



8th
International
Academic
Conference on
Places and
Technologies

PROCEEDINGS

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Keeping up with technologies to imagine and build together sustainable, inclusive, and beautiful cities

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+TECHNOLOGIES** ²³



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LOGIES
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WORD OF THE CONFERENCE DIRECTOR

_ Aleksandra Djukic

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Belgrade - Faculty of Architecture;
Director of the Conference

This Proceedings from the 8th International Conference Places and Technologies: Keeping up with Technology to act Responsively with Urban Environment, which was held in Belgrade in October 2023, contributes to the discussion about the future of society and places and the role of technology in it and discussions with respect to strategy for responsive quality environment. More than 85 papers from 20 countries were presented during the conference. The organizers of the conference were: University of Belgrade (Faculty of Architecture) and Professional Association Urban Laboratory (UrbanLab). This time we have a joint event with CIRRE conference which contributed with 18 conference papers.

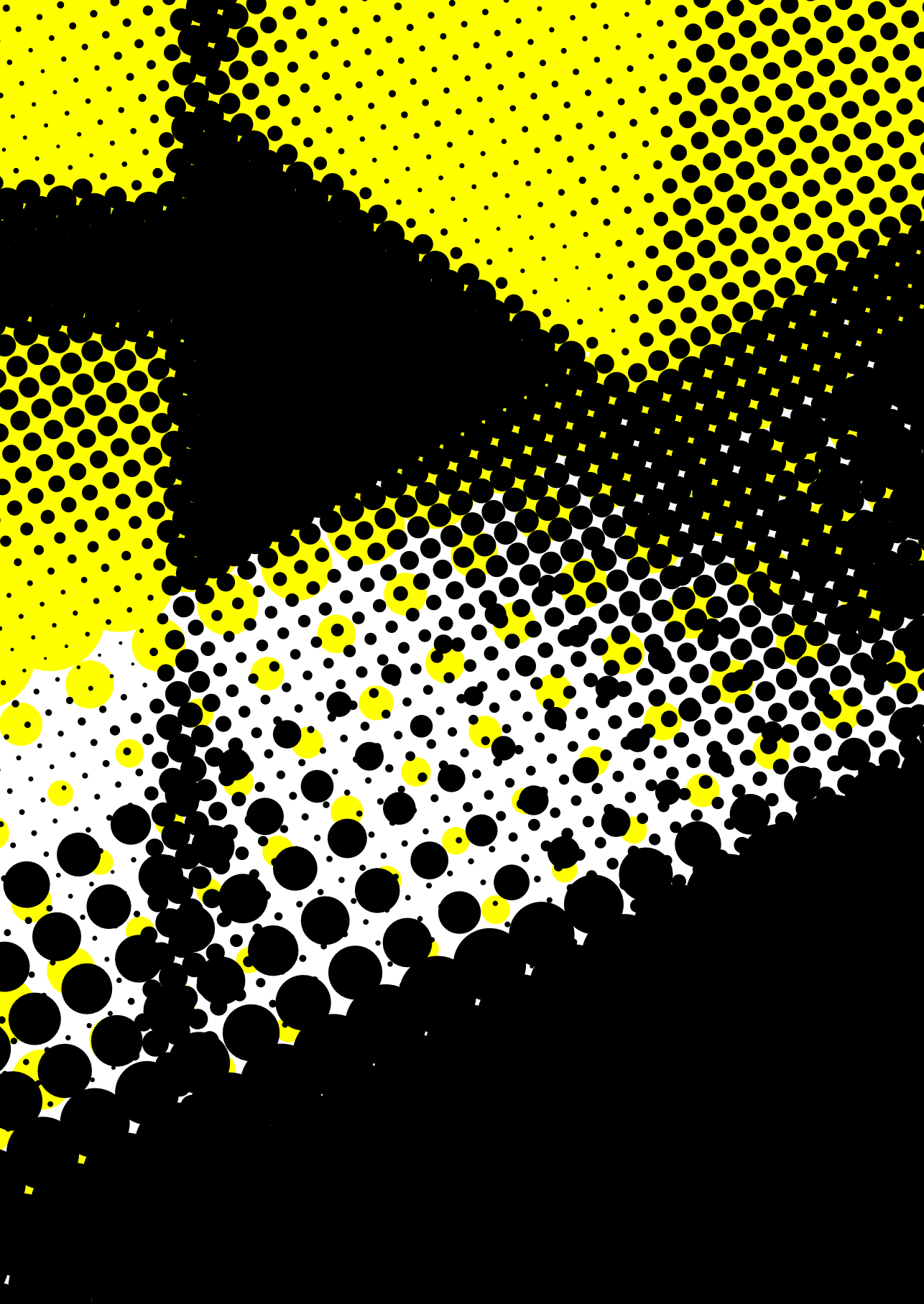
The conference aimed to raise questions about the future of cities and the environment, emphasizing the critical role of technology in designing innovative solutions to enhance urban spaces. It underscored the importance of a multidisciplinary approach, bridging engineering, humanities, and social sciences to address urban challenges effectively. New urban and building concepts predominantly rely on Information and Communication Technologies (ICT) to drive progress and responsiveness to various urban development aspects.

The conference proceedings is divided into seven main parts in correlation with the scale of planning and construction - spatial planning, urban planning, urban design, architectural design, architectural technologies, architectural education and close domains of the place and technologies, focusing on responsive spatial and urban planning, design, architecture, heritage protection, education and technological advancements in architecture. Each section delves into specific topics such as morphology, sustainable construction, cultural heritage, digital technologies, identity, teaching architecture and urban planning and climate resilience.

The event's significance lies in promoting the integration of smart technologies and modern urban concepts for sustainable city development, addressing diverse urban issues through academic research and collaboration. Different problems in the domains of urban design and planning, architectural design, building technologies, urban sociology, ICT, transport and traffic studies, resilience of place, climate change, adaptive reuse, cities and health, landscape architecture, identity, heritage etc. are presented and discussed in more than 80 conference papers made by professors, researchers, and PhD students from all over Europe and the world.

The conference serves as a platform for global researchers to enhance their academic standing, foster research networks, and initiate new scientific endeavors, contributing to the scientific advancement of Serbia and the region.

Places and Technologies conference become traditional international event gathering researchers all around the world and has provided an opportunity for them to advance their positions in the academic hierarchy, to build their research networks and to develop new scientific projects. Presentation and the quality of the papers that are results of new studies, debates and research strengthen our ambition to keep the importance of our conference among many European ones.



