

CONFERENCE
PROCEEDINGS

**5th INTERNATIONAL
ACADEMIC CONFERENCE ON
PLACES AND TECHNOLOGIES**

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PLACES AND TECHNOLOGIES 2018

THE 5TH INTERNATIONAL ACADEMIC CONFERENCE ON PLACES AND TECHNOLOGIES

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TABLE OF CONTENTS

IMAGE, IDENTITY AND QUALITY OF PLACE: URBAN ASPECTS

THE EFFECT OF BEHAVIOURAL SETTINGS ON THE REGENERATION OF URBAN DYNAMIC ARTS, CASE STUDY: TEHRAN AZADI SQUARE Yasaman NEKOU Ali Entezarinajafabadi	3
DEVELOPMENT SCENARIOS OF THE ZAGREB'S SATELLITE TOWN DUGOSELO - "THE CITY OF THE FUTURE" Lea Petrović Krajnik Damir Krajnik Ivan Mlinar	11
SUSTAINABILITY OF MODERN-DAY UTOPIAS AS SEEN IN MASS MEDIA Aleksandra Til	18
URBAN DENSIFICATION OF THE POST-SOCIALIST CITY AND ITS IMPLICATIONS UPON URBAN STRUCTURE: A STUDY OF NIS, SERBIA Milena Dinić Branković Ivana Bogdanović Protić Mihailo Mitković Jelena Đekić	25
MUSEUM QUARTERS VS CREATIVE CLUSTERS: FORMATION OF THE IDENTITY AND QUALITY OF THE URBAN ENVIRONMENT Ekaterina Kochergina	35
URBAN NON-MECHANICAL CODE AND PUBLIC SPACE Aleksandra Đukić Valentina Milovanović Dubravko Aleksić	43
ADDRESSING THE SOCIO-SANITARY EMERGENCY IN AFRICA: THEORIES AND TECHNIQUES FOR DESIGNING A COMMUNITY HEALTH CENTRE IN MALI Adolfo F. L. Baratta Laura Calcagnini Fabrizio Finucci Cecilia M. L. Luschi Antonio Magarò Massimo Mariani Alessandra Venturoli Alessandra Vezzi	50
THE NETWORK OF LOCAL CENTERS AS A TOOL FOR STRENGTHENING THE SUPER-BLOCK COMMUNITIES: BELGRADE VS. ROME Predrag Jovanović Aleksandra Stupar	58
TRANSFORMATION OF IDENTITY OF SAVAMALA DISTRICT IN BELGRADE Aleksandra Đukić Jelena Marić Tamara Radić	66
THE CULTURE OF MEMORY AND OPEN PUBLIC SPACE - BANJA LUKA Jelena Stankovic Milenko Stankovic	73

IMAGE, IDENTITY AND QUALITY OF PLACE: ARCHITECTURAL ASPECTS

IMPROVEMENT OF SOCIAL HOUSING THROUGH THE MIXING CONCEPT IMPLEMENTATION Nataša Petković Grozdanović Branislava Stojković Vladana Petrović Aleksandar Keković Goran Jovanović	83
---	----

IMPROVING THE IDENTITY OF NON – SURROUNDED COMMUNAL SPACES WITH USING ARCHITECTURAL PROGRAMING. CASE STUDY: NAJAF ABAD (ESFAHAN), IMAM KHOMEINI SQUARE 91
Ali Entezarinajafabadi YasamanNekoui

A CONTRIBUTION TO THE STUDY OF THE ARCHITECTURAL OPUS OF NATIONAL STYLE WITH MODELS IN FOLK ARCHITECTURE AND NEW INTERPOLATIONS 100
Katarina Stojanović

SHOPPING CENTRE AS A LEISURE SPACE: CASE STUDY OF BELGRADE 108
Marija Cvetković Jelena Živković Ksenija Lalović

ARCHITECTURAL CREATION AND ITS INFLUENCE ON HUMANS 119
Nikola Z. Furundžić Dijana P. Furundžić Aleksandra Krstić-Furundžić

INNOVATIVE METHODS AND TECHNOLOGIES FOR SMART(ER) CITIES

POTENTIAL OF ADAPTING SMART CULTURAL MODEL: THE CASE OF JEDDAH OPEN- SCULPTURE MUSEUM 131
Sema Refae Aida Nayer

AN INNOVATIVE PROTOCOL TO ASSESS AND PROMOTE SUSTAINABILITY IN RESPONSIBLE COMMUNITIES 140
Lucia Martincigh Marina Di Guida Giovanni Perrucci

GEOHERMAL DISTRICT HEATING SYSTEMS DESIGN: CASE STUDY OF ARMUTLU DISTRICT 148
Ayşe Fidan ALTUN Muhsin KILIC

DATA COLLECTION METHODS FOR ASSESSMENT OF PUBLIC BUILDING STOCK REFURBISHMENT POTENTIAL 157
Ljiljana Đukanović Nataša Čuković Ignjatović Milica Jovanović Popović

SMART HOSPITALS IN SMART CITIES 165
Maria Grazia Giardinelli Luca Marzi Arch. PhD Valentina Santi

