.cities.2021.103491](https://doi.org/10.1016/j.cities.2021.103491).
- [29] Neiderud, C.J. (2015). How urbanization affects the epidemiology of emerging infectious diseases. *Infection Ecology & Epidemiology*, 5(1), article number 27060. doi: [10.3402/iee.v5.27060](https://doi.org/10.3402/iee.v5.27060).
- [30] Rosenberg, C.E. (1992). *Explaining epidemics: And other studies in the history of medicine*. Cambridge: Cambridge University Press.
- [31] Samuelsson, K., Barthel, S., Colding, J., Macassa, G., & Giusti, M. (2020). Urban nature as a source of resilience during social distancing amidst the coronavirus pandemic. *OSF Preprints*. doi: [10.31219/osf.io/3wx5a](https://doi.org/10.31219/osf.io/3wx5a).
- [32] Satam, M. (2022). Influenza pandemic and the development of public health infrastructure in Bombay city, 1919-1935. *Planning Perspectives*, 37(1), 53-76. doi: [10.1080/02665433.2021.2009012](https://doi.org/10.1080/02665433.2021.2009012).
- [33] Sharifi, A., & Khavarian-Garmsir, A.R. (2020). The COVID-19 pandemic: Impacts on cities and major lessons for urban planning, design, and management. *Science of the Total Environment*, 749, article number 142391. doi: [10.1016/j.scitotenv.2020.142391](https://doi.org/10.1016/j.scitotenv.2020.142391).
- [34] Snowden, F.M. (2019). *Epidemics and society: From the Black Death to the present*. New Haven: Yale University Press.
- [35] Sumanti, A.E., Xian, G.E., & Novianto, D. (2023). The effect of pandemics towards sustainable architectural evolution. *City and Built Environment*, 1, article number 8. doi: [10.1007/s44213-023-00010-3](https://doi.org/10.1007/s44213-023-00010-3).
- [36] Sutcliffe, A. (1981). *Towards the planned city*. Oxford: Blackwell Publishers.
- [37] Traveling Canuks. (n.d.). *25 awesome day trips from Vancouver, Canada*. Retrieved from <https://travelingcanucks.com/2025/01/day-trips-from-vancouver/>.
- [38] Ugolini, F., et al. (2020). Effects of the COVID-19 pandemic on the use and perceptions of urban green space: An international exploratory study. *Urban Forestry & Urban Greening*, 56, article number 126888. doi: [10.1016/j.ufug.2020.126888](https://doi.org/10.1016/j.ufug.2020.126888).
- [39] UN-Habitat. (2021). *Cities and pandemics: Towards a more just, green and healthy future*. Nairobi: United Nations Human Settlements Programme.
- [40] Verderber, S. (2003). Architecture for health – 2050: An international perspective. *The Journal of Architecture*, 8, 281-302. doi: [10.1080/1360236032000134808](https://doi.org/10.1080/1360236032000134808).
- [41] Wang, Q., et al. (2022). Aerosol transmission of SARS-CoV-2 due to the chimney effect in two high-rise housing drainage stacks. *Journal of Hazardous Materials*, 421, article number 126799. doi: [10.1016/j.jhazmat.2021.126799](https://doi.org/10.1016/j.jhazmat.2021.126799).
- [42] World Health Organization. (n.d.). *COVID-19 and urban health*. Retrieved from <https://www.who.int/teams/social-determinants-of-health/urban-health/covid-19>.
- [43] Zhang, X., Sun, Z., Ashcroft, T., Dozier, M., Ostrishko, K., Krishan, P., McSwiggan, E., Keller, M., & Douglas, M. (2022). Compact cities and the Covid-19 pandemic: Systematic review of the associations between transmission of Covid-19 or other respiratory viruses and population density or other features of neighbourhood design. *Health & Place*, 76, article number 102827. doi: [10.1016/j.healthplace.2022.102827](https://doi.org/10.1016/j.healthplace.2022.102827).
- [44] Zhao, P. (2022). Analysis of COVID-19 clusters involving vertical transmission in residential buildings in Hong Kong. *Building Simulation*, 16, 701-711. doi: [10.1007/s12273-022-0929-5](https://doi.org/10.1007/s12273-022-0929-5).
- [45] Zhu, X., & Xu, J. (2023). After the pandemic is before the pandemic: Rethinking urban priorities, assumptions and planning approaches. *Heliyon*, 9(10), article number e20763. doi: [10.1016/j.heliyon.2023.e20763](https://doi.org/10.1016/j.heliyon.2023.e20763).
- [46] Zhuk, K. (2021). Hong Kong: The economic oasis of Asia. A Chinese region with a European approach to life. *Investory News*. Retrieved from <https://investory.news/gonkong-ekonomichnij-oazis-azii/>.