CONTENT

COMMITTEES

12 SCIENTIFIC COMMITTEE; ORGANIZING COMMITTEE; TECHNICAL COMMITTEE

KEYNOTES

- 16 EMBRACING THE PRINCIPLES OF CIRCULAR ECONOMY FOR SUSTAINABLE BUILT ENVIRONMENTS: NEW TRENDS, APPROACHES AND CHALLENGES
_ **Katerina Tsikaloudaki**
- 17 GREEN URBAN RENEWAL STRATEGIES IN THE CONTEXT OF ZERO NET LAND TAKE
_ **Ivana Katurić**

SPATIAL PLANNING

- 19 EXPLORING SPATIAL HETEROGENEITY OF URBAN HEAT ISLAND THROUGH BUILT ENVIRONMENT MORPHOLOGY
_ **Han Liang Lin _ Li-Ting Chung _ Chi Feng Lai**
- 26 ANALYSIS OF SUCCESSFUL WASTE MANAGEMENT IN LARGE CITIES - THE EXAMPLE OF TOKYO
_ **Marko Simić _ Ivan Garić _ Vladimir Vučenov _ Dragoljub Sekulović**
- 34 THE SKOPJE CONTACT ZONE – A KEY TO A SUSTAINABLE FUTURE OF THE CITY
_ **Ana Lukic Korobar _ Lidija Trpenoska Simonovic**

URBAN PLANNING

- 44 THE EIBENTHAL INITIATIVE: AN INFORMAL MODEL FOR SUSTAINABLE DEVELOPMENT
_ **Ştefana Bădescu _ Ana Branea _ Mihai Danciu**
- 52 SHRINKING AND NON-GLOBAL CITIES: SIMILARITIES AND DIFFERENCES
_ **Branislav Antičić**
- 60 PARTICIPATORY DESIGN FOR SUSTAINABILITY
_ **Jernej Markelj _ Aleksandar Petrovski _ Jan Kazak**
- 68 COLLABORATIVE APPROACH FOR INTEGRATING NATURAL AND CULTURAL HERITAGE FOR SUSTAINABLE URBAN DEVELOPMENT: THE CASE OF ACTION PLAN FOR SOMBOR WITHIN DANURB+
_ **Danijela Milovanović Rodić _ Ana Šabanović _ Branislav Antičić _ Aleksandra Đukić**
- 75 PRESENTATION OF EXISTING METHODS BASED ON MULTI AGENT SYSTEMS WITH THE PURPOSE OF ROAD PLANNING
_ **Julijan Jurak _ Krešimir Osman _ Matija Sikirić _ Ljupko Šimunović**
- 83 POST-INDUSTRIAL TERRITORY DEVELOPMENT UNDER AN ARCHITECTURAL AND URBAN DEVELOPMENT PROJECT AS ILLUSTRATED BY THE VOLGOGRAD TRACTOR PLANT
_ **Dmitrii Klimov**

- 92 REVITALIZATION OF RURAL AREAS ON REGIONAL LEVEL AS A DRIVER FOR ECOLOGICAL TRANSITION AND SUSTAINABLE DEVELOPMENT IN SERBIA
_ **Milica Igić** _ **Milena Dinić Branković** _ **Jelena Đekić** _ **Mihailo Mitković** _ **Milica Ljubenočić**
- 102 THE CONSEQUENCES OF CENTRALIZED DEVELOPMENT OF TOURIST INFRASTRUCTURE: THE EXAMPLE OF BUDVA PROMENADE
_ **Milena Bismiljak** _ **Eva Vaništa Lazarević** _ **Jelena Marić**
- 110 SMART CITY CRITERIA
_ **Dashnor Kadiri** _ **Morana Pap** _ **Bojan Baletić**
- 117 GOING GREEN-LESS: A MORPHOLOGICAL AND FUNCTIONAL STUDY OF DECREASING GREEN PUBLIC SPACES IN NOVI BEOGRAD, SERBIA
_ **Ivan Filipović** _ **Kosta Stojanović**
- 125 MEDIATIC APPROACH TO URBAN SPACE: A COMPREHENSIVE DISPLAY PERSPECTIVE
_ **Zhao Lei** _ **Wang Tie**
- 135 RECLAIMING THE OLD INTO THE NEW CITY CONCEPT: REVISITING THE "NEIGHBOURHOOD UNIT" CONCEPT AND ITS RELEVANCE FOR THE 15-MINUTE CITY MODEL - A CASE STUDY OF "DOMCHE" IN SKOPJE
_ **Elena Andonova** _ **Jasmina Siljanoska**
- 143 DIGITAL NOMADS AS ENGINES FOR RURAL REVITALIZATION: THE DEVELOPMENT STRATEGY OF PÉCSDEVECSER, HUNGARY
_ **Noémi Kókai** _ **Donát Rétfalvi**
- 150 STUDY ON THE CONSTRUCTION MODE OF NATIONAL PARK FROM THE PERSPECTIVE OF YANGTZE RIVER CIVILIZATION INHERITANCE: CHU JINAN CITY SITE NATIONAL HERITAGE PARK
_ **Bálint Bachmann** _ **Chen Kun**
- 156 VERTICALITY OF CADASTRAL PLOT: MULTIPURPOSE FUNCTION IN SPACE
_ **Marko Milosavljević** _ **Dejan S. Đorđević** _ **Zlatko Stojmenović**
- 164 APPROACH TO THE CARTOGRAPHY OF GRANADA WITH ECOSYSTEM APPROACH: FOUNDATIONAL TRAIT, URBAN FABRIC, GREEN INFRASTRUCTURE AND HABITABILITY
_ **Juan Luis Rivas-Navarro** _ **Belén Bravo-Rodríguez** _ **Elisa Larisa Negoita**
- 172 FACTORS OF INTEGRATION AND SOCIAL COHESION OF URBAN FACILITIES IN THE NORTHERN AND SOUTHERN PERIPHERIES OF GRANADA
_ **Belén Bravo-Rodríguez** _ **Juan Luis Rivas-Navarro** _ **Cecilia Hita-Alonso** _ **Pilar Martos-Fernández**
- 180 GEODATA AND GIS AS A DECISION-MAKING SUPPORT INSTRUMENT IN HEALTHY CITY GOVERNANCE
_ **Ksenija Lalović** _ **Ratka Čolić** _ **Veljko Dmitrović** _ **Rastko Čugaj**
- 190 GREEN SPACE DEVELOPMENT MONITORING FOR THE SMART CITY: A NOVEL AI BASED METHODOLOGY FOR THE ASSESSMENT OF URBAN GREEN
_ **Christina Petschnigg** _ **Alexander Pamler** _ **Daniel Pfeiffer** _ **Harald Urban** _ **Guenter Koren** _ **Torsten Ullrich**
- 198 ELEMENTS OF THE GEODESIGN FRAMEWORK AS A TOOL FOR GREEN INFRASTRUCTURE PLANNING ON A LANDSCAPE SCALE
_ **Boris Radić** _ **Suzana Gavrilović** _ **Sinisa Polovina**
- 207 COMPUTATIONAL MODELLING AND SIMULATIONS - THE FUTURE OF PREDICTING GROWTH AND DEVELOPMENT OF SUSTAINABLE CITIES
_ **Dijana P. Furundžić** _ **Nikola Z. Furundžić** _ **Aleksandra Krstić-Furundžić**
- 212 URBAN TRANSPORT INFRASTRUCTURE AND SUSTAINABLE MOBILITY
_ **Božidar S. Furundžić** _ **Daniilo S. Furundžić**