INNOVATIVE METHODS AND TOOLS

PRIMARY AND SECONDARY USES IN CITIES – PRINCIPLES, PATTERNS AND INTERDEPENDENCE 175
Marina Čarević Tomić Milica Kostreš Darko Reba

MODELLING AND ANALYSING LAND USE CHANGES WITH DATA-DRIVEN MODELS: A REVIEW OF APPLICATION ON THE BELGRADE STUDY AREA 183
Mileva Samardžić-Petrović Branislav Bajat Miloš Kovačević Suzana Dragičević

INNOVATIVE DECISION SUPPORT SYSTEM 190
Mariella Annese Silvana Milella Nicola La Macchia Letizia Chiapperino

URBAN FACILITY MANAGEMENT ROLE	196
Alenka Temeljotov Salaj Svein Bjørberg Carmel Margaret Lindkvist Jardar Lohne	
ANALYSES OF PUBLIC SPACES IN BELGRADE USING GEO-REFERENCED TWITTER DATA	205
Nikola Džaković Nikola Dinkić Jugoslav Joković Leonid Stoimenov Aleksandra Djukić	
SENTIMENT ANALYSIS OF TWITTER DATA FOR EXPLORATION OF PUBLIC SPACE SENTIMENTS	212
Miroslava Raspopovic Milic Milena Vukmirovic	
CITIES AND SCREENS: ARCHITECTURE AND INFORMATION IN THE AGE OF TRANSDUCTIVE REPRODUCTION	217
Catarina Patricio	
CITIZEN EMPOWERMENT, PUBLIC PARTICIPATION AND DEMOCRATIC CITIES	
CITIES AS PLATFORMS FOR SOCIAL INNOVATION: AN INVESTIGATION INTO HOW DIGITAL PLATFORMS AND TOOLS ARE USED TO SUPPORT ENTREPRENEURSHIP IN URBAN ENVIRONMENTS	227
Margarita Angelidou	
PROBLEM ISSUES OF PUBLIC PARTICIPATION IN HERITAGE CONSERVATION: GEO-MINING PARKIN SARDINIA	235
Nađa Beretić Arnaldo Cecchini Zoran Đukanović	
A METHODOLOGY FOR STAKEHOLDER EMPOWERMENT AND BENEFIT ASSESSMENT OF MUNICIPAL LONG-TERM DEEP RENOVATION STRATEGIES: A SURVEY WITHIN SOUTH-EASTERN EUROPEAN MUNICIPALITIES	242
Sebastian Botzler	
THE OPPORTUNITIES OF MEDIATED PUBLIC SPACES: CO-CREATION PROCESS FOR MORE INCLUSIVE URBAN PUBLIC SPACES	249
Inês Almeida Joana Solipa Batista Carlos Smaniotta Costa Marluci Menezes	
ARCHITECTURE AS SOCIAL INNOVATION: EDUCATION FOR NEW FORMS OF PROFESSIONAL PRACTICE	255
Danijela Milovanović Rodić, Božena Stojčić Aleksandra Milovanović	
CITY AS A PRODUCT, PLANNING AS A SERVICE	262
Viktorija Prilenska Katrin Paadam Roode Liias	
RAJKA: CHANGING SOCIAL, ETHNIC AND ARCHITECTURAL CHARACTER OF THE "HUNGARIAN SUBURB" OF BRATISLAVA	269
Dániel Balizs Péter Bajmócy	
POSSIBLE IMPACT OF MIGRANT CRISIS ON THE CONCEPT OF URBAN PLANNING	279
Nataša Danilović Hristić Žaklina Gligorijević Nebojša Stefanović	

TOWARDS DIMINUISHING DISADVANTAGES IN MIGRATION ISSUES IN SERBIA
(FROM 2015) THROUGH PROPOSAL OF SOME MODELS 287

Eva Vaništa Lazarević Jelena Marić Dragan Komatina

ARCHITECTURAL DESIGN AND ENERGY PERFORMANCE OF BUILDINGS

APPLICATION OF ENERGY SIMULATION OF AN ARCHITECTURAL HERITAGE
BUILDING 303

Norbert Harmathy Zoltán Magyar

APPLICATION OF TRADITIONAL MATERIALS IN DESIGN OF ENERGY EFFI-
CIENT INTERIORS 311

Vladana Petrović Nataša Petković Grozdanović Branislava Stoiljković Aleksandar Keković
Goran Jovanović

DETERMINATION OF THE LIMIT VALUE OF PERMITTED ENERGY CLASS FOR
THE KINDERGARTENS IN THE NORTH REGION OF BOSNIA AND HERZEGOVI-
NA 318