Ігор Гнесь

Доктор архітектури, професор
Національний університет «Львівська політехніка»
79013, вул. Степана Бандери, 12, м. Львів, Україна
<https://orcid.org/0000-0003-0810-7681>

Любов Соловій

Кандидат архітектури, доцент
Національний університет «Львівська політехніка»
79013, вул. Степана Бандери, 12, м. Львів, Україна
<https://orcid.org/0000-0002-1627-030X>

Василь Мацола

Аспірант
Національний університет «Львівська політехніка»
79013, вул. Степана Бандери, 12, м. Львів, Україна
<https://orcid.org/0009-0002-7339-8841>

Вплив епідемій та пандемій на архітектурно-містобудівні трансформації міст

Анотація. Метою дослідження стало виявлення та систематизація архітектурно-містобудівних трансформацій міст, міської інженерної інфраструктури й житлового середовища, що відбувалися у відповідь на епідемії та пандемії. Методологія дослідження базувалася на міждисциплінарному підході, що поєднував історико-ретроспективний, порівняльний і просторово-аналітичний методи із залученням сучасних урбаністичних та епідеміологічних досліджень. Дослідження показало, що від найдавніших систем водопостачання та каналізації у містах Стародавнього Сходу й античності до комплексних санітарних реформ XIX століття та модерністських ідей «здорового міста», архітектурно-планувальні рішення послідовно використовувалися як інструмент протидії поширенню інфекційних захворювань. У статті здійснено історико-аналітичний огляд трансформацій міського простору під впливом епідемій, а також акцентовано увагу на сучасному етапі, пов'язаному з пандемією COVID-19. Показано, що сучасний етап характеризувався зміщенням фокусу з базових санітарно-інженерних рішень на морфологічні параметри житлового середовища, зокрема щільність і поверховість забудови, конфігурацію спільних просторів і ефективність природної аерації. Особливу увагу приділено аналізу просторових параметрів житлової забудови, які опосередковано впливали на епідеміологічні ризики, зокрема поверховості та щільності забудови. На основі сучасних міждисциплінарних емпіричних досліджень було проаналізовано статистично підтверджені кореляції між збільшенням щільності, поверховості житла та більш інтенсивним поширенням інфекції. Підкреслено роль аерозольних шляхів передачі інфекції через спільні інженерні системи багатоповерхових будівель. Узагальнено проектно значущі висновки щодо допустимих рівнів інтенсивності використання простору, а також ролі відкритих і напіввідкритих просторів у зниженні ризиків передачі інфекцій та зменшенні психологічного напруження під час тривалого карантину. Також, акцент зроблено на значенні ефективного природного та механічного провітрювання, організації повітрообміну у спільних зонах (сходові майданчики, коридори, ліфтові холи) та запобіганні утворенню застійних повітряних зон. Практичне значення роботи полягає у формуванні архітектурно-містобудівних рекомендацій, спрямованих на підвищення пандемічної стійкості житлового середовища, в діапазоні «район – багатоквартирний житловий будинок»

Ключові слова: передача вірусної інфекції; житлове середовище; інженерна інфраструктура; поверховість забудови; пандемічна стійкість; архітектура здоров'я

ARCHITECTURAL STUDIES
International Journal about Architecture

Volume 11, No. 4
2025

Managing editor:
O. Kviatkovska

Signed to the print 19.12.2025
Format 60×84/8
Conventional Printed Sheet 11.9
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 11, № 4
2025

Відповідальний редактор:
О. Квятковська

Підписано до друку 19.12.2025 р.
Формат 60×84/8
Ум. друк. арк. 11,9
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>