URBAN DESIGN

- 221 TENSIONS OF URBAN DEVELOPMENT IN POST-SOCIALIST CITIES: THE CASE STUDY OF COMMUNITY – BASED INITIATIVE FOR PRESERVATION AND TRANSFORMATION OF OPEN PUBLIC SPACE IN BANJA LUKA
_ Ana Špirić _ Aleksandra Đukić
- 230 THE OBJECTS BUILT OUTSIDE AN URBAN CONTEXT AS A PROBLEM IN FURTHER URBAN PLANNING AND ARCHITECTURAL DESIGN
_ Velimir Stojanović
- 238 STUDY ON UPDATING STRATEGIES OF TRANSFORMING FROM AN OLD INDUSTRIAL ESTATE TO AN INDUSTRIAL HERITAGE COMMUNITY
_ Jie Tan _ Hutter Akos
- 246 SHAPING RESIDENTIAL OPEN SPACE IN URBAN DENSIFICATION: GUIDING THE PROCESS TO PRESERVE ENVIRONMENTAL QUALITY AND HEALTHY LIFESTYLES IN NIŠ, SERBIA
_ Milena Dinić Branković _ Milica Igić _ Mihailo Mitković _ Jelena Đekić
- 256 THE HISTORICAL PROCESSES OF TRANSFORMATION OF THE SPACE THROUGH URBAN DESIGN COMPETITIONS: THE CASE STUDY OF INDEPENDENCE SQUARE IN PODGORICA
_ Nemanja Milićević _ Ema Alihodžić Jašarović _ Eva Vaništa Lazarević _ Jelena Marić
- 267 THE FUTURE PROSPECTS OF THE RESIDENTIAL TOWERS IN THE MACEDONIAN CITIES
_ Marija Petrova
- 277 POSSIBLE USES OF INTERACTION DESIGN TO SUPPORT PARTICIPATORY PROCESSES IN PUBLIC SPACE AND PRE-TESTS BASED ON VISUAL ATTENTION
_ Araf Öykü Türken _ Cenk Hamamcıoğlu
- 287 INFORMAL LOW-RISE HOUSING IN THE SUBURBAN CONTEXT AS A PATTERN FOR THE NEW NEIGHBOURHOODS: THE CASE OF CITY OF TETOVO, NORTH MACEDONIA
_ Vlera Tachi
- 295 LIVING LAB, TECHNOLOGICAL SIMULATION
_ Aleksandra Kondraciuk
- 304 VIRTUAL REALITY FOR IMPROVING WALKABILITY
_ Stefan van der Spek _ Marijke Koene _ Cor Wagenaar
_ Sijmen A. Reijneveld _ Jolanda Tuinstra _ Manda Broekhuis
- 312 MORE-THAN-HUMAN DESIGN PRACTICE: REVIEW OF APPROACHES IN MAPPING SUBJECTIVE PARAMETERS OF PEDESTRIAN EXPERIENCES
_ Nikola Mitrović

ARCHITECTURAL DESIGN

- 320 THE COMPLEXITIES AND CONTRADICTIONS OF SUSTAINABLE DESIGN AESTHETICS
_ Ana Kisjan _ Dubravko Aleksić _ Tijana Vujičić
- 325 HYBRID SPACES, HYBRID PLACES IN THE ARCHITECTURE OF THE OFFICE BUILDING
_ Ana Vračević _ Dina Stober

ARCHITECTURAL TECHNOLOGIES

- 334 THE IMPROVEMENT OF THE NEW OFFICE BUILDINGS' ADAPTABILITY: GENERAL RECOMMENDATIONS
_ Damjana Nedeljković _ Tatjana Jurenić _ Aleksandra Čabarkapa

- 340 REFURBISHMENT OF THE EXISTING MULTI-FAMILY HOUSING STOCK FROM THE PERIOD OF POST-WAR MASS CONSTRUCTION: SPATIAL AND ENERGY BENEFITS
_ Ljiljana Đukanović _ Bojana Lević
- 348 MATERIAL EFFICIENCY: PATTERN DESIGN TECHNIQUES FOR 3D PRINTED RIB-STIFFENED FLOOR SYSTEMS
_ Maša Žujović _ Radojko Obradović _ Jelena Milošević
- 356 POSSIBILITIES OF STAGED RENOVATION OF REINFORCED CONCRETE FACADES OF MULTI-FAMILY BUILDINGS IN THE CENTRAL ZONE OF NEW BELGRADE
_ Nikola Macut _ Tijana Žišić _ Jelena Ivanović-Šekularac
- 364 RECONSTRUCTION OF THE HERITAGE BUILDING OF THE ŽIČA MONASTERY FOR THE PURPOSE OF SUSTAINABILITY
_ Nenad Šekularac _ Jelena Ivanović-Šekularac _ Nikola Macut _ Tijana Žišić
- 371 KNAUFTERM3D – SOFTWARE FOR MODELLING AND CALCULATION OF BUILDINGS ENERGY EFFICIENCY PROPERTIES
_ Aleksandar Rajčić
- 379 COMMON BIM USES: EXPERIENCE-BASED RESEARCH
_ Motasem Altamimi _ Márk Balázs Zagorác _ Miklós Halada
- 387 THE IMPORTANCE OF SUSTAINABLE TIMBER CONSTRUCTION IN ACHIEVING LOW CARBON FOOTPRINT BUILDINGS
_ Peter Markus
- 393 ON THE EVALUATION OF THE IMPACT OF CLIMATE CHANGE ON THE ENERGY PERFORMANCE OF PREFABRICATED AND CONVENTIONAL BUILDINGS
_ Stella Tsoka _ Katerina Tsikaloudaki _ Theodoros Theodosiou _ Kondylia Velikou
- 400 NEW TECHNOLOGIES IN ARCHITECTURAL HERITAGE PRESENTATION: ISSUES OF AUTHENTICITY
_ Jovana Tošić
- 407 ENERGY SAVINGS POTENTIAL IN MODULAR ENVELOPE RENOVATIONS OF PREFABRICATED RESIDENTIAL BUILDINGS IN BOSNIA-HERZEGOVINA AND SERBIA
_ Darija Gajić _ Budimir Sudimac _ Aleksandar Rajčić _ Slobodan Peulić _ Jelena Rašović
- 416 CAPABILITIES AND CHALLENGES IN BUILDING RENOVATION: APPLYING THE SUSTAINABILITY PRINCIPLES IN AN OFFICE BUILDING IN THESSALONIKI, GREECE
_ Katerina Tsikaloudaki _ Katerina Karanafti _ Theodoros Theodosiou _ Konstantinos Laskos _ Stella Tsoka
- 424 THE IMPORTANCE OF DAYLIGHT-SAVING TIME FOR ENERGY SAVINGS IN BELGRADE LATITUDE AND CLIMATE
_ Marija Grujić _ Nikola Knežević
- 432 FACADE PANEL PARAMETRISATION IN THE MODERNIST HERITAGE OF NEW BELGRADE: A MULTIPLE-CASE STUDY
_ Djordje Mitrović