Darija Gajić Biljana Antunović Aleksandar Janković

ARCHITECTURAL ASPECTS OF ENERGY AND ECOLOGICALLY RESPONSIBLE
DESIGN OF STUDENT HOUSE BUILDINGS 326

Malina Čvoro Saša B. Čvoro Aleksandar Janković

ENERGY EFFICIENCY ANALYSES OF RESIDENTIAL BUILDINGS THROUGH
TRANSIENT SIMULATION 332

Ayşe Fidan ALTUN Muhsin KILIC

INNOVATIVE TECHNOLOGIES FOR PLANNING AND DESIGN OF “ZERO-ENER-
GY BUILDINGS” 340

Kosa Golić Vesna Kosorić Suzana Koprivica

ENERGY REFURBISHMENT OF A PUBLIC BUILDING IN BELGRADE 348

Mirjana Miletić Aleksandra Krstić-Furundžić

TYOLOGY OF SCHOOL BUILDINGS IN SERBIA: A TOOL FOR SUSTAINABLE
ENERGY REFURBISHMENT 357

Nataša Čuković Ignjatović Dušan Ignjatović Ljiljana Đukanović

ARCHITECTURAL DESIGN AND NEW TECHNOLOGIES

EVALUATION OF ADVANCED NATURAL VENTILATION POTENTIAL IN THE
MEDITERRANEAN COASTAL REGION OF CATALONIA 367

Nikola Pestic Jaime Roset Calzada Adrian MurosAlcojor

TRENDS IN INTEGRATION OF PHOTOVOLTAIC FACILITIES INTO THE BUILT
ENVIRONMENT 375

Aleksandra Krstić-Furundžić Alessandra Scognamiglio, Mirjana Devetaković, Francesco
Frontini, Budimir Sudimac

INTEGRATION OF NEW TECHNOLOGIES INTO BUILDINGS MADE FROM CLT	389
Milica Petrović Isidora Ilić	
INTEGRATION OF SOLAR WATER HEATING SYSTEMS INTO GREEN BUILDINGS BY APPLYING GIS AND BIM TECHNOLOGIES	394
Kosa Golić Vesna Kosorić Dragana Mecanov	
IMPLEMENTING ADAPTIVE FAÇADES CONCEPT IN BUILDINGS DESIGN: A CASE STUDY OF A SPORTS HALL	402
Aleksandar Petrovski Lepa Petrovska-Hristovska	
SIMULATION AIDED ENERGY PERFORMANCE ASSESSMENT OF A COMPLEX OFFICE BUILDING PROJECT	409
Norbert Harmathy László Szerdahelyi	

ARCHITECTURAL DESIGN AND PROCESS

THE HABITABLE BRIDGE: EXPLORING AN ARCHITECTURAL PARADIGM THAT COMBINES CONNECTIVITY WITH HABITATION	421
Ioanna Symeonidou	
REFURBISHMENT OF POST-WAR PREFABRICATED MULTIFAMILY BUILDINGS	428
Aleksandra Krstić-Furundžić, Tatjana Kosić, PhD	
THE FUTURE (OF) BUILDING	438
Morana Pap, Roberto Vdović, Bojan Baletić	
COMPARISON OF ARCHITECTS' AND USERS' ATTITUDES TOWARD SPATIAL CHARACTERISTICS OF APARTMENTS	445
Ivana Brkanić	
DIGITAL VS. TRADITIONAL DESIGN PROCESS	453
Igor Svetel Tatjana Kosić Milica Pejanović	
CREATING THE EASTERN CAMPUS CONCEPT AT THE UNIVERSITY OF PÉCS - CONNECTED THE FACULTY OF BUSINESS AND ECONOMICS	461
Péter Paári Gabriella Medvegy Bálint Bachmann	

BUILDING STRUCTURES AND MATERIALS

SUSTAINABILITY BENEFITS OF FERROCEMENT APPLICATION IN COMPOSITE BUILDING STRUCTURES	471
Aleksandra Nenadović Žikica Tekić	
POSSIBILITIES OF ENERGY EFFICIENT REFURBISHMENT OF A FAMILY VILLA IN BELGRADE: A CASE STUDY	479
Nenad Šekularac Jasna Čikić Tovarović Jelena Ivanović-Šekularac	

ENHANCING THE BUILDING ENVELOPE PERFORMANCE OF EXISTING BUILDINGS USING HYBRID VENTILATED FAÇADE SYSTEMS	485
Katerina Tsikaloudaki Theodore Theodosiou Stella Tsoka Dimitrios Bikas	
STRUCTURAL ASPECTS OF ADAPTIVE FACADES	493
Marcin Kozłowski Chiara Bedon Klára Machalická Thomas Wüest Dániel Honfi	
STRATEGIZING FOR INFORMAL SETTLEMENTS: THE CASE OF BEIRUT	500
Hassan Zaiter Francesca Giofrè	
THE IMPACT OF USERS' BEHAVIOUR ON SOLAR GAINS IN RESIDENTIAL BUILDINGS	509
Rajčić Aleksandar Radivojević Ana Đukanović Ljiljana	
PRESERVATION OF ORIGINAL APPEARANCE OF EXPOSED CONCRETE FACADES, CASE STUDY: RESIDENTIAL BLOCK 23, NEW BELGRADE	517
Nikola Macut Ana Radivojević	

ADAPTIVE REUSE

CONVERSION AS MODEL OF SUSTAINABLE SOLUTION FOR DEVASTATED INDUSTRIAL COMPLEXES	529
Branko AJ Turnšek Aleksandra Kostić Milun Rancić	
SILO CONVERSION - POTENTIALS, FLEXIBILITY AND CONSTRAINTS	537
Branko AJ Turnšek Ljiljana Jevremović Ana Stanojević	
ARCHITECTURE OF MULTIPLE BEGINNINGS AS A TOOL OF SUSTAINABLE URBAN DEVELOPMENT	545
Milan Brzaković Petar Mitković Aleksandar Milojković Marko Nikolić	
INHABITING THE TOWER. THE PARADIGM OF THE FORTIFIED TOWERS OF MANI AND THE REUSE PROJECT	556
Rachele Lomurno	
ADAPTIVE REUSE THROUGH CREATIVE INDUSTRY TOOLS: CASE OF URAL-MASH, YEKATERINBURG, RUSSIA	564
Eva Vaništa Lazarević Timur Abdullaev, Larisa Bannikova	

URBAN MOBILITY, TRANSPORT AND TRAFFIC SOLUTIONS

POLICY FOR REDUCING EMISSIONS IN AIRCRAFT OPERATIONS IN URBAN AEREAS BASED ON REGULATORY AND FISCAL MEASURES	579
Marija Glogovac Olja Čokorilo	
SIMULATING PEDESTRIAN BEHAVIOUR IN SCHOOL ZONES – POSSIBILITIES AND CHALLENGES	586
Ljupko Šimunović Mario Ćosić Dino Šojat Božo Radulović Domagoj Dijanić	

MODEL OF SMART PEDESTRIAN NETWORK DEVELOPMENT USING AN EDGE-NODE SPACE SYNTAX ABSTRACTION FOR URBAN CENTRES 593

Bálint Kádár

THE ROLE OF SMART PASSENGER INTERCHANGES IN THE URBAN TRANSPORT NETWORK 604

Bia Mandžuka, Marinko Jurčević, Davor Brčić

CLIMATE CHANGE, RESILIENCE OF PLACES AND HAZARD RISK MANAGEMENT

THE IMPACT OF CLIMATE CHANGES ON THE DESIGN ELEMENTS OF CONTEMPORARY WINERIES - CASE STUDIES 617

Branko AJ Turnšek Ana Stanojević LjiljanaJevremović

DETERMINATION OF COMMUNITY DEVELOPMENT POLICIES USING URBAN RESILIENCE AND SYSTEM DYNAMICS SIMULATION APPROACH 626

Zoran Keković Ozren Džigurski Vladimir Ninković

QUALITIES OF RESILIENT CITY IN SYSTEMS OF PLANNING SUSTAINABLE URBAN DEVELOPMENT. AN INTRODUCTORY REVIEW. 634

Brankica Milojević Isidora Karan

PLACE-BASED URBAN DESIGN EDUCATION FOR ADAPTING CITIES TO CLIMATE CHANGE 641

Jelena Živković Ksenija Lalović

IMPROVING URBAN RESILIENCE, INCREASING ENVIRONMENTAL AWARENESS: NEW CHALLENGE OF ARCHITECTURAL AND PLANNING EDUCATION 652

Aleksandra Stupar Vladimir Mihajlov Ivan Simic

URBAN RESILIENCE AND INDUSTRIAL DESIGN: TECHNOLOGIES, MATERIALS AND FORMS OF THE NEW PUBLIC SPACE 659

Vincenzo Paolo Bagnato

THERMAL COMFORT OF NIŠFORTRESS PARK IN THE SUMMER PERIOD 666

Ivana Bogdanović Protić Milena Dinić Branković Petar Mitković Milica Ljubenović

LANDSCAPE ARCHITECTURE AND NATURAL BASED SOLUTIONS

SMALL ISLANDS IN THE FRAMEWORK OF THE U.E. MARINE STRATEGY – CHERADI'S ARCHIPELAGO IN TARANTO 679

Giuseppe d'Agostino Federica Montalto

LANDSCAPE AWARENESS AND RENEWABLE ENERGY PRODUCTION IN BOSNIA AND HERZEGOVINA 686

Isidora Karan Igor Kuvac Radovan Vukomanovic

SAVAPARK – A RESILIENT AND SUSTAINABLE NEW DEVELOPMENT FOR ŠABAC 692

Milena Zindović Ksenija Lukić Marović

ADRIATIC LIGHTHOUSES. STRATEGIC VISIONS AND DESIGN FEATURES 702

Michele Montemurro

LANDSCAPE ARCHITECTURE AND INFRASTRUCTURES: TYPOLOGICAL INVENTORY OF GREEK WATER RESERVOIRS' LANDSCAPE 710

Marianna Nana Maria Ananiadou-Tzimopoulou

THE BASIN OF THE MAR PICCOLO OF TARANTO AS URBAN AND LANDSCAPE "THEATRE" 717

Francesco Paolo Protomastro

INTERWEAVING AND COMPLEXITIES OF THE MAN-MADE ENVIRONMENT AND NATURE 725

Dženana Bijedić Senaida Halilović Rada Čahtarević

BUILT HERITAGE, NEW TECHNOLOGIES AND DANUBE CORRIDOR

DIGITAL TOOLS IN RESEARCHING HISTORICAL DEVELOPMENT OF CITIES 737

Milena Vukmirović Nikola Samardžić

APPLICATION OF BIM TECHNOLOGY IN THE PROCESSES OF DOCUMENTING HERITAGE BUILDINGS 751

Mirjana Devetaković Milan Radojević

GIS-BASED MAPPING OF DEVELOPMENT POTENTIALS OF UNDERVALUED REGIONS – A CASE STUDY OF BAČKA PALANKA MUNICIPALITY IN SERBIA 758