ARCHITECTURAL EDUCATION

- 441 SHAPING A BETTER FUTURE: CONTEXTUAL LEARNING AND TEACHING OF STRUCTURAL DESIGN IN THE PROCESS OF ARCHITECTURAL EDUCATION
_ Aleksandra Nenadović _ Jelena Milošević
- 449 SUSTAINABLE FLUIDITY IN AESTHETICAL PERSPECTIVES OF CONTEMPORARY ARCHITECTURE: POST-INDUSTRIAL DEVELOPMENT OF DANUBE'S WATERFRONT IN BELGRADE
_ Bojana Jerković-Babović

- 456 TOWARD THE IDEAS OF THE NEW EUROPEAN BAUHAUS: THE APPLICATION OF THE DIGITAL TOOLS IN THE UNIVERSITY CURRICULA
_ Vladimir Mihajlov _ Aleksandra Stupar _ Ivan Simic
- 465 LEED IN ACADEMIC ARCHITECTURAL EDUCATION
_ Nataša Čuković Ignjatović _ Dušan Ignjatović
- 472 CREATIVE EDUCATION: NEW APPROACHES AND TRANSFORMATION OF TEACHING METHODOLOGY FOR INSPIRING STUDENTS
_ Eva Vaništa Lazarević _ Jelena Marić _ Milena Vukmirović
- 482 WORKCAMP IN HIGHER EDUCATION IN URBANISM: EXPERIENCE FROM DANURB+ BUILDING CAMP FOR STUDENTS IN GOLUBAC, SERBIA
_ Milorad Obradović _ Aleksandra Djukić _ Jelena Marić _ Branislav Antonić _ Nikola Mitrović

CLOSE DOMAINS TO PLACES AND TECHNOLOGIES

- 490 NEW GENERATIVE AND AI DESIGN METHODS FOR TRANSPORTATION SYSTEMS AND URBAN MOBILITY DESIGN, PLANNING, OPERATION, AND ANALYSIS: CONTRIBUTION TO URBAN COMPUTING THEORY AND METHODOLOGY
_ Dragana Ćirić
- 504 TENSILE MEMBRANE STRUCTURES IN PUBLIC SPACES / CASE STUDY
_ Aleksandar Vučur _ Isidora Zimović _ Nebojša Stanošević
- 512 URBAN AIR MOBILITY DEVELOPMENT IN WESTERN BALKAN (WB6) REGIONAL PARTNERS
_ Olja Čokorilo _ Anja Stamenić _ Lidija Tomić
- 519 SOCIAL PERCEPTION AND ACCEPTANCE OF GEOTHERMAL SYSTEMS
_ Aleksandar Petrovski
- 526 URBAN INTERFACE DESIGN STRATEGIES BASED ON THE ADAPTABILITY OF 5G MILLIMETRE WAVE MOBILE COMMUNICATION
_ Hu Tianyu _ Gabriella Medvegy _ Ágnes Borsos _ Wang Tie
- 539 A HUMAN SOCIETY NEEDS HUMAN PLACES
_ Pieter de Haan
- 550 FOSTERING INNOVATION: UNIVERSITY-INDUSTRY COLLABORATION NETWORKS IN ARCHITECTURAL RESEARCH
_ Milijana Živković _ Eva Vaništa Lazarević _ Jelena Marić _ Jelena Milošević
- 558 ARTIFICIAL INTELLIGENCE APPLIED TO CULTURAL HERITAGE AND SUSTAINABILITY: A PORTUGUESE CASE STUDY
_ Janaina Cardoso de Mello _ Gabriel Ko Freitag e Silva _ Gyamarco Pereira Nascimento Secci
- 566 EVALUATING THE RELEVANCE OF COMPUTATIONAL DESIGN IN ARCHITECTURE AS A VIABLE RESPONSE TO THE AFFORDABLE HOUSING CHALLENGE
_ David Ojo _ Gabriella Medvegy _ Ágnes Borsos
- 573 BELGRADE UNIVERSITY ENDOWMENTS LEASE MANAGEMENT
_ Danilo S. Furundžić _ Nemanja Šipetić

8TH CONFERENCE OF INTERDISCIPLINARY RESEARCH ON REAL ESTATE - CIRRE 2023

- 582 THE ROLE OF PUBLIC SPACE IN SHAPING THE QUALITY OF LIFE FOR OLDER RESIDENTS: THE CASE OF SLOVENIA
_ Ajda Šeme _ Richard Sendi _ Maša Filipovič Hrast _ Boštjan Kerbler

- 597 COMPARISON OF THE QUALITY OF LIFE IN HOUSING ESTATES FROM SOCIALIST AND POST-SOCIALIST ERA: THE CASE OF SLOVENIA
_ **Boštjan Kerbler** _ **Ajda Šeme** _ **Richard Sendi**
- 611 METHOD FOR 3D NEIGHBORHOOD MODEL CREATION IN CITYGML STANDARD AS BASIS FOR URBAN SIMULATION TOOLS
_ **Galina Voitenko** _ **Hannes Harter** _ **Niki Gaitani**
- 623 APPLICATION OF BLOCKCHAIN TECHNOLOGY IN ENERGY TRADING
_ **Asha Chathurini Wijethilake Haputhanthirige** _ **Champika Liyanage** _ **Ruchira Yapa** _ **Susantha Udagedara**
- 635 PLANNING VISION AND THE SERVICE OF SPATIAL PLANNING
_ **Ivan Stanić**
- 641 TOLERANCE TO URBAN WINDOW VIEWS IN REGARD TO VARIOUS VARIABLES
_ **Živa Kristl** _ **Ajda Fošner** _ **Martina Zbašnik-Senegačnik**
- 648 THE ARCHITECTURE OF PUBLIC BUILDINGS AS TRANSFORMATIVE MODEL TO WARDS SUSTAINABILITY
_ **Mihajlo Zinoski** _ **Jana Brsakoska** _ **Kire Stavrov**
- 654 HIGHER PRICES, SMALLER SPACES: CORRELATION BETWEEN APARTMENT PRICES AND ARCHITECTURAL PRACTICES IN SKOPJE
_ **Mihajlo Zinoski** _ **Vebi Fazliu** _ **Valmir Dalipi**
- 662 FROM CLASSICAL MANAGEMENT TO URBAN HERITAGE FACILITY MANAGEMENT: MOBILITY AND ACCESSIBILITY IN URBAN HERITAGE AREAS
_ **Bintang Noor Prabowo**
- 673 CITIZENS' INVOLVEMENT IN THE DESIGN PROCESS OF PUBLIC SPACES: THE CASE OF ELGESETER STREET IN TRONDHEIM, NORWAY
_ **Clémence Magnière** _ **Mahgol Afshari**
- 685 THE SCIENCE OF PLAY: CONFESSIONS OF AN ENGINEER EXPLORING SCIENCE AND TECHNOLOGY STUDIES. AN STS ANALYSIS OF SERIOUS GAMES AND CO-PRODUCTION
_ **Coline Senior**
- 693 SEMI-STRUCTURED INTERVIEWS AS THE FOUNDATION FOR INTERDISCIPLINARY RESEARCH ABOUT THE BUILT ENVIRONMENT, HEALTH, AND HAPPINESS
_ **Elham Andalib**
- 704 PREVIEW INCREASED INVESTMENTS AND DIFFERENTIATION IN HEALTH CARE REAL ESTATE
_ **Jan Veuger**
- 716 REDUX: IMPACT, TRENDS AND DEVELOPMENTS IN SOCIAL REAL ESTATE
_ **Jan Veuger**
- 723 USING CITIZEN PARTICIPATION METHODS TO IDENTIFY STRATEGIES FOR INCREASED ACTIVE MOBILITY - CASE ELGESETER STREET OF TRONDHEIM
_ **Mahgol Afshari** _ **Alenka Temeljotov-Salaj** _ **Agnar Johansen**
- 735 COWORKING SPACES - IS IT JUST A BUZZWORD, OR DOES IT HAVE POTENTIAL?
_ **Margareth Berstad**
- 747 IDENTIFICATION OF POTENTIAL IMPACTS OF CLIMATE CHANGE AND THE ADAPTATION OPTIONS IN LOW-COST STRATA RESIDENTIAL BUILDING IN MALAYSIA
_ **Mustafa Omar**
- 758 NEED FOR CREATIVE COMPETENCIES IN ENGINEERING EDUCATION
_ **Olav Torp** _ **Elham Andalib** _ **Alenka Temeljotov Salaj**

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POSSIBILITIES OF STAGED RENOVATION OF REINFORCED CONCRETE FACADES OF MULTI-FAMILY BUILDINGS IN THE CENTRAL ZONE OF NEW BELGRADE

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ABSTRACT

The central zone of New Belgrade represents an architectural and urban complex which construction began in the early sixties of the twentieth century. In the period from the early sixties to the end of the seventies, multi-family buildings were constructed in blocks: 21, 22, 23, 28, 29 and 30, and today they are classified as the most representative examples of domestic architecture. Based on its architectural and urban characteristics, the central zone has the status of a spatial cultural-historical entity from 2021. Although this zone represents a cultural asset, the multi-family buildings in the blocks are examples of buildings that in the past few decades have not undergone any planned renovations of facade envelopes. The goal of the work is to present the possibilities of restoring facade envelopes through the process of staged renovations while considering ways of treating the envelopes that potentially preserve the original appearance - given that the selected buildings are treated as architectural heritage. Different reinforced concrete facade assemblies and existing damages also require different approaches in staged renovations, as a legitimate solution to this problem. Unplanned and unorganised works aimed at the restoration of facade envelopes led to significant damage and general degradation of both their non-transparent and transparent zones. Despite such problems, the owners of the apartments in the buildings were forced, due to the lack of organised renovations, to individually solve the encountered problems of facade assemblies. This primarily refers to the replacement of dilapidated windows and doors in facade envelopes, while the treatment of non-transparent zones was not carried out according to plan. This led to unfavourable situations in which the degradation of facades is not prevented. By applying staged methods of renovation and activating tenants, these problems can potentially be overcome, which is the main goal of this paper.

KEYWORDS _ *New Belgrade, reinforced concrete facades, façade renovation, multi-family housing*

INTRODUCTION

The principles of staged renovation represent one of the variants of the way of renovation and energy improvement of buildings that can be applied today (EC Directive of 25 October 2012, 2012). On the territory of European countries, staged renovation has a significant application, and it is stated that it is important to carry out various types of renovation within buildings at certain intervals (Fritz et al., 2019). For the purposes of this paper, the principles of staged renovation, which is the renovation and improvement of the entire building, will not be considered, but the concept of renovation should be applied only in the areas of the facade envelopes of residential buildings. Also, the paper will not consider the processes that precede the formation of staged reconstruction, and refer to different research processes, as well as the process of forming the approach itself in the reconstruction. The goal is to show the basic steps in staged renovation that are the steps of renovation of reinforced concrete facades that can be applied and to show possible renovation scenarios.

The Central Zone of New Belgrade is an area that, from 2021, enjoys the status of a cultural asset as a spatial cultural-historical entity (Sl. Glasnik RS, 2021). Based on such a status, in today's circumstances, every intervention must be monitored by the Cultural Monument Protection Institute of the City of Belgrade, in order to obtain appropriate documents from the domain of technical protection measures. Also in today's time, there is a significant carelessness of tenants, a lack of initiative to implement activities aimed at the renovation of buildings, as well as the inability of tenants to cover the costs of renovation. Due to such complex situations, the stage renovation of facade envelopes is one of the possible renovation strategies. By properly analysis and establishing appropriate solutions based on the found condition in the buildings, it is possible to plan a certain number of stages on the basis of which the renovation would be carried out. The stages would represent a series of steps in the restoration, and the steps themselves would be designed in such a way that the most critical damages should be repaired first. Since the common and private parts of the building are defined by domestic regulations (Sl. Glasnik RS, 2016, 2020), the most common problems arise related to the maintenance of the common parts, which includes the facade envelopes. Such problems point to one of the solutions, which is reflected in the application of stage renovation, by which the acquisition of money could be carried out in stages with the aim of realizing certain repairs, which would perhaps represent a more acceptable solution for today's circumstances.



Figure 1: Examples of residential buildings in Central Zone of New Belgrade

POSSIBLE SCENARIOS OF STAGED RENOVATION OF CONCRETE FACADES

For the purposes of this paper, three possible scenarios for the renovation of reinforced concrete facades of multi-family buildings are formed (Table 1). The scenarios were derived on the basis of field research, which included analysis of blocks in the Central Zone of New Belgrade. Previous

research has established that various problems are present in non-transparent and transparent zones of facade envelopes. This situation aims to consider appropriate ways of restoring facades while respecting various factors. This primarily refers to the consideration of methods of restoration and protection of the original appearance, given that the objects belong to a zone that has the status of a cultural property (Sl. Glasnik RS, 2021). On the other hand, different types of damages are evident that need to be repaired so that the buildings can continue to have their primary functions.

Table 1: Presentation of scenario goals of staged renovation

	Renovation – damage repair	Preservation of original appearance	Energy improvement measures
Scenario I	- treatment of joints of facade elements (outside)	- preservation of original appearance	- replacement of windows and doors
Scenario II	- treatment of the entire surface of facade elements (outside)	- preservation of original appearance	- replacement of windows and doors
Scenario III	- treatment of the entire surface of facade elements (outside and inside)	- preservation of original appearance	- replacement of windows and doors, - replacing or adding new layers of thermal insulation (inside)

The defined scenarios of staged renovation are based on three general goals of the renovation of buildings and their facade envelopes. The goals relate to rehabilitation, preservation of the original appearance and energy improvement of reinforced concrete facades (Macut, 2022). By inspecting the existing state of reinforced concrete facades in the Central Zone of New Belgrade, various damages were identified, which are represented in different extents on the facade surfaces. Problems stemming from decades of non-maintenance and unplanned renovations have led to a situation where the renovation of facade assemblies is indispensable. Different types of damage such as small cracks, cracks, to serious damage in the form of broken parts of the facade, the presence of corrosion and deterioration of the final layers, as well as the constructive layers of the facade elements require different approaches in their restoration and return to functional conditions. On the other hand, due to significant damage, the buildings must be treated as cultural assets during the restoration process, considering the existing status. Because of such a situation, facades must have a special treatment with the application of appropriate technical protection measures issued by the Cultural Monument Protection Institute of the City of Belgrade. The treatment of facades implies the renovation of both non-transparent and transparent zones, and in this connection, the renovation of transparent zones today represents a significant factor that can be treated as a measure of energy improvement of facade envelopes. In addition to the renovation of transparent zones by replacing existing windows and doors, it is possible to treat non-transparent zones by replacing or adding new thermal insulation layers. Based on the stated objectives, three scenarios were defined, which will be explained in more detail below.

When it comes to the replacement of windows and doors in the case of the selected buildings, it must be emphasized that a significant percentage of those transparent surfaces have already been restored by installing new ones, but the initiators of these activities were only owners of flats. In the given buildings, planned window and door replacements were not done at the level of the entire building, but were only individual activities of the owners. Today, it can be observed that the percentage of replaced windows and doors reaches 70% of the total area of transparent zones. Related to that, the question arises whether during one of the steps of the staged renovation, only the worn-out original windows and doors are changed, or whether all the windows are changed as planned. Such a question requires a separate analysis, which is not the subject of this paper, given that it is about buildings in protected zones. Certainly, the replacement of worn-out windows and doors is indispensable, in order to achieve energy improvement to a certain extent. On the other

hand, the performance of the energy upgrade is questionable, because the tenants replaced the windows and doors unevenly, where they usually differ according to their energy performance. Although such problems are evident, the goal is to show possible scenarios for the restoration of both non-transparent and transparent zones of facade envelopes.

SCENARIO I OF STAGED RENOVATION

The first defined scenario is based on one of the basic problems that is present in the case of the selected buildings. This refers directly to the problem of damaged joints between facade elements. Decades of exploitation and, in many cases, unprofessional interventions have led to the problem of water and moisture penetration, as well as blowing in the joint zones (Giebeler et al., 2009). Such problems adversely affect people's stay in their apartments or other types of space. In this regard, the first renovation scenario aims at the treatment of joints, and then a certain type of energy improvement, which is reflected in the replacement of windows and doors (Figure 2). In the case of the selected buildings, access to maintenance and activation of tenants in order to form building renovation strategies is a significant problem. Such a problem manifests itself through poor communication between tenants in buildings, lack of interest of tenants and the inability to make an agreement on how to pay for renovation costs. Due to the aforementioned existing problems, staged renovation of this type can give certain results. The first step in the renovation would be the extensive restoration and repair of the joint zones between the facade elements, where the horizontal and vertical joints would be repaired in parallel. Such an approach would prevent further unwanted damage to facade elements, as well as damage to the interior spaces of buildings. This type of building maintenance would lead to a situation where in one time interval only treatment is carried out in the zones of facade element joints, and in the second step the replacement of worn windows and doors is considered.

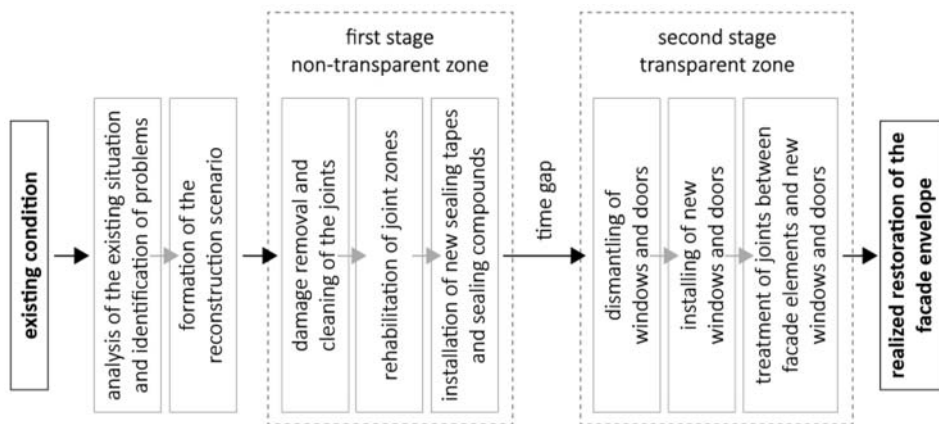


Figure 2: Diagram of the activities of the Scenario I

SCENARIO II OF STAGED RENOVATION

In the case of the Scenario II, non-transparent zones have a complete treatment in order to repair all the present damages. How different types of damage are represented on the selected facades, such as: small cracks, mesh cracks, cracks, areas with broken parts of facade elements and structural layers, occurrences of corrosion, damaged protective layers of concrete, damages in joint areas, etc. (Broomfield, 2003), it is necessary to treat such surfaces in order to repair them (Figure 3). The first phase in the formation of Scenario II represents the treatment of non-transparent zones with the aim of their renovation. Such renovation does not have the character of energy improvement, because with

this process, damaged surfaces are only returned to their original functional and designed state, and their energy improvements are not made by installing additional thermal insulation layers. The goal of this type of rehabilitation is to carry out the entire treatment of non-transparent zones, primarily from the outside of the facade surfaces, in order to prevent the penetration of various unfavourable atmospheric influences and to ensure a certain level of comfort in the interior spaces of buildings. In order to form and later realize such a complex renovation process, it is necessary to carry out preliminary research and identify the existing damages.



Figure 3: Diverse types of façade damages

The second stage of renovation according to the defined Scenario II refers to the treatment of transparent surfaces. As in the case of Scenario I, the same process of replacing worn out windows and doors can be in operation. The main goal is to carry out certain energy improvement of transparent zones, by installing new windows and doors, which will correspond to the possible requirements in the field of technical protection measures issued by Cultural Monument Protection Institute of the City of Belgrade. With this scenario, it is possible to fully restore the non-transparent and transparent zones with the possible preservation of the original appearance of the non-transparent zones, while the renovation of the transparent zones is carried out in such a way that the original appearance of the facades is not changed to a certain extent (Figure 4).

When it comes to the technological procedure for the implementation of Scenario II, it is certain that the renovation of the external surfaces can be carried out in several ways. Their implementation directly depends on the surface of the facade that contains damage. Based on that, with the necessary analysis process, it can be determined whether it is necessary to apply scaffolding in the reconstruction process or whether it is possible to realize the reconstruction by construction workers who will only use mountaineering equipment for work. The use of mountaineering equipment in the case of Scenario I is expected considering the treatment of only joint zones, while the use of scaffolding is more certain in Scenario II.

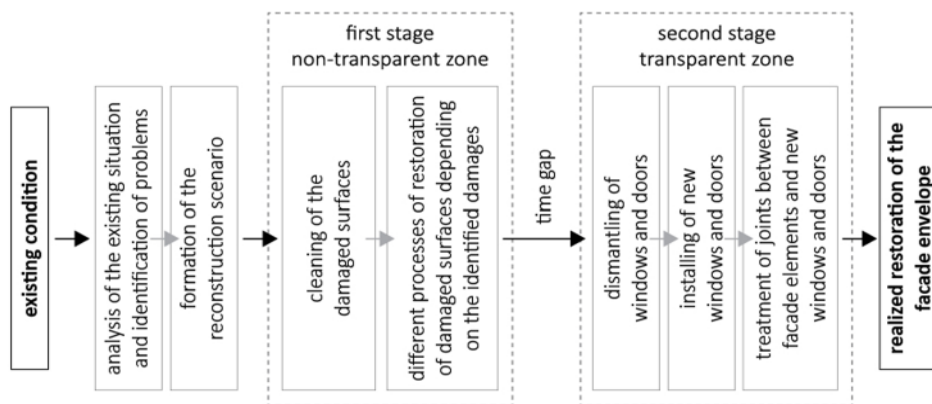


Figure 4: Diagram of the activities of the Scenario II

SCENARIO III OF STAGED RENOVATION

The defined activities in the renovation process in Scenario III are similar to the activities in Scenario II. This refers to the complete treatment of all external surfaces of non-transparent zones in order to restore them. The restoration of non-transparent zones is also in this case the subject of previous extensive research that must be done in order to form an appropriate strategy for their renovation. The principle of renovation and energy improvement of transparent zones is based on the same activities that were presented in the previous staged renovation scenarios. The difference compared to Scenario I and Scenario II is that in Scenario III, another large-scale activity is introduced, which is the treatment of non-transparent zones in the interior of buildings (Figure 5).

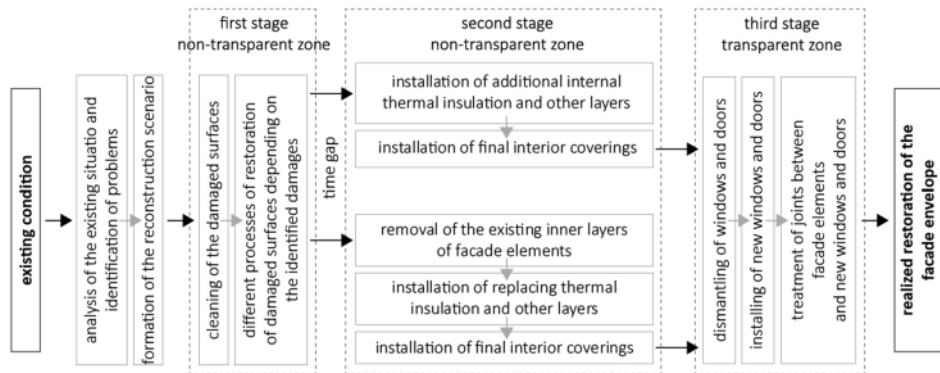


Figure 5: Diagram of the activities of the Scenario III

The treatment of internal surfaces of non-transparent zones can include various activities that primarily depend on the existing condition of facade elements, their structure and applied materials. Based on this, the processes that can include the removal of the existing inner layers and the installation of new replacement layers or the installation of new additional layers depend on it. The goal of such processes is to carry out the energy improvement of non-transparent zones. Considering the possible goal of renovation, this approach represents the most complex process of renovation because the works are carried out in the interiors of apartments and other spaces in buildings, which can directly impair the possibility of staying in flats during such interventions. Due to such methods of renovation, an extensive analysis of the functioning of the building during the execution of works is necessary. Such renovations can be applied to protected buildings, such as buildings in the Central Zone. The execution of works according to this scenario includes activities that are realized in the outer zones of the facades, and then they are realized in the inner zones, which primarily refers to the replacement of windows and doors and interventions on non-transparent surfaces.

DISCUSSION

In order to facilitate the discussion, an evaluation was conducted on the advantages and disadvantages of the three reconstruction scenarios that were previously defined. Given that the focus of this study is on architectural objects that are proclaimed a cultural asset as a spatial cultural-historical entity, the preservation of the original facade appearance takes precedence. As a result, the extent of facade renovation in the given scenarios has been adjusted to various possibilities based on the existing conditions of the facade (Table 2).