Ranka Medenica Milica Kostreš Darko Reba Marina Carević Tomić

MAPPING THE ATTRACTIVITY OF TOURIST SITES ALL ALONG THE DANUBE USING GEOTAGGED IMAGES FROM FLICKR.COM 766

Bálint Kádár Mátyás Gede

INVENTARISATION AND SYSTEMATIZATION OF INDUSTRIAL HERITAGE DOCUMENTATION: A CROATIAN MATCH FACTORY CASE STUDY 777

Lucija Lončar Zlatko Karač

CULTURAL LANDSCAPE OF ANCIENT VIMINACIUM AND MODERN KOSTOLAC – CREATION OF A NEW APPROACH TO THE PRESERVATION AND PRESENTATION OF ITS ARCHAEOLOGICAL AND INDUSTRIAL HERITAGE 785

Emilija Nikolić Mirjana Roter-Blagojević

ALTERNATIVE TERRITORIAL CHANGES OF HOUSING ESTATES TOWARDS A SUSTAINABLE CONCEPTION 793

Regina Balla

HERITAGE, TOURISM AND DANUBE CORRIDOR

- CULTURAL TOURISM IN THE BALKANS: TRENDS AND PERSPECTIVES. 807
Kleoniki Gkioufi
- CULTURAL TOURISM AS A NEW DRIVING FORCE FOR A SETTLEMENT REVIT-
ALISATION: THE CASE OF GOLUBAC MUNICIPALITY IN IRON GATES REGION,
SERBIA 814
Branislav Antonić Aleksandra Djukić
- CULTURAL AND HISTORICAL IDENTITY OF TWIN CITIES KOMÁR-
NO-KOMÁROM 823
Kristína Kalašová
- PLACE NETWORKS. EXPERIENCE THE CITY ON FOOT 830
Milena Vukmirovic Aleksandra Djukić Branislav Antonić
- STORIES WITH SOUP - CULTURAL HERITAGE MOMENTS ALONG THE DAN-
UBE RIVER 837
Heidi Dumreicher Bettina Kolb Michael Anranter
- ETHNIC AND TOPONYMIC BACKGROUND OF THE SERBIAN CULTURAL HERI-
TAGE ALONG THE DANUBE 844
Dániel Balizs Béla Zsolt Gergely

SPATIAL AND RURAL DEVELOPMENT

- BEAUTIFUL VILLAGE PROJECT: AN ARCHITECTURAL AND LANDSCAPE DESIGN
STRATEGY FOR NON-HERITAGE VILLAGES IN HEBEI PROVINCE 859
Dapeng Zhao Bálint Bachmann Tie Wang
- CHANGES IN DEVELOPMENT OF NORTHERN CROATIA CITIES AND MUNICI-
PALITIES FROM 1991 TO 2011: MULTIVARIABLE ANALYTICAL APPROACH 869
Valentina Valjak
- SPECIFICS OF DYNAMICS OF SHRINKING SMALL TOWNS IN SERBIA 879
Milica Ljubenović Milica Igić Jelena Đekić Ivana Bogdanović-Protić Ana Momčilović-Petroni-
jević
- BALANCED REGIONAL DEVELOPMENT OF RURAL AREAS IN THE LIGHT OF
CLIMATE CHANGE IN SERBIA– OPPORTUNITIES AND CHALLENGES 888
Milicalgić MilicaLjubenović Jelena Đekić Mihailo Mitković
- COLLABORATIVE RESEARCH FOR SUSTAINABLE REGIONALDEVELOPMENT:
EXPERIENCES FROM “LEARNING ECONOMIES” ITALY-SERBIA BILATERAL
PROJECT 899
Jelena Živković Ksenija Lalović Elena Battaglini Zoran Đukanović Vladan Đokić

ASSESSMENT OF VALUE OF BIOMASS ENERGY POTENTIAL FROM AGRICULTURAL WASTE IN LESKOVAC FIELD AND ITS IMPORTANCE IN THE SETTLEMENT DEVELOPMENT PLANNING 908

Mihailo Mitković Dragoljub Živković Petar Mitković Milena Dinić Branković Milica Igić

MULTIFUNCTIONAL FACILITIES – FROM PRIMARY FUNCTIONS TO SPATIAL LANDMARKS (STUDY OF TWO CASES IN SERBIA AND BOSNIA AND HERZEGOVINA) 918

Aleksandar Videnovic Milos Arandjelovic

PRESERVATION OF ORIGINAL APPEARANCE OF EXPOSED CONCRETE FACADES, CASE STUDY: RESIDENTIAL BLOCK 23, NEW BELGRADE

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ABSTRACT

Block 23, located in New Belgrade presents multifamily residential block constructed during 1970s. It was designed in the manner of the era of Brutalism. Consequently, exposed concrete was selected and applied as the main material for bearing structures and façade envelopes. This period was typical for the mass production of multifamily buildings and in the efforts to perform faster construction of buildings, prefabricated building systems were in use.

Technique of prefabricated production enabled the production of specific shapes of façade elements. Therefore, architects of the buildings in the Block 23 designed different types of facade elements resulting with specific architectural expression of this urban complex. In general, facade elements can be classified in specific groups by their shapes and dimensions. In the analysed block, five main groups of elements are present such as: parapets, one storey panels, linear elements, panels between windows and decorative elements.

After approximately 40 years of exploitation followed with different causes of damages and decay of exposed concrete, the condition of those elements deteriorated and they need to be reconstructed and renovated. Since these buildings do not fulfill the requirements of nowadays regulation regarding energy efficiency of buildings they also require energy rehabilitation. Having all this in mind, this paper strives to analyse potential solutions for reconstruction and energy renovation of these prefabricated concrete facades with respect to the need of preservation of their original appearance. This complex problem is supported by the fact that the block has the status of previous protection as the architectural and cultural heritage of one important period of Serbian architecture.

Keywords: Exposed concrete, Prefabricated facades, Residential block, Original appearance, Facades reconstruction

Introduction

The main topic of this paper is defined as the set of the problems which have to be solved in case of preserving the original appearance of concrete facades. Case study presents residential Block 23 in New Belgrade designed by the Serbian architects Aleksandar Stjepanović, Božidar Janković and Branislav Karadžić in the manner of the era of Brutalism. There are several reasons for selecting this block for analysing in the paper. In the first place, the Block 23 has the status of previous protection as architectural heritage of the huge era of Modernism but the buildings which are approximately 45 years old are not in a good condition, so they need to be renovated. Another reason is related to the type of applied façades. In the whole block the same type of exposed concrete façades is omnipresent. The facades are also not in

1 Corresponding author

a good condition since they are damaged during the period of exploitations. Another problem is that they have never been reconstructed or renovated since the construction period. The problem of energy efficiency of selected buildings is also present since façade structures are not in accordance with regulation related to the problem of energy efficiency of buildings. With the existing damages on façades, problems of reconstruction and energy renovation of Block 23 presents the great effort, having in mind the simultaneous need for preservation of the original appearance of façades and the need for energy renovation.

Applied constructions and materials of buildings in residential Block 23, New Belgrade

Residential block 23 was designed in late 1960s, but buildings were constructed during the whole decade of 1970s. Block has specific urban composition which was created by combining three types of residential buildings (Figure 1). According to the design solution, three types of residential buildings are classified by their heights and shapes.

For this huge construction project architect and civil engineers defined the specific systems of construction. In the first place, it is necessary to explain the applied systems of bearing structures. Type 1 and Type 2 of buildings were built with combined bearing system. [Čulafić, 1978] Those systems present combination of industrial pre-casted skeletal system IMS and system of bearing walls cast in-situ. Skeletal systems were for the use in the zones of flats. Systems of bearing walls were designed for zones of vertical and horizontal communications and in the planned zones of flats with the purposes of seismic walls. Floor constructions are produced as pre-casted hollow cored slabs, which rely on the columns and walls. Type 3 of buildings were designed with systems of bearing walls. They also have the purpose of receiving seismic impacts. Walls are casted in-situ and have variable dimension of profiles throughout the floors. Floor constructions were designed in systems of hollow cored pre-casted slabs which rely on the walls. Analysed buildings also have the specific number of pre-casted non-bearing façade elements and some of them are present in the façade structures of all three types as unitised elements with specific functions. Reinforced concrete presents the main material for bearing and non-bearing elements. Architects designed residential buildings with elements of exposed concrete, in the manner of Brutalism. Surfaces of façade planes were designed with the lot of number of different specific details. Elements were produced with smooth, cannellured or rough surfaces, according to the ideas of the architects and the applied building technology. Domination of exposed concrete diversity of façade elements represent a special value and recognition mark of this specific urban block.



Figure 1: Position of Block 23 and types of residential buildings: Type 1, Type 2, Type 3 (source Macut, N., 2016)

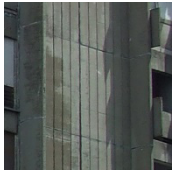


Typology of applied façade elements

Two main types of façade elements are defined throughout the detailed analysis of residential buildings of Block 23. According to the applied systems of construction façade elements can be classified as elements cast in-situ or pre-casted elements. Every of defined types are produced from exposed reinforced concrete.

Cast in-situ reinforced concrete elements

Defined type presents in most of the cases design solution for bearing walls (Table 1). Those walls were cast in-situ and have heights of one floor. They were built in zones of vertical and horizontal communications between two wings of flats as seismic and bearing walls. In case of Type 2 walls were also positioned between the flats with the purpose of dividing and seismic walls casted in-situ. Exposed bearing walls were constructed with specific manner of finishing, so the surfaces are either cannellured or smooth, which was achieved by special type of formwork. Type 3 of analysed buildings has thicker walls which have height of one floor. They are also designed as seismic walls. All of them were built from exposed reinforced concrete with specific profiling and finishing according to the design. Review of applied types of façade wall are presented in Table 1.