Table 2: Presentation of scenario goals of staged renovation

	Advantages	Disadvantages
Scenario I	<ul style="list-style-type: none"> - renovation of facade element joints - energy efficient improvement of the transparent zones of the facade - the whole process can be finished using mountaineering equipment, with no need for scaffolding 	<ul style="list-style-type: none"> - not the entire surface of non-transparent zones of the facade is improved - there is no energy efficient improvement of non-transparent areas of the facade
Scenario II	<ul style="list-style-type: none"> - energy efficient improvement of the transparent zones of the facade - repairs are made to the non-transparent parts of the facade 	<ul style="list-style-type: none"> - there is no energy efficient improvement of non-transparent areas of the facade
Scenario III	<ul style="list-style-type: none"> - renovation of external facade surfaces is underway - energy efficient improvement of transparent and non-transparent zones of the facade 	<ul style="list-style-type: none"> - the impossibility of using the interior space during the execution of the works because they are carried out from the inside - adding layers in the interior reduces the useful area of the apartment - the impossibility of repairing thermal bridges on the facade completely - the possibility of condensation

CONCLUSIONS

Depending on the existing condition of the facade envelope and the possibility of financing the energy efficient refurbishment, the selection of the fitting renovation scenario, which is set out in the paper, is made.

In the first scenario, the focus of the renovation is on enhancing the sealing of joints in the facade to minimize water and moisture penetration and prevent further deterioration. Window and door replacements are also planned to improve energy efficiency. All of these renovations can be conducted using only mountaineering equipment without the need for scaffolding. However, this scenario does not address the overall thermal issues of non-transparent facade areas.

The second scenario improves upon the first by additionally rehabilitating damaged non-transparent parts of the facade. However, thermal characteristics of these areas are still not addressed.

The third scenario requires more extensive research, time, and financial investment. It involves comprehensive interior and exterior renovations. Non-transparent facade areas are fully rehabilitated with the addition of thermal insulation and other protective layers from the interior. Transparent facade elements are also upgraded through window and door replacements. This scenario achieves the highest level of progress in terms of energy efficiency. However, it has drawbacks such as the long duration of the works, disruption of normal usage of the apartments during renovations, occupation of interior space by additional layers, and the potential of forming thermal bridges after insulation installation, which can be challenging to repair while preserving the facade's original appearance.

Based on the provided information, it is crucial to conduct a detailed assessment of the building's condition prior to commencing renovations. This assessment will inform the selection of the most appropriate scenario based on available time and financial resources, ensuring that facade renovations achieve improved energy performance while preserving the building's original state and mitigating further deterioration. To ensure the effectiveness of these works, it is essential to carry out simultaneous renovations on the entire facade envelope of a single building. This approach will lead to improved energy performance and the preservation of the building's original condition, thereby slowing down further deterioration.

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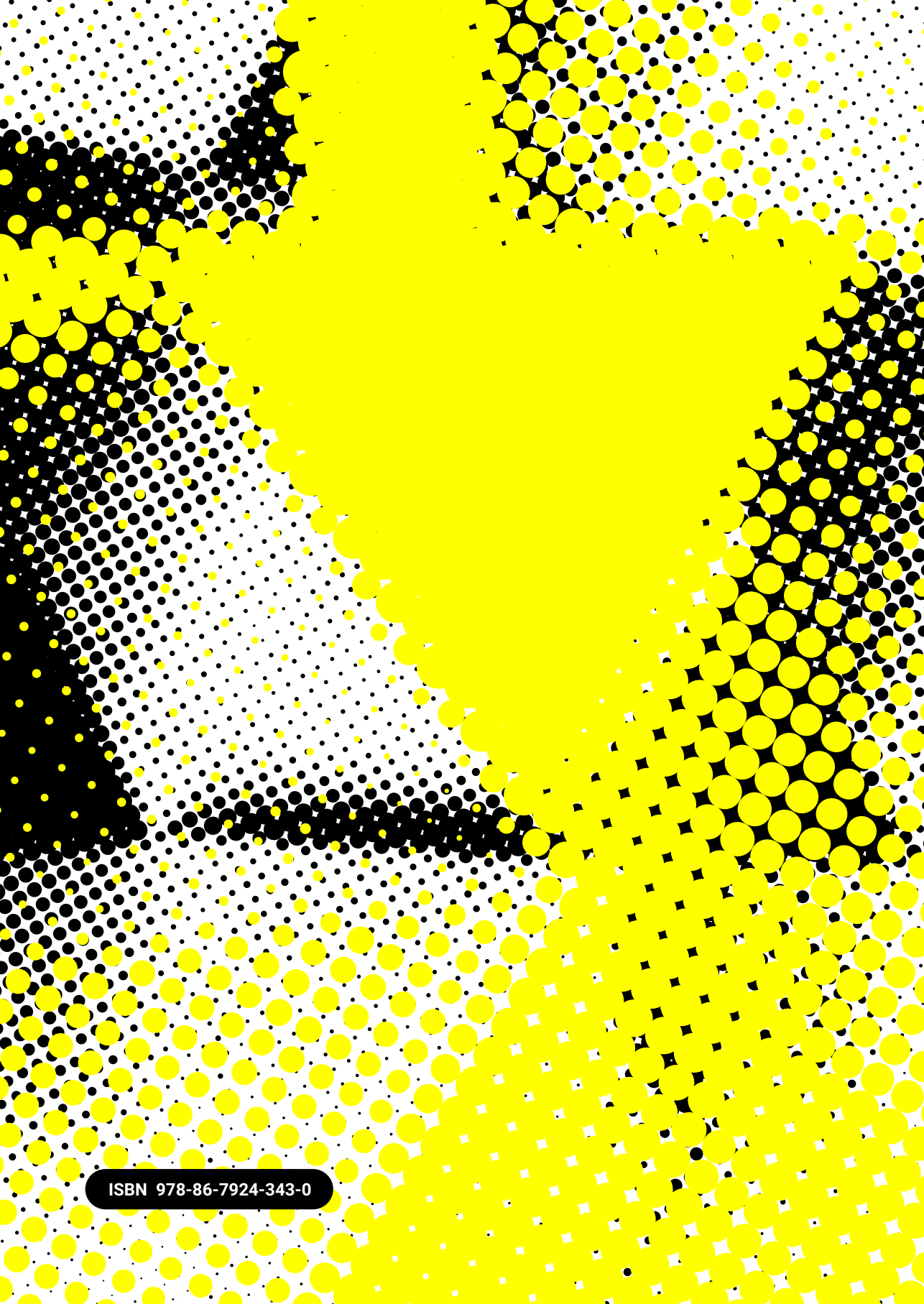
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