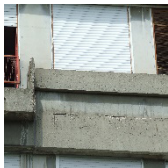
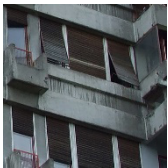
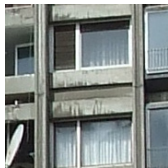

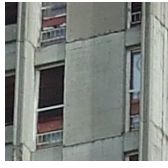



Table 1: Review of applied types of façade walls (source Macut, N., 2016)

TYPE OF ELEMENT	TYPE OF BUILDING		
	TYPE 1	TYPE 2	TYPE 3
BEARING WALL			

Prefabricated reinforced concrete elements

Types of elements are defined in groups according to the detailed analysis of façade structures. The design concept enabled the combination of several prefabricated elements, resulting with variety of formal expressions of buildings. First group is represented by linear elements and in case of analysed buildings they are placed horizontally in the zones of floor constructions (Table 2). Parapets of exposed concrete present a type of unified prefabricated elements with the same geometry which was created of two prefabricated elements standing one on the other. Main element is fixed to the floor construction, while the other is set on the main one representing a window sill. One floor height exposed concrete prefabricated panels were in use as façade elements. The panels are fixed in the zones of floor constructions and have different shapes and finishing with smooth, rough or cannellured planes. Panels were produced as independent elements of façade or as the finishing layers of cast in-situ bearing walls. The last ones present the group of others as the group of most different elements which are present on façades. They also have different functions and positions such as: decorative plastic elements designed for different positions on façades, railings of the terraces and flat roofs, flower pots.

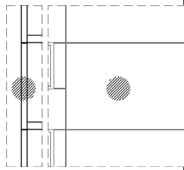

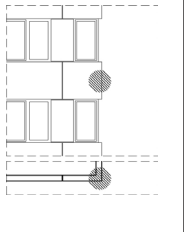

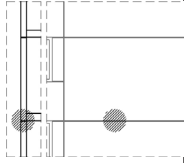

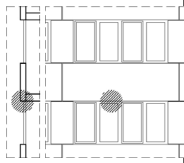

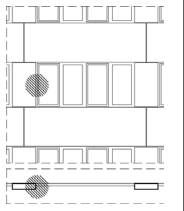

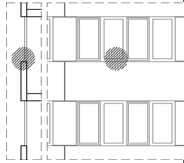

Table 2: Review of applied types of façade elements (source Macut, N., 2016)

TYPE OF ELEMENT	TYPE OF BUILDING		
	TYPE 1	TYPE 2	TYPE 3
LINEAR			
PARAPET			
ONE FLOOR HEIGHT	/		
OTHERS			

Types of damages on façade elements

The present damages on reinforced concrete walls are classified by the specific criteria. First step of classification is related to the present types of façade elements. The damage diagnostic methodology considered the field work which included the mapping of their exact position on façades. Each of defined types of reinforced concrete elements is possible to analyse, enabling every damage to be mapped and then classified [Macut, Radivojević, 2016]. (Table 3)

Table 3: Presence of different types of damages on analysed building types (source Macut, N., 2016)

	TYPE OF ELEMENT	TYPE 1, TYPE 2 OR TYPE 3 OF BUILDINGS
FREE SURFACE		
FREE EDGE OF ELEMENT		
HORIZONTAL JOINT		
WINDOW LINTEL		
WINDOW JUMBS		
WINDOW SILLS		

Detailed mapping of positions of possible damage show their presence in the following positions:

- free surface of element,
- free edge of element,
- horizontal joint,
- window lintel,
- window jambs,
- window sills.

Those positions are defined according to the geometry of analysed façades of residential buildings in Block 23. When the step of defining positions of damages present on the façades is done, then it is necessary to conduct a precise analysis of each damage. Their classification included the definition of their causes. Damages of reinforced concrete can be caused by several factors such as:

- applied technology,
- design process,
- time factors - ageing of elements and maintenance of building.

Reinforced concrete as building material is a result of specific production technologies and installation techniques. Their inadequate application can provoke different types of damages on façade planes during the exploitation period. Several types of damages can be caused by:

- the segregation of concrete mixture,
- small covering layer of concrete for protection of steel bars of reinforcement which induces the corrosion of steel bars,
- abrasion and erosion of façade elements,
- different types of cracks,
- scrapped pieces of concrete from the façade element.

Possible measures of façade reconstruction

Existing condition of Block 23 requests large scale reconstruction of whole buildings. Since the Block 23 has a status of previous protection as an architectural and urban heritage, this paper explores the possible scope of reconstruction, emphasizing the need to preserve the original appearance, i.e. the exposed concrete.

In this process there are two problems that need to be considered. The first one refers to the decay of façade planes and methods of their repair, while the second one investigates the possible measures and methods of energy renovation of façades.

Repair of damages

There are specific approaches in the treatment of damages on façade planes. Due to the recognition of the values of the analysed block, method of intervention includes the aspect of authenticity which should be respected. Therefore, damage repair includes the analysis of the achieved look of the façade element after the intervention which should be harmonized with the original appearance.

Similar investigations pointed out that selection of a particular method of repair depends on the extent of the damage of the façade element [Heinemann, 2013]. Generally speaking, damages could be repaired based on one of the following scenarios:

- repair of small scale damage by using modern, compatible materials;
- repair of damage by placing new layers over the original material;








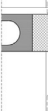




- replacing whole elements with a new, same or different structure from the original.

Possible measures of energy renovation of façades

Block 23 was built in the period prior to the time of adoption of regulations regarding energy efficiency of buildings. Therefore, energy performances of analysed buildings do not fulfil nowadays requirements for thermal comfort of buildings. Required energy improvement of façade elements can be based on two principle methods: from the interior side of the façade element, or from the exterior side.

According to the analysis of existing façade elements four groups of the most present façade elements were identified: linear ones, parapet elements, large elements (one floor height) [Krstić, 2003] either prefabricated or cast in-situ (Table 4). Each of selected elements has specific geometry and structure which affect the possibility for energy renovation.

Table 4: Possible measures of energy renovation (source Macut, N., 2018)

TYPE OF ELEMENT		TYPE 1, TYPE 2 OR TYPE 3 OF BUILDINGS		
		EXISTING CONDITION	INTERNAL PLACEMENT OF THERMAL INSULATION	EXTERNAL PLACEMENT OF THERMAL INSULATION
LINEAR		 <ul style="list-style-type: none"> -NO THERMAL INSULATION -THERMAL BRIDGE 	 <ul style="list-style-type: none"> -THERMAL BRIDGE -REPLACED WINDOW -THE ORIGINAL APPEARANCE 	 <ul style="list-style-type: none"> -NO THERMAL BRIDGE -REPLACED WINDOW -NEW APPEARANCE
	PARAPET	 <ul style="list-style-type: none"> -WITH THERMAL INSULATION -THERMAL BRIDGE 	 <ul style="list-style-type: none"> -THERMAL BRIDGE -REPLACES WINDOW -THE ORIGINAL APPEARANCE 	 <ul style="list-style-type: none"> -NO THERMAL BRIDGE -NEW APPEARANCE
ONE FLOOR HEIGHT	PREFABRICATED	 <ul style="list-style-type: none"> -WITH THERMAL INSULATION -THERMAL BRIDGE 	 <ul style="list-style-type: none"> -THERMAL BRIDGE -THE ORIGINAL APPEARANCE 	 <ul style="list-style-type: none"> -NO THERMAL BRIDGE -NEW APPEARANCE
	CAST IN-SITU	 <ul style="list-style-type: none"> -NO THERMAL INSULATION -THERMAL BRIDGE 	 <ul style="list-style-type: none"> -THERMAL BRIDGE -THE ORIGINAL APPEARANCE 	 <ul style="list-style-type: none"> -NO THERMAL BRIDGE -NEW APPEARANCE

Prefabricated elements present one important group which are designed and applied on all three types of buildings. From the perspective of energy performance of a building, the way they were used and combined with other façade elements, together with a lack of thermal insulation, induces the presence of linear heat losses on façades. Adequate solution for the problem of energy renovation [Pravilnik o EEZ, 2011] can be found in the placement of external layer of thermal insulation with specific façade finish. However, this method may be used without limitations for the buildings which are not recognized as architectural heritage. In other case, placement of external layer of insulation compromised the original appearance of the building. In this case, protection of original appearance can be achieved with the internal application of insulation layer.

Parapets built as exposed concrete panels are present on all three types of analysed buildings. Original structure of parapets is composed of three thin layers of: concrete, internal thermal insulation and plaster, but not in a sufficient thickness to fulfil the nowadays requirements. First possibility refers to the replacement of existing thermal insulation with the new one, which would inevitably lead to the application of much thicker insulation layer, influencing the reduction of the net area in the flats. On the other hand, this method does not exclude the presence of liner thermal bridges, which are present as result of applied construction details. Other renovation approaches are related to the installation of external insulation layer and new finishing layer, with or without the replacement of the existing thermal insulation. In these cases, the original appearance is endangered since the renovated façade gives completely new look of the building.

Applied façade elements designed with one floor height were constructed as prefabricated panels or cast in-situ. Originally, some of them were additionally insulated with an internal thermal insulation, but this was not a general rule. The analysis of technical documentation pointed out that many of the cast in-situ walls were designed without any layer of thermal insulation. The energy improvement methods are of the same nature as in the case of previously described façade elements.

Conclusion

The conducted analyses show that the emphasis on the need for preservation of original excludes the application of certain methods of energy renovation and points us to the solutions that bring partial solutions and different kind of problems and dilemmas. Such approach requires compromises regarding the achievement of necessary thermal performances of façade elements and favours the intervention on the internal side of façade elements.

Better results might be expected to be achieved by the combination of façade repair with the window replacement which is proved to be the energy improvement measure which influences the most energy balance of the building, or by investigation of application of new, innovative materials that enhance the thermal properties of building structures.